

**REPRODUCTIVE PERFORMANCE AND MILK
PRODUCTION OF SOKOTO RED GOATS IN
ADAMAWA STATE, NIGERIA**

BY

**YAHYA, Muktar Magaji
(Ph.D/AS/06/0190)**

MARCH, 2014

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STATE, NIGERIA**

BY

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**A THESIS SUBMITTED TO THE DEPARTMENT OF
ANIMAL SCIENCE AND RANGE MANAGEMENT,
MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY
YOLA, ADAMAWA STATE, NIGERIA IN PARTIAL
FULFILMENT OF THE EQUIREMENTS FOR THE
AWARD OF THE DEGREE OF DOCTOR OF
PHILOSOPHY IN ANIMAL PRODUCTION AND
MANAGEMENT**

DECLARATION

I hereby declare that this thesis was written by me and it is a record of my own research work. It has not been written before in any previous application for a higher degree.

References made to published literature have been duly acknowledged.

Yahya Muktar Magaji

Date

APPROVAL PAGE

This thesis entitled “**Reproductive Performance and Milk Production of Sokoto Red Goats in Adamawa State, Nigeria.**” by **Yahya Muktar Magaji (Ph.D/AS/06/0190)** meets the regulations governing the award of Doctor of Philosophy (Ph.D) in Animal production and Management, Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty Allah who gave me the intellectual ability to undertake the Doctoral research and thesis. The work is also dedicated to my Parents and Family.

ACKNOWLEDGEMENTS

My first appreciation goes to the Almighty Allah for his guidance and for providing me with a sound health through the period of this great task of my life. My profound gratitude also goes to my Major supervisor Prof M. S. Yahaya and my co-supervisor Prof. A. Kibon for their patience, continued assistance, pieces of advice and cooperation which made this work a success. May Allah reward them abundantly.

I would also acknowledge the contribution of Dr. H. D. Nyako. Dr. M. B. Ardo, Dr. Mohammed Abdulkadir, Dr. B. Yakubu. Dr. T. F. Mbahi, Mallam Hassan, Mr. Gworgwor, Dr. P. Mbaya, Dr. A. G. Bobbo and Dr. Alkali who contributed in many ways toward the success of my studies.

I also wish to express my appreciation to my parents, brothers and sisters for their remarkable knowledge of child up-bringing as well as their moral support. May Allah reward them abundantly.

I am also indebted to my friends, colleagues and well wishers, though too much to mention for their constant encouragement and assistance in many aspects. This work would not have been completed without the mention of Mallam Aminu Hayatu who did all that he could to see me through this work, May Allah reward him.

I am grateful to my wife Zara'u and Children Mahmud and Fadimatu for their forbearance and tolerance while I undertake this course. May Allah bless them.

Abstract

Studies were carried out on goat farmers in Adamawa State and at the Research farm of Modibbo Adama University of Technology, Yola to evaluate goats production and management systems, milk production and consumption and reproductive performance of Sokoto red goats. Survey was conducted in Benue trough block. In experiment 1 thirty (30) structured questionnaires were randomly distributed to sample farmers. The data were analysed using simple percentages. The result showed that only 12.08% of goat farmers used goats as dairy animals. Respondents reasons for non-consumption of goat milk were (58.29%), low milk yield (15.17), odour (17.54%) and health (9.0%). Breeds of goats reared were Sokoto red (67.9), Sahel (6.20%) and others (25.83%). Farmers reasons of keeping goats included income generation (64.58%), milk production (12.08%), meat production (8.75%), ceremonies (2.5%) and others (12.08%). Male respondents constituted 87.92%, while 77.50% were married, 13.33% singles, 3.75% divorced and 5.42% widowed. Farmers that were within the range of 30-35 years constituted the majority (30.42%) while those within the age of 42-47 years possessed the largest number of goats per household. Illiterates constituted 42.9%, while majority (40.42%) of farmers used free range system of management. Most farmers used family labour (60.83%). Milking was mostly done twice daily (51.73%), while farmers that processed their milk formed 62.52%. Lack of feed constituted the major (40.42%) problem of farmers followed by diseases (23.33%) while pes de petit ruminant (PPR) constituted the major (51.73%) disease of goats. In experiment 2, twenty does were used, they were grouped in to four (4) groups of five animals each. Group 1 was the control while treatments 2, 3 and 4 were supplemented with maize bran, cotton seed cake and groundnut hay in a complete randomized block design. Total weight gain, supplement feed intake and gestation length of does and birth weight and total weight gain of kids during first parity showed significant ($p<0.05$) differences between the treatment groups. While milk yield did not show any differences between treatment groups. Proximate composition of milk during first parity did not show any differences between treatment groups for all parameters measured during early and mid-lactation except on fat ($p<0.05$), Lactose ($p<0.01$) and Ash ($p<0.01$) during late lactation. During second parity supplement feed intake of does and total weight gain of kids showed significant ($p<0.001$) differences between groups. Kidding interval ($p<0.01$), gestation length ($p<0.01$) and birth weight of kids ($p<0.05$) also showed significant differences between groups while milk yield did not show difference. In experiment 3, sixteen does were used and were grouped and supplemented as in experiment 2. Total weight gain, supplement feed intake and puberty age of F_1 generation does showed significant ($p<0.001$) differences between groups while milk yield did not show any difference between groups. Farmers should be enlightened on the importance of goats as a dairy animal and more work should be done on selecting the high yielding dairy goats to develop a local dairy animal.

Key Words: Does, Parity, Kids, Kidding interval and Gestation length.

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CHAPTER ONE

INTRODUCTION

The major problem facing the third world countries is how to increase the biological value of their menu, improve and maintain the productive potentials of their domestic livestock, given adverse ecological and physiological constrains (Okonkwo *et al.*, 2011). Many developing countries have for long been plagued with the problem of a worsening situation of inadequate consumption of animal protein (Zahraddeen *et al.*, 2010). The energy and protein intake are grossly inadequate in these countries, leading to low weight for age, and height, various degrees of stunting, higher susceptibility to disease infections, high pre-weaning morbidity and mortality most especially among children who are vulnerable (PRB, 2012).

In most tropical countries of Africa, population growth has out stripped food supply. This has brought persistent call for the improvement of the nutritional status of the citizens through substantial increase in the intake of animal protein. An average Nigerian takes about 7.5g of protein daily. This level is far below the recommended level of 36 g. This low protein intake is connected with the fact that the production of large animals with slow production rate is given more encouragement than short cycle animals with high fecundity rate, low cost of investment, small body size which make it suitable for backyard rearing and easy consumable by a family (Ajimohun *et al.*, 2012, Ohagenyi *et al.*, 2012).

Figures of animal protein intake in Nigeria as reported by various researchers are; 4.5g/head/day (Zahraddeen *et al.*, 2010, 7.5g/head/day Nyako *et al.*, 2009) with all figures being far below the recommended value of 36g by FAO.

This shortage is due to inadequate feed supply, low productivity, prevalence of disease, long generation interval of indigenous animals, poor storage and high cost of products (Raji *et al.*, 2012).

The demand for dairy products in Nigeria has increased tremendously in recent years due primarily to the rapidly expanding population and increasing income of the working population. Growth in domestic milk production, however has been insufficient to meet the demand of the growing population. Statistics showed that, Nigeria's domestic milk supply is less than 50% of the demand for milk products. The need to

narrow the gap between demand and supply for the milk products which is mainly from cattle necessitates the urgent need to promote the use of other livestock species such as goats to augment the domestic milk supply in Nigeria. (Akpa *et al.*, 2002).

The low consumption of animal protein is closely related to the level of income in developing countries since the protein products are more expensive than other foods. However increased production associated with improved processing and preservation techniques of animal products will enhance availability and increased consumption of animal protein.

The traditional pastoral and agro pastoral farmers constitute the main milk producers. Although these farmers keep cattle, sheep and goats, they obtain milk mainly from cows. A large proportion of the settled rural and semi urban dwellers also keep goats primarily for meat production and generation of cash income. Thus goat milk is rarely used for human consumption, except by some rural dwellers especially among shuwa Arab, kanuri and pastoral Fulani people who used it for feeding infants(Akpa *et al.*, 2002). The measures to be adopted to correct the nutritional deficiencies in both child and adult populations experienced in developing countries of the world are still subjects of widely differing opinions. There is however, almost complete unanimity of opinion on the fact that milk and milk products seem bound to play a leading role in the improvement of the nutrition of the people, especially in areas where protein malnutrition is most prevalent. Milk is unique as a balanced source of most human dietary needs. It has been reported that some people such as the nomadic pastoralist of West Africa live for months exclusively on milk. For people in the developing countries, the significance of milk lies mainly in its contribution of those nutrients which are not abundant in cereals, roots and vegetables and which constitute the staple diet in these areas. However, because of the scarcity of milk in these areas and since production of milk cannot be increased rapidly to meet the needs of the people, large quantities of powdered milk have to be imported under various aid programmes which is used in the treatment of “ Kwashiorkor” a complex of protein-calorie malnutrition syndrome(Loosli *et al.*, 1999).

1.1 Problems Statement

To meet the increasing demand for milk and milk products with rapid growth in human population, the development of milk production and processing techniques to

improve the shelf life and keeping quality of milk and its products should be encourage. Comparatively, milk consumption per head in developed countries still stands at about 200kg per year without changes since 15years ago while this is less than 10kg per year in many sub-saharan African countries (Luka, 2012).

Nigeria is endowed with large number of small ruminants, which are yet to be fully exploited for milk production. Goats which are readily available in most rural and urban households and are the largest group of ruminant livestock in Nigeria with ownership spread across all ages and sexes have not been fully used for milk production. The development of Nigerian dairy goats will require a critical evaluation of all the locally available breeds and their potential for milk production (Akpa *et al.*, 2002).

1.2 Justification

Nigeria has the highest goats population in west Africa and other developing countries, it is surprising that emphasis on milk production has been placed only on cattle despite the low cost of management and acquisition of goats (Devendra, 1980^a).

Keeping goats in Nigeria is mainly for meat production and it contributes about 30% of the country's meat supply but little or no milk is produced by these animals. Dairy production is therefore, centered around cattle in Nigeria and other developing countries. This indicates that goats milk is rarely consumed in Nigeria probably due first to the taboo associated with goats milk which is said to have characteristic "goatly" odour and secondly due to lack of knowledge of the high nutritional quality of goats milk (Luka, 2012).

Among the indigenous breeds of goats, the Red Sokoto has greater potential for producing milk. In spite of these impressive statistics of milk, its potential values is not realized due to low productivity resulting from high mortality, low growth rate, low reproductive performance, poor management, socio-economic and genetic factors (Akinsoyin *et al.*, 1982 and Adegbola, 1998). This situation calls for proper management, supplementation and selection of these does for high milk production.

Goats provide their owners with a vast range of useful products and services. They are small, hardy animals and are easier to maintain than cattle. Goats are intelligent, independent and possess greater ability to fight and fend for themselves. They are used to

trample seeds into the soil for the farmers of the ancient Egypt (Devendra and McLeroy, 1982).

Goats can be regularly milked for small quantities of milk. In harsh environments, goats often produce milk when cattle have dried up. Goat milk is highly nutritious and has a similar nutritional profile to human milk. Goat milk contains 4.6% fat, 4.7% lactose, 3-4% protein and 0.8% ash. The higher proportion of short and medium chain fatty acids, compared with the milk of other livestock species, allows for goats milk to be digested easily by infants and those with digestive problems. Goat milk is an excellent source of calcium and phosphorus for growing children and can provide vital supply of vitamin A which is often deficient in the diets of infants in Nigeria. The Sokoto red (Maradi) goats is the most numerous (about 17million) and widely distributed breed of goats in Nigeria. It is characterized by its uniformly dark red coat color, short and horizontal ears and horns in both sexes. The mature body weight varies between 30-35kg in males and 25-30kg in females. They produce meat, skin and milk (Oni, 2002).

The red Maradi goat is of average size and has gained an international reputation for the qualities of its skins which because of the quantities traded, is esteemed in London and Paris. The greatest populations are found on either side of the Niger/Nigeria border, in Maradi, Zinder, Zaria and Sokoto. The size is average, the head is fine, the horns are of average development, are triangular, flattened and face backwards. The ears are long and drooping or horizontal. The neck is slender and short in the male. The body is full, the coat color is chestnut with uniform mahogany colored tints. They are very prolific, twin births are common and three or four – kid births are not unusual. Milk production is sufficient to feed the young and varies from 0.2kg to 0.5kg over 80-100days in the dry season and from 0.5kg to 1.5kg over 100-200days in the rainy season (Pagot, 1992).

Adamawa is one of the states with very high concentration of wide variety of livestock. The environmental resource distribution and abundance, especially vegetation and water, ethno-cultural and historical factors are of significance in the understanding of the livestock industry. The state is therefore divided in to four pastoral blocks based on similarities in ecological conditions; they are Toungo Block, Jada Mayo Belwa Block, Benue trough Block and Hong-Michika Block. The goats population of the state is put at between 3.5-4 million. The distribution of goats in the state is as follows; Benue block

(50.5%), Hong-Michika block (27.3%), Toungo block (15.%) and Jada-Mayo-Belwa block 7.2% (Adebayo and Tukur, 1999).

Goats are relatively cheap to buy. Flocks can be built up until they contain many goats which spread risk inherent in livestock ownership. They are often used as a first step up and out of poverty.

1.3 Objectives of the Study

1. To investigate the small holders and pastoral dairy goats farmers in Adamawa State.
2. To investigate other uses and constraints of goat production in Adamawa state
3. To investigate through nutrition and selection the milk production of red Sokoto goats.
4. To investigate the reproductive performance of the common goat breed in the study area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and Domestication of Goats

The goats were probably the first animal to be domesticated. This long association between goat and humans indicates the variety of functions the goats can provide. The goat was first used for meat production, but it also preceded the cow as a dairy animal. The frequency with which goats were represented in decorative or ornamental items indicate the value placed on the animal by humans over a long period. Domestication is associated with three of the oldest civilizations; the Nile in northeast Africa, the Tigris-Euphrates in western Asia the Indus in the Indian sub-continent. Also there is an evidence of early domestication in south-east Asia. From these centres of domestication people migrated in pre-historic times with their goats and other animals to many parts of the world (Devendra and McLeroy, 1982).

The wild ancestors of the domesticated goats are *Capra aegagrus* of Persia and Asia minor. The common goats of most Europe and Asia are derived from *Capra falconeri* the Angora goat from a class aegagrus and falconeri. Most modern African breeds of goats are believed to be derivatives of Asia and Mediterranean breeds. It is however common to classify African breeds based on coat colour, height and horn types (Akinwumi, 1992).

Globally, goat production yields 60% of its value as milk, 35% as meat and 5% as skin. The world goats population was estimated to be 706 million with more than 90% from developing countries. Nigeria has over 4% of the current world production (Zahraddeen *et al.*, 2008^a). They weigh less than 35kg when fully grown. The external features that serve to differentiate the goats from the sheep are the beared and strongly odour ferrous tail glands of the male, the body is covered with hair while in sheep it is hair-wool or wool (Devendra and McLeroy, 1982). They have long snout and upright tail, the mouth is unusual by having a mobile upper lip and a grasping tongue (Akinwumi, 1992). Three distinct breeds are found in Nigeria. They include the West African long-legged (Sahel, Arab, Maure, Taureg), Red Sokoto (Maradi) and the west African Dwarf (Cameroun Dwarf, Fouta Djallon and Kirdi). Many other types perhaps known as Borno

white, Borno red, Kano Brown and Maiduguri Brown are named according to their areas of origin (Devendra and McLeroy, 1987).

In 1981, the number of goats in the tropics was examined at 243.49million or 59% of the world goats population which was distributed as follows; Africa 129.7 million (27.6%) 15.5 Million (3.3%). Asia and Oceania 98.3million (20.9%), the number in developed countries being 25.5million (5.3%) (Pagot, 1992).

The goat population in Nigeria makes it to be second most important livestock species. Thus with a population of over 34.5million goats in the country, only India could be said to possess more goats than Nigeria in the tropics and subtropics (Oni, 2002).

Goat like remains were found in the ruins of the Swiss lake dwellings of the new stone age and according to historical records, domestic goat and sheep were driven over the damp fields of the Nile Valley to trample the seeds in to the soil for the farmers of the Ancient Egypt. Also according to Old Testament literature, Goats were very versatile help mates to man in Biblical days. They furnished milk for food, fiber for clothing and skin for bottles and serve as the object of sacrificial offering for Jehovah (Ensminger, 1970).

The goat was brought to Africa by migrating pastoralist from Asia. Domestic goat can be traced to Egypt as far back as the Badarian age when the goat were used extensively for meat and their skin were often used to wrap the dead (Devendra, 1980^a).

Nigeria is endowed with large number of small ruminants which are yet to be fully used for milk production. Goats are the largest group of ruminant livestock in Nigeria totaling about 34.5 million, predominantly owned by rural households (Akpa *et al.*, 2002). Goats are capable of adapting to harsh environments because of their digestive efficiency for cellulose, high fertility and shorter generation interval. The adequacy of browsing materials for goats in Nigeria to meet their reproductive requirement is becoming doubtful (Fasanya *et al.*, 1992).

Most goats live in areas of low potential for arable agriculture or in the semi-arid areas, in these areas, the management practices need to be quite different. These goats are kept for meat to be eaten during celebration or sold in times of need. The goats are sometimes milked, but the milk is very low. In some areas there seems to be a reluctance to drink goats milk instead of cow milk even though it is of equal if not better nutritional

value as the fats and proteins in goats milk are digested more easily (McDonald and Low, 1985).

The goat has long been a popular milk animal in the old world, where it is often referred to as the poor man's cow. When travelling or vacationing, Asiatics frequently take their goats with them in order to be assured of milk supply. Thus, it is interesting to recall that the late Mahatma Ghandi of India took two milk goats with him on his last visit to England (Esminger, 1970).

With increasing human population, especially in high potential areas, there is an excellent case for a greatly increased number of milk goats. A family can keep a goat on small pieces of waste land or steep ground and feed crop residue. Five or six milk goats can be kept on same amount of feed and grazing area as required by the cow. One goat will provide sufficient milk for the family. However, it must be realized that dairy goats require same careful attention as dairy cow and the temperate breeds need extra care and shed during hot weather. Farmers who cannot provide good management may be advised to keep crossbred goats, rather than the pure breed varieties. A good milking goat should have deep wide-sprung ribs a long sloping rump, a large elastic udder and teats and large milk veins. Breeding should take place five months before the start of rains so that goats will kid at the beginning of the rains when food supplies are good and does will be able to produce plenty of milk. One male can serve 30 – 40 females. Heat normally last for 24 – 36 hours but sometimes only for few hours. The gestation period is 150 days. Females should be bred at 18 months, while the pregnant doe should be dried off 6 – 8 weeks before she is due to kid. Relative to body weight, good milking goats gives much more milk than a cow (McDonald and Low, 1985).

2.2 Goats and Nigerian Economy

The status of Nigerian ruminant livestock population shows that Goats are 35,500,000, sheep 22,100,000 and cattle 13,900,000 which are located mostly in the Sahelian ecological zone. Sheep and goats contribute 17 and 12% meat and milk consumed in Sub-Saharan Africa. Average flock size of small holder farmers is between 3-5 goats per house hold (Makun *et al.*, 2008). In Adamawa State the ruminant livestock population is estimated at 2.8 million cattle, 2.0 million sheep and 4.0 million goats (Tukur and Ardo, 1999). Farmers keep these animals as a source of food (Meat and

Milk), for personal interest, for prestige, as a tradition, for ceremonial activities and security against crop failure. Waste products such as feces and urine obtained from these animals serve as manure for crop production (Oni, 2002). Other attributes they possess are high fertility, faster turnover rates due to early maturity, short generation interval, high digestive efficiency of cellulose, ability to fit into all agricultural systems and prevailing demand for mutton and goat meat further placed them in a unique position (David – West, 1985).

Three distinct groups of goats are found in Nigeria, and each has its unique utility. While the West African Dwarf Goat is known for her resistance to trypanosomiasis and tolerance to harsh environmental conditions, the Red Sokoto breed is distinct for her excellent meat and milk yields, high skin quality, twinning ability and other characteristics. The multicoloured Sahel breed is characterized by her high prolificacy, multiple births (twin, triplet and quadruplets) and good meat quality, but poor meat yields (Okonkwo *et al.*, 2011).

Sheep and goats are not only sources of meat, milk, hide and skin but also have socio-cultural values as measure of wealth. They are also used as sacrificial animals during festivals. Seeds of many trees are scarified by passing through the goat's digestive system, fastening germination and natural re-vegetation. (Adegbola, 1999). The economic importance of goats also includes their significant contribution to local and international markets of skin and leather as well as their place in indigenous customs and religions (Bogoro *et al.*, 1999). Small ruminant production is more significant than cattle rearing or crop farming in Sahelo Sudan zone of Nigeria. They are mostly managed by women and children. Their production therefore allows for socio-cultural and economic roles for these classes of people (Osinowo, 1999).

Small ruminants are excellent biological models in genetic and physiological studies (Luka, 2012). They are useful for alley farming as they can be integrated with crops and browses especially fast growing and protein rich leguminous trees such as *Leucaena leucocephala* (Adegbola, 1998). They are cheaply fed using agro-industrial by-products, crop residues and non- protein nitrogen sources. They convert materials not directly consumed by families to meat, making them not in direct competition with man for food and, their small size are well suited for home production and can cheaply be

raised by families (Oyawoye, 1999). Different breeds have their own favourite environment. The drier north has higher small ruminant population than the humid south (Otchere and Kalla, 1990).

Goat meat is an important part of the diet in southern Asia, the middle east, Africa and Latin America, especially the Caribbean. Goat meat is sometimes preferred to other meats, although in certain places goat meat is a taboo due to local customs. Some goats are good milkers. Under stressful condition milk is a valuable dietary supplement, it is nutritious, easily digested and usually commands high premium prices. It makes excellent cheese and yoghurt and can be used by people allergic to cow milk (David – West, 1983). It has also been reported that milk from goats has special characteristics such as high digestibility, distinct alkalinity and therapeutic use in medicine. Goat milk has been shown to be tolerated by children and infants suffering from hypersensitivity to cow milk. The small size of goats relative to cattle contributes to their wide distribution and ease of management among women and children who provide the bulk labour in small family farms. Goats have important drought survival strategy in marginal cropping areas where mixed farming is prevalent, they also serve as an insurance against crop failure because they are liquid asset (Zahraddeen *et al.*, 2008^b).

There is an urgent need to exploit the potential of alternative dairy animals such as goats whose milk is yet to be nationally accepted for consumption in Nigeria in order to supplement milk from cows (Egwu *et al.*, 1994), which served as a source of protein to consumers and provision of subsistence income to small ruminant farmers. The goat is known to produce a relatively higher milk yield per unit of live weight compared with the cow (Devendra, 1980^b). As a dairy animal, the doe is known to produce three times as much as the ewe (Wilson, 1989). Goat milk has some properties like scarcity of tubercle bacilli, high proportion of small fat globules which facilitate easy digestion, anti-allergic properties and lower lactose content for lactose intolerant individuals. (Williamson and Payne, 1978). Goat milk is a valuable source of amino-acids (Histidine, aspartic acid and tyrosine) and has a relatively high content of vitamin A, nicotinic acid, chlorine and ascorbic acid compared with milk from other animal species. The milk of goats has been specially recommended for the sick because it is said to be rich in certain nutrients not found in large quantities in other milk sources (Gefu, 2002).

Because of the importance of goats, the sultan of Turkey proposes in 1881 an edict prohibiting the exportation of goats, expecting to confine the mohair industry to Asia minor and forever hold a monopoly on the mohair trade. Thirty years later in 1910, South Africa followed suit, passing a law for the same purpose. Subsequently events provide that Turkey and South Africa were too late in their efforts to hold a monopoly on mohair trade and its products. The goats utilize browse which would be of little or no value to sheep and cattle and keep the brush from crowding out the natural grasses. They are also for clearing land of brush(Esminger, 1970).

Goats pay dividends for good management. It is unfortunate, therefore, that there is a widespread and common belief that goats will thrive despite neglect. This popular conception is not true. The successful goat's raisers apply the same careful care and management to goat raising as is given to any other profitable livestock enterprise.

Unfortunately, there is a wide prevailing popular belief that goats will eat and do well on anything from newspapers to rusty tin cans. This is erroneous, like other animals that are hungry or suffering from minerals or vitamin deficiency, they will develop depraved appetites and chew on many things, but they prefer good quality, whole some feeds and will pay dividends when so fed (Ensminger, 1970).

2.3 Nigerian Breeds of Goats and their Characteristics

2.3.1 Red sokoto goats

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.*, 1991). The population of Red Sokoto goats spread South and East from Sokoto through the savannah belt giving rise to Kano Brown (Ngere *et al.*, 1984). The Red Sokoto goat is found throughout the sub-humid zones of Nigeria. It is a medium sized breed with reddish brown coat color with an average liveweight of 30kg and is kept for its milk, meat and skin (Bunmi *et al.*, 2003). The breed is characterized by its uniformly dark red coat color, short and horizontal ears, and horns in both sexes. The mature body weight varies between 30-35kg in males and 25-30kg in females. The Kano Brown and Borno white are believed to be strains of the Sokoto Red. The skin of the Red Sokoto goat, known as Morocco leather is used in leather industries locally and abroad, and commands a high premium in

world markets. The best leather is obtained from young animals fed sufficiently well for them to be fully grown by one year of age (Osinowo, 1992, Oni, 2002).

2.3.2 West african dwarf goats

The breed is also known as cameroun Dwarf, Fouta Djalon, Kirdimi. Nigerian breed is found in west and central Africa, and are believed to have been brought from east and north east, particularly from Somalia where similar dwarf goats are still found. They were brought to the south along the trading routes between Egypt, Somalia and Sudan from where they spread west throughout the continent. They are indigenous to the forest and derived savanna zones of west Africa and are well adopted to the humid zone (Devendra and McLeroy, 1982). The breed is hardy, short legged and is restricted to the high altitude areas and humid forest of the south. Their population increases from drier or desert areas to wetter parts (Zahraddeen *et al.*, 2008^a). The breed is small in size, usually black occasionally all white animals can be seen. The breed in semi-arid areas resembles the Red Sokoto goats in their body proportion. The ears are erect and legs are short and thick. Mature body weight varies from 20-25kg in both sexes (Oni, 2002).

2.3.3. Sahel goats

Its other names are Arab, Maure, and Tuareg. Sahel goat is long legged, medium to large size and are found in the arid regions in the north of west Africa where rainfall is low and vegetation is sparse. They do not adapt to humid conditions and so are referred to as “desert” goats. The ears are Pendulous and the legs longer than those of other breeds. Horns are long, flat, twisted in males and stake-shaped in females and is well adapted to its habitat (Wilson, 1988). The mature body weight varies from 35-40kg in males and 25-30kg in females. It is used for meat, skin and milk, though very little milk is produced (Devendra and McLeroy, 1982; Devendra and Burns, 1983).

2.4 Management systems of goats in Nigeria

Efficient management of goats demands that all aspects of the life cycles will be given appropriate husbandry attention. Goats require adequate care and management so that they will give high performance and production. Management of goats in the tropics is influenced to a large extent by the people who own them and the geographical location (Devendra and McLeroy, 1982),. The average flock size of goats of small holder farmer is between 3-5goats. In west Africa, traditional goat production is characterized by free

roaming in the day and tethering at night or during cropping season. In many places in Nigeria goats managed in traditional systems scavenge on road side forage, unimproved range land and are mainly supplemented with kitchen waste (Makun *et al.*, 2008). The flock herd size is generally more in the north than in the south (Adegbola, 1999). The performance of sheep and goats under the traditional system is generally low due to poor management, low plane of nutrition, uncontrolled breeding and poor health care. The best system for rural poor is the semi-intensive production so as to take advantage of free crop residues on harvested farm lands and green pastures. Animals are supplemented with concentrates and allowed to graze for 6-8hours before returning them to their houses, but the best method worldwide is the intensive system where feed, water and housing are provided (Gefu. 2002).

2.4.1 Intensive system

The intensive system is one in which the goats are fed in confinement with limited access to land (Devendra and McLeroy, 1982). In west Africa the intensively reared animals are housed and given medication and improved nutrition. The system involves complete confinement of the animals either in pastures or in pens where feed and water are provided. Improved nutrition could be achieved through the use of cut and carry grasses, legumes or browse supplemented with salt lick. There is effective conversion of crop residues or supplements to products of high biological value such as meat and milk, there is control of reproduction, improved performance and hygienic conditions, collection and used of faecal materials as farm yard manures, reduction in cases of parasitic diseases and little or no damage to the environment (MacDonald and Low, 1985). Feeding under fattening is a common practice in most parts of Northern Nigeria. In urban areas, the practice is a secondary occupation rather than pastoralist and agro-pastiralist. The system is not beneficial to the rural poor due to its high level of input on feeding and health care involvement (Otchere and Kallah, 1985).

2.4.2 Semi-intensive system

This system of management represents a varying degree of compromise between the intensive and extensive system of management. The system involves grazing the animals on any available herbage during the day and housing them during the night. On the other hand, they are fed supplement in the morning and evening and the animals are

observed for diseases and veterinary care is provided (Otchere and Kalla, 1985). These involves complete restriction of animals in the rainy season and non-restriction during the dry season. In the cropping season, goats usually remain confined in compounds for most of the day and are only grazed 6-8hours before returning them to their houses or tethered for few hours daily. The goats are sometimes starved in the morning to facilitate easy management in the field. The system facilitates tick control and other pest infestation which are necessary during early morning grazing by hired boys (Alhassan, 1992). The number of animals usually owned under this system ranged from 5-25 goats(Osinowo and Abubakar, 1998).

2.4.3 Extensive system/free range/traditional

In Nigeria and West Africa, goats are reared extensively at subsistence level and these animals fend for themselves without any deliberate effort by man to supplement or improve the plane of nutrition. In Nigeria, the extensive system of husbandry is mainly traditional with individuals keeping 2-4 animals on which investment is minimal but returns are still high. This system of husbandry is characterized by trekking long distances and exposure to high ambient temperatures. Animals lose body weight while moving. The traditional system of management is characterized by high incidence of diseases and parasitism, together with the adverse effects of tropical climate. Other characteristics include losses to stealing, motor accidents, poisoning by crop farmers and conflicts between livestock owners and crop farmers, losses to predators and indiscriminate mating (Otchere and Kallah, 1985). Under the traditional system, small ruminants scavenge and browse available feed stuffs with no special provision of forage or housing and with minimal management. The entire village stock are considered as single inter breeding stock with no attempt to control mating since very few males are required for breeding and most families sale or consume all the male offsprings. Animals receive virtually no veterinary care and mortality rates are relatively high (Upton, 1987). Goats graze over large areas of unwanted or marginal lands which are unsuited for alternative agricultural use, a very low level of family labour represents the main input. Extensive production is probably the most popular system of goat production. Little management is practiced except letting them loose and shutting them at night. For the large herds, usually some form of paid labour is employed. Probably because of cheap

family labour and higher returns from these systems of management, the flock size tend to be relatively large compared to those in the intensive method. Both tethering and the extensive systems are typical of the village system in Africa, parts of central America and Southeast Asia (Devendra and McLeroy, 1982).

2.4.4 Tethering system

This system is practiced in the tropics during cropping season to prevent animals from going into farms. In humid zone its practice is mainly due to land pressure. The animals are tied with long ropes to allow for a degree of movement but not long enough to allow them cause damage to near bye farms (Taiwo, 1986). Two methods are common; Tied to peg or fence line. Goats are tied by a rope, 1-3 together. The length of the rope represents the area available for grazing and browsing and is usually short 3-5m in length. By shifting the peg or choosing a different tree or post, free access to fresh grazing area is provided. Secondly tied to a ring on a wire between two pegs. A rope is tied to ring which slides on a wire about 3m long in between two pegs. A goat tied to this ring can move along parallel to the wire on either side. This method provides a rectangular area for grazing. Water is provided when the goats are shifted to shelter at night. Very little or no concentrates, salt or animal block are provided. This system is common in Southeast Asia, Central America, the Caribbean and elsewhere. A variation of this method is the combination of tethering and grazing up to 5 goats at a time led by ropes held by women and children (Devendra and McLeroy, 1982). This system is mostly practiced during the farming season to prevent animals from going in to farm lands. In the humid zones it is practiced mainly due to land pressure (Taiwo, 1986).

2.4.5 Herding

It is practiced in sub-humid and part of sahelian zones. The animals are herded in large numbers and are fed freshly cut grasses in rainy season. In the dry season, the animals are sent to graze under supervision during the day and housed at night when they return (Luka, 2012).

2.5 Limitations of goat production

The success of any livestock production enterprise depends largely on adequate and qualitative nutrition. Majority of small ruminant farmers in Nigeria practice the extensive system of management which does not make provision for adequate feeding. In

the northern region of Nigeria where most of the nation livestock are concentrated, there is a long and pronounced dry season lasting for six to nine months, often causing serious feed shortage for animals. The prolonged dry season and high temperatures are also accompanied by rapid deterioration in the nutrient quality of available pasture, hence the basic nutritional requirement of the animals during pregnancy or lactation are not met. Majority of Nigerian small holder goat farmers resort to the easily available, cheap and abundant crop residue from post-harvest farm operation to feed their animals instead of using the expensive conventional concentrate. These crop residues are also limiting in nutrients necessary for maintenance and production (Malau-Aduli *et al.*, 2005).

Nutrition is perhaps the most important consideration in livestock production and management. Most of the reproductive problems and disorders in farm animals are associated with bad management. This is evident in the forms of inadequate feeding, poor housing, pests and diseases, among others. However, one of the major improvement objectives in livestock production, particularly of ruminants is to increase the number of young weaned per dam which depend on the number of new born per parturition. This inturn depends on the number of ova and fetuses which die during pregnancy and birth process. The causes of embryonic death early in pregnancy are not well understood, but in general, dams in good body condition at mating have a lower rate of embryonic mortality than dams in poor condition, and they also have a decreased incidence of reproductive problems (Zahraddeen *et al.*, 2010).

The dry season is a critical period for small ruminant in the sub-humid zone of Nigeria because of feed scarcity (Malau-Aduli *et al.*, 2003). Diseases and parasites form one of the main constraints to goat production in many parts of the tropics. The economic losses due to diseases and parasites are large especially in densely populated areas where veterinary and diagnostic services are weak. Disease and parasites also reduce the condition of the goats and the overall production. Low plane of nutrition, poor management and lack of sanitation and hygiene also affect the health and performance of goats. Poor feeding and management also have the effect of reducing the resistance of animals to attack by disease organisms and parasites (Devendra and Mcleroy, 1982). During the dry season, the commonly available roughages are hay, straw, stovers, silage and crop residues which are poor in quality, their digestibility are usually low and

sometimes worsened by the way they are conserved (Lakpini, 2002^b). The excessive high temperatures during the dry season also results in decrease feed intakes, retarded growth, delayed onset of sexual maturity, hence low productivity (Luka, 2012).

2.6 Reproduction in goats

Puberty is reached at an age which varies considerably with breed and also among individuals within a breed. In goats sexual maturity is reached early, but mating should be delayed to ensure that the dam is able to accommodate the foetus without having to compete with the available nutrients for her own growth. For this reason, age is not as good a criteria as live weight by which to determine the right time for mating. Mating is also conditioned by environmental factors, including nutritional state, ambient temperature and the use of artificial insemination. In bucks, sexual excitement is exceptionally high, while in does it occurs periodically. In the tropics, estrous activity is greater than in temperate climates. The average length of estrous cycles is 18 – 24 days and oestrus lasts for 5 – 10 hours (Devendra and Mclerory, 1982).

Report also showed that there is a difference in the age of first estrus between does born as singles or twins; single kids started at 194.4 days and 13.1 kg liveweight and twin kids started at 296.5 days and 13.5 kg liveweight. The presence of male triggers oestrus in the female, ovulation occurs 12 to 36 hours after the start of oestrus and mating should be arranged accordingly. Fertility and prolificacy increase with age of the goat i.e. the proportion of twins and triplet births increased from 19% in the first kidding to 79% in the second and later kiddings. Insufficient dietary energy and protein are often the main limiting factors of efficient goat production in tropical environments (Devendra and Mclerory, 1982).

Genetic improvement began at the beginning of the 1940s in Niger by mass selection programmes, elimination of mottled males by castration, and by diffusion of selected fertile males. The distribution of the red goat is extensive and exports to other countries of West Africa have been carried out with success (Pagot, 1992).

The gestation period for goats is 21 weeks (5 months). The udder of the dam usually becomes turgid and enlarges. If care for the doe is adequate, kidding should present no difficulty (Abolude, 2002).

Failure to kid at first kidding may not necessarily indicate poor performance. Selection should be based on more than one record. Thus only females which fail to produce after consecutive opportunities should be culled. Dams which produce more than one offspring at first parturition are likely to be of good performance (Oni, 2002).

Goats have longer estrous period and gestation period of one or two days longer than sheep. Does are bred so that their kids are dropped when they are approximately two years of age (Ensminger, 1970).

2.7 Nutrient requirement of goats

Most dairy goat production is based on making the best use of improved pastures in rainy season, and of early cut, properly cured hays and silages. Does should be rested (dry) for at least six weeks prior to freshening. During this period, they have three important jobs (a) recovering from the milk production period and resting the mammary gland. (b) Developing the unborn kid (70% of its development occurs during the last six weeks of pregnancy) (c) Storing up body reserves for the next milking period. Feed only good quality roughage during the first two to three weeks of the dry period. Then feed a dry cow concentrate with the quality of concentrate feed being determined by the condition of the doe and the quality of available forage. A few days prior to kidding, about 50% of the concentrate should be replaced by bran. The bran being laxative and bulky is desirable at kidding time. Does fed an all-forage ration will produce about 30% less milk than does fed concentrates in average amounts. This is because a goat stomach is not big enough to hold all the roughage necessary to get the amount of energy needed for maximum milk production. To provide the energy, grain must be fed. Also the concentrate should supply the needed protein, vitamins and minerals. Grass hays will require a 16 – 18 percent protein concentrate, while a 12-14 percent protein concentrate will generally suffice when legume hay or silage is fed. At birth and for first three to four days of life, kids should receive colostrum. When the feeding of milk or other special meals is discontinued, replacement does should have an abundance of other feeds, especially of good quality roughage so that their growth will not be retarded (Ensminger, 1970).

Prediction of milk composition and yield from specified diets is an important aspect of management. When predicting ruminant production, ruminant models are

required because, the amount and type of available nutrients absorption in the lower gastro-intestinal tract differ considerably from the profile of the nutrient ingested, owing to the activities of the ruminal microbes. Milk production with un-supplemented sugarcane diets and supplements that increase the availability of amino acids in the small intestine are recommended. Substitution of some of the sugarcane with feed stuffs having higher lipid content such as rice bran, increased milk production. Adding a concentrate containing wheat meal, rice meal, corn grain and bone meal increased the predicted milk production compared with cows fed sugarcane/urea alone (*Kebreab et al.*, 2001).

In a report when thirty three adult Damascus goats (does) weighing 29kg were fed 0.6kg/day of a concentrate diet plus *ad libitum* rice straw, green acacia or berseem clover hay and water *ad libitum*; the total milk yield over ten (10) weeks and the milk composition (total solids, fats and protein percentage) were significantly different between the three groups. Group B having the highest and group R the lowest, these suggest the need for supplemental feeding (*Shetawi et al.*, 2001).

Goats are naturally browse animals but a good goat range in addition to furnishing abundant palatable evergreen brush, should provide a mixture of grasses and broad leaved herbs. The mineral and water requirements for goats are similar to those of sheep (*Ensminger*, 1970).

Total dry mater feed offered should be 3-4% of the body weight with the roughage constituting at least 60% and concentrate supplementation of not more than 40%. The requirement for maintenance will be met if the total feed fed contains 11.5% protein and 2.7Mcal/kg DM energy, for pregnant and lactating animals, 15% protein and of 3.2Mcal/kg DM energy are adequate to meet their requirements at the recommended rate of feeding (*Lakpini*, 2002^a).

Feeding animals aims at meeting the nutritional requirements for maintenance and production and these requirements vary depending on species, age, size, stage of development and stage of production. The quantity of feed voluntarily taken in to meet the nutritional requirement depends on the palatability, digestibility and nutrient density of the feeds. The availability of nutrients in a feed fed to an animal is determined by its digestibility and the nature and quantity of anti-nutritional substances it may contain.

Feeds that are rich in nutrients but not available to the animal either because they are not palatable or contain large quantity of crude fibre which makes them inaccessible for digestion can be processed to improve their nutritive values. Most feeds do not singly contain all the nutrients at required quantity for maintenance and production in animal and so have to be combined in to concentrate or supplements to meet the nutritional requirements. Beside meeting the nutritional requirement for maintenance and production in animals, the choice of feedstuffs depends on its availability and cost (Lakpini, 2002^b).

During the early wet season, the water content in pasture is very high and goats have to eat large quantity to meet their dry matter requirement. This often precipitates diarrhea in them. As the pasture matures, the dry matter content increases. The nutrient contents and digestibility increase up till when the plants begin to flower and then decline. To minimize the occurrence of diarrhea, they should be feed hay, straw or stover in the morning before feeding on the fresh pasture and withdrawn gradually as the pasture matures. For adult breeding males and dry females, natural pastures grazed or provided in sufficient quantity are adequate for maintenance. For an average doe, 200g – 300g of maize offal, sorghum or millet offal, wheat bran or sun-dried poultry litter will be adequate during pregnancy and lactation and 100-200g/day if it is an oilseed cake. Feeding is increased during dry season because of the poor quality of roughage; their digestibility is low and sometimes worsened by the way they are conserved. Therefore the levels of feeding need to be stepped up. The breeding males and dry females, often grazing needed to be supplemented with 250-350g of cereal by product, sun-dried deep litter poultry waste or 159-250g of oil seed cake fortified with 0.5% common salt and 0.5% bone meal. As for pregnant or lactating does, after grazing they need to be supplemented with 300-500g of cereal by products or sundried poultry waste or 200-350g oil seed cake per head daily. Newly born kids must be allowed to suckle their dams at least within the first 7 days to enable them get passive immunity through colostrum and weaned at 3 months of age. The orphan new-born kids can be foster-mothered or artificially reared using feeding bottle. At about the age of 6 weeks, the young ones can be introduced to a good quality hay to nibble on. They can further be introduced to a small quality of concentrate as from the age of 10 weeks till weaning at 3 months. Weaners can be grazed with same precaution for the adults during early wet season and

supplemented with 25g of cereal by product or 15g oil seed cake per head daily during rainy season and double during the dry season. Water should be available always (Lakpini, 2002^b).

2.8. Nutrition of the goat

Goats have special feeding habits which differ from those of other ruminants, and lead to the destructiveness of the former when uncontrolled. By means of their mobile upper lip and very prehensile tongue, goats are able to graze on very short grass and to browse on foliage not normally eaten by other domestic livestock. In addition, they are inquisitive feeders, with a feed range from herbage and tree bark to skins and cloth. Unlike sheep, goats relish eating aromatic herbs in areas of sparse food supply, and hence can penetrate deep in to the desert. It has also been suggested that the assumption of bipedal stance in order to utilize forage overhead affords goats a competitive advantage over other ruminants. Feed accepted by one goat is sometimes not acceptable to another and they do not thrive well when kept on a single type of feed for any length of time, they prefer to select from many varieties of feeds. Goats can distinguish between bitter, sweet, salty and sour tastes, and show a high tolerance for bitter taste than cattle (Devendra and Burns, 1995). It is important to ensure adequate feeding to enhance productivity. This observation contradicts the widely prevailing belief that goat will eat and do well on something from newspaper to rusty tin cans. Like other animals that are hungry or suffering from mineral deficiencies, they will develop depraved appetite and chew on many things (Ensminger, 1983).

Sheep and goats are better adapted than cattle to arid tropics, probably because of their superior water and nitrogen economy. Cattle, sheep and goats often are grazed together because they utilize different plants. Goat graze, browse (shrubs) and some forbs (broad-leaved plants), cattle graze tall grasses and some forbs, and sheep graze short grasses and some forbs which are mostly weeds. Several studies have shown that grazing goats will choose up to 75% of their diet from available browse species. However, the types and proportions of feed should be related to the function of the goat. Dry does and bucks that are not actively breeding, perform satisfactorily on ample browse, good pasture and good quality grass and legume hay. If grass is short and hay is of poor quality, and goats are milking well, feeding of supplemental concentrates is necessary.

Over feeding of concentrate can cause diarrhea or obesity which interferes with reproduction and subsequent lactation. Pregnant does should be fed to gain weight in order to ensure adequate nutrition of the kids. A doe should be in good flesh, but not fat, when she kids, because she draws from her body reserves for milk production. The use of iodized or trace-mineralized salt along with dicalcium phosphate or bone meal usually provide enough minerals if hay or pastures are available (Field and Taylor, 2012).

The feed requirements of animals do not necessarily remain the same from day to day or from period to period. The age and size of the animal, the kind and degree of activity, climatic conditions, the kind, quality and amount of feed, the system of management and the health condition of the animals are all continually exerting a powerful influence in determining the nutritive needs. How well the feeder understands, anticipates, interprets and meets these requirements usually determines the success or failure of the ration (Ensminger, 1970). Generally young growing goats and lactating goats need more protein than the bucks or dry does. A ration containing 12-15% protein is desirable for bucks and dry does but 15-20% protein may be better for young goats and for does that are heavy milkers. Kids must be allowed to nurse their dam to obtain colostrum. It is advisable to encourage young kids to eat solid feed at an early age (2-3 weeks) by providing leafy legume hay and palatable fresh concentrates, because solid feeds are less expensive than milk replacers. Rams should never be allowed to run with doe goats and buck goats should never be run with ewes. These animals will mate when the females come in heat, if they conceive, the pregnancy will usually terminate at about 3 or 4 months (Field and Taylor, 2012).

Few drops of rain does not disturb their grazing until the rain becomes heavy (Ogebe *et al.*, 2000). This observation contradicts that of Gall (1981) that goats will not tolerate rains and that they run out of the rain at the first few drops. Goats have marked ability to identify pasture species of high palatability as they went straight to some relish forage (Morand-Fehr, 1981). The average grazing period of goats without resting was between 8.00 hours and 12.00 hours, while grazing hours was reduced during excessive sunny days and on exclusively wet days resulting from rainfall (Ogebe *et al.*, 2000).

2.8.1 Feeding habits of goats

Goats are very inquisitive animals, much more so than other ruminants and they can walk long distances in search of food. This feeding behavior assists them in meeting their nutrient requirement. They feed on a wide variety of feed stuffs, mainly tree and shrub leaves and grasses. They are able to utilize feeds not normally eaten by cattle or sheep (Devendra and McLeroy, 1982).

2.8.2 Dry matter intake

The dry matter intake of goats indicates their capacity to utilize feed voluntarily. Intake depends on the breed of goat (meat or milk) and on the environment. Dairy goats in temperate regions usually consume dry matter at the rate of 5 to 6 percent of liveweight whereas in the tropics this intake is lower at around 4 to 5 percent of liveweight. Meat goats in the tropics seldom exceed an intake of 3% of live weight (Devendra and McLeroy, 1982). The basic dry matter requirement of goats has been reported to be between 2-3 percent of their body weight per day. The West Africa Dwarf (WAD) goat requires dry matter intake (DMI) of 2.5 percent per body liveweight while the larger breeds require 3 percent of their body weight. A goat of about 28kg requires 3kg of feed per day (Peacock, 1996). Indigenous goats kept for meat and dairy purposes in the tropics when fed to appetite, will have DMI within the range of 1.8% to 4.7 % of body weight and that is equivalent to 40.5 to 131.1g/day/kg body weight. Meat breeds have a daily DMI of 1.8%-3.8% of body weight daily. The Jamnapari, a dairy breed, has slightly higher DMI, being 2.0% - 4.7% body weight with corresponding intake of 27g-40.5g/day/kg body weight. The temperate breeds in the tropics however had DMI ranging between 2.8% and 4.9% of body weight, similar to that of Jamnapari, but somewhat higher in proportion to body weight. Goats on maintenance and sub-maintenance rations had a low DMI of 1.4-1.7% of body weight, equivalent to 43.5-46.9g/kg body weight daily (Devendra and Burns, 1995).

2.8.3 Energy requirement

Lack of energy – hunger-is probably the most common nutritional deficiency of goats. It may result from lack of feed or from the consumption of poor quality feed. Inadequate amounts of feed may result from overgrazing, drought, snow covering the feed or from a low dry matter content of lush. Also poorly digested low-quality forage

leads to reduced feed intake. The energy needs of goats are largely met through the consumption and digestion of roughages. Grains are used to raise the energy level of the ration during periods when supplementation is necessary (Ensminger, 1983). The energy requirement for maintenance is the amount of food which causes no gain or loss in body weight. The input of nutrients is such that they are just adequate to meet the basic requirements for body function. The average values for metabolizable energy (ME) per kg body weight daily were 429.98KJ for the tropics and 396.85 for temperate conditions. These writers also reports on the energy requirements for pregnancy of 681.9KJ of ME per kg body weight daily in India, 739.0kJ of ME per kg body weight daily for West African Dwarf goats in Nigeria and 602.5kJ per kg body weight daily for katjang goat in Malaysia. It was also found that the requirements for does bearing twin kids was 10% higher than for those bearing singles (Devendra and Burns, 1995).

Peacock (1996) reported that a goat of about 10 kg liveweight will require 2.3 Mj/ME/day for maintenance and growth of about 100g/day. A study with West African Dwarf kids gave the digestible energy (DE) and Metabolizable Energy (ME) requirement for maintenance of 124.42 ± 3.27 Kcal/day/kg body weight and 100.78 ± 4.5 kcal/day/kg body weight respectively (Mba *et al.*, 1982). Akinsoyinue *et al.*, (1982) also recommended that 83.39kcal ME/day/kg body weight each day for confined goats, while figures for semi-intensive and extensive conditions were calculated on the basis of increments of 20 and 40 percent respectively in order to account for the increased muscular activity under these conditions. (Devendra and McLeroy, 1982).

2.8.4 Protein requirement

Goats need protein for maintenance, growth, reproduction and for production of milk and wool. Wool is rich in sulphur containing amino-acid, cystine which is derived from feeds and rumen synthesis. Green pastures and legumes hays are excellent sources of protein, but it may be desirable to provide protein rich supplements such as cotton seed meal. The protein requirements are affected by growth, pregnancy, lactation, size, age, body condition, rate of gain and protein energy ratio (Ensminger, 1983). The minimum protein requirement for maintenance in the tropics range from 0.590g digestible crude protein (DCP) per kg bodyweight. The variability arises as a result of a variety of

nitrogen-free, low nitrogen rich diets given. Whatever diet is used, it is important to ensure that adequate energy is provided (Devendra and McLeroy, 1982).

The levels of dietary energy and protein also have significant effects. When dietary energy is adequate, the derivation of the DCP requirement for maintenance represents a more accurate value than when it is not. The requirement of protein for maintenance of goats studied in the Asian countries have been reported to be quite high 1.41-3.45g DCP/day/kg body weight than those reported from Africa 0.64-2.20g DCP/day/kg body weight. During pregnancy and lactation, the DCP requirement of West African Dwarf goats for maintenance was found to be 1.24g per kg body weight daily. This study also indicated that goats fed with groundnut cake require 53% more protein than urea-fed goats for each gram of liveweight increase. It has been concluded that urea is more efficiently utilized by goats than the nitrogen in protein rich concentrates (Devendra and Burns, 1995). The digestible crude protein requirement for West African Dwarf kids for maintenance and liveweight gain were reported to be 0.853 ± 0.133 and 0.030 ± 0.00 g/day/kg respectively (Mba, *et al.*, 1982). A 20kg goat will require 26g/day/wkg for maintenance and 46g/day/wkg for production and 100g gain/day (Peacock, 1996).

It is advisable to balance energy and nitrogen sources at both ruminal and intestinal levels while formulating diets for ruminants. This can be achieved through careful blending of feeds to meet the nutrient requirements of ruminant animals. Microbial protein synthesis is higher when the rate of energy and nitrogen release is synchronized. Poor utilization of dietary nitrogen in grass and silage has been improved through the inclusion of readily fermentable carbohydrate sources, which lead to increase in the synthesis of microbial protein with subsequent improvement in animal performance. There are basically four types of protein sources used in feeding animals which include plant protein, animal protein, marine protein and non-protein nitrogen. The selection of a given protein to use in formulating a diet is affected by its availability and cost, content and availability of amino-acids and presence of toxic compounds in supplements (Luka, 2012).

Ruminants can use amino acids as sources of energy. To use proteins in this way the animal must deaminate them in the liver. If this becomes excessive, the metabolic

load on the liver reduces its ability to achieve other functions. Rations containing more than 200g crude protein/kg DM have been reported to result in reduced fertility and even very high yielding dairy cows, giving more than 50 litres of milk a day, should not need more than 190g crude protein/kg DM. The microbial population in the rumen functions best in neutral mildly acidic conditions (pH 6.0-7.0). If the pH falls much below pH 6.0, this discriminates against volatile fatty acid forming microbes and favours those that produce lactic acid. The optimal pH for cellulose digestion is 6.0 – 6.8, for formation of volatile fatty acids is 6.2-6.6, for synthesis of protein is 6.3-7.4 and for lactate production is 5.9-6.2 (Chamberlain and Wilkinson, 2010).

2.9 Milk production

Milk may be defined as the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy milking animals, excluding that obtained within 15 days or 5 days after parturition or such periods as may be necessary to render the milk practically colostrum-free, containing the minimum prescribed percentages of milk fat and milk solid-not-fat. As a major enterprise, the market milk industry is of comparatively recent origin even in developed dairying countries. Though ancient written records report milk as an important food, its processing and distribution as a separate commercial business did not develop in these countries until the concentration of population in the cities reached a high level in the middle of the nineteenth century (Sukumar, 1991).

Akpa *et al.*, (2002) in their study of six Fulani herds under agro pastoral management where new born kids suckle their dams freely for seven days to collect colostrum and where milking was done twice daily reported that, the initial yield of milk per\kg\day was 0.946, peak yield 1.209, total yield 79.827 and daily yield was 0.664kg per day respectively for the 92 does with parity ranging from 1-5. Seasonal effects indicated that does that kidded during the late dry season gave more milk than those kidded during the early dry season. The report also stated that variations on milk yield of Sokoto red goats of the different herds may be attributed mainly to variations in nutrition and management and strain of does to some extent. And that the lowest milk yield was observed in the first parity and the apparent highest yield in the second and third parities.

Also litter size affects milk yield as goats with multiple kids produce more milk than those with singles.

2.10 Importance of goats milk

Milk is an almost ideal food. It has high nutritive value. It supplies body building proteins, bone forming minerals and health giving vitamins and furnishes energy giving lactose and milk fat. Besides supplying certain essential fatty acids, it contains the above nutrients in an easily digestible and assimilable form. All these properties makes milk an important food for pregnant mothers, growing children, adolescents, adult invalids, convalescents and patients. During early years each household maintains its family cow or secured its milk from its neighborhood who supplied those living close by. As the urban population increases, fewer households will keep a cow for private use. The high cost of milk production, problems of sanitation restricted the practice and gradually the family cow in the city was eliminated and city cattle were all sent back to rural areas. Gradually farmers within short distances began delivering milk over regular routes in the cities. This was the beginning of the fluid milk sheds which surround large cities of today (Sukumar, 1991).

In recent times under nutrition and protein-calorie malnutrition have been recognized in the developing countries of the world. The measures to be adopted to correct the nutritional deficiencies in both child and adults as opined was the milk, because milk plays a vital role in the improvement of the nutrition of people. Milk is unique as a balanced source of most man's dietary needs. It provides proteins, energy, calcium, phosphorous, riboflavin B₁₂ and vitamin A. The milk can also be used in the treatment of "Kwashiorkor", a complex of calorie malnutrition syndrome (Loosli *et al.*, 1999).

In a study of animal protein intake and effects of age on level of protein consumption, it was revealed that about one-third of the people in the study area indicated that children have the greatest access to milk. Women are not indicated to be consuming large quantity of milk and this could be due to their poor economic condition. It was reported that when skimmed milk supplement was fed to lactating women to raise the protein content of their energy inadequate diet from 25-50g to 100/day, they observed that the amount of milk secreted as well as the amount consumed by the child increased

significantly and the child gained more weight. It was also observed that as protein intake increased from 4g/day to 6g/day, nitrogen balance and milk consumed increased significantly. It is noted that the principal effect of protein deficiency on milk secretion was a decrease in volume (Adama and Tsado, 2003).

The contribution of small ruminants especially goats to the average annual rural household income is estimated at 15% in Botswana. About 85% of the household in the study area rear goats. The farm gate price was used to compute the total value of home-consumed milk and products. The average farm gate price was set at 0.95dollar/kg of goat milk. The major component of the gross revenue for both cattle and goat rearing enterprises was the milk output for 70% and 67% respectively. This was because for many households, keeping livestock mean having a gradually growing herds of animals that enable 1 and 2 animals to be disposed of if there are urgent financial obligation, whereas the animals are milked all the time either to satisfy the households demand for milk or to sell (Panin, 2000).

Goats are efficient users of water, an ample quality of clean portable water are essential for high milk production by lactating does. They can also adapt to water shortages of the tropics. Goats also have tolerance to heat stress due to its resistance to the absorption of radiant heat due to the shiny coat, reduced water loss to urine and faces and an increased ventilation rate (Devendra and McLerory, 1982).

Goats are very friendly and can be kept by all categories of people including women, children and civil servants. Its milk compares well with that of cow nutritionally. Tubercle bacillus infection rate is very low. Its fat globules and protein are smaller in size than those of cow milk. Therefore goats milk is more easily digested than cow milk. The high digestibility of goats milk as well as high content of vitaminB₁₂ makes it helpful in relieving stress like constipation and insomnia. Goat milk has medicinal value for treating peptic ulcer and other digestive troubles because of its high buffering qualities. It is good for children or people allergic to cow milk. Goat is cheap to acquire and maintain. Its feed requirement is not as high as that of a cow. Therefore, goats milk can be produced more efficiently using limited resources (Otaru, 2002).

2.11 Milk yield and composition

Goats produce 1.6% of the total world milk supply. In some countries, goats milk accounts for up to 50% of the total milk, production (Ensminger, 1970).

Among the important factors that influence goat milk yield are the breed, temperature, season and nutrition. Other factors such as age, udder size and shape and body weight are variations among individual goat population that influence milk yield. Environmental temperatures ranging from -5 to 24⁰c are a comfortable range for lactating animals. Beyond 20⁰c, milk yield and constituents e.g. fats are reduced owing to heat stress which can affect the secretion of regulatory hormones like thyroxin, growth hormone and insulin. Cooler environments are therefore necessary for lactating goats to express their potentials, but below -5⁰c, blood flow to mammary gland is affected. There is a need for proper feeding of lactating animals. No goat will fulfill its optimum milk yield unless it is well fed and provided with adequate clean drinking water (Otaru, 2002).

Feeding berseem hay resulted in more than two fold increase in milk production compared with feeding rice straw, while feeding *acacia* resulted in an increased of about 65% in milk production compared with feeding rice straw and a decrease of about 20% compared with feeding berseem hay. But when the practices were evaluated economically, feeding rice straw was the most economical followed by berseem hay and then *acacia* (Shetawi *et al.*, 2001).

Most tropical cattle belong to the zebu (*Bos indicus*) type, their dairy potential is poorly developed, they have low milk yields, are late maturing and usually do not let down milk unless they are stimulated by the sucking of the calf. A widely used strategy for improving the dairy potential of tropical livestock is the introduction of genetic material from exotic dairy breeds of animals either by importing stock of both sexes in large number or by acquiring male animals or their semen for cross breeding with indigenous females. Importation of temperate breeds was successful only in places where heat stress is moderate, good feeding and management are provided and veterinary services are available. Cross breeding has in most cases led to a dramatic increase in productivity in first cross bred generation (F₁), but further upgrading by repeated back crossing to exotic bulls has often resulted in problems which can be ascribed to lack of adaptation. Results showed that for a practical breeding scheme in a single nucleus herd

suggest that, a genetic gain of about 36kg of milk per year can be achieved simply by selection of young male animals on the basis of pedigree and females on the basis of pedigree and their first lactation performance (Systad and Ruane, 1998).

Lactating does must be fed individually and concentrates may be given during milking time. The yield of goats are relatively higher per unit live weight to cows, the milk yield per day per kilogram live weight for goats were 22.0 and 35.6kg respectively. Goats milk is a valuable source of amino-acids (Histidine acid and tyrosine) compared with cow's milk, which has larger amount of non-protein nitrogen. The sodium, iron and copper contents of goat's milk are relatively high. Goat milk has high contents of vitamin A compared with cow's milk. An important feature of goats milk is that, unlike cow's milk, it contains no precursor of vitamin A, the vitamin being present intact (Devendra and McLeroy, 1982).

In comparison with cow's milk, goat's milk has smaller fat globules, a higher mineral content and a sweeter flavor. Goats milk form a fine, soft curd during digestion, thus making it more easily digested than cow's milk for some children and older people who cannot use cow's milk. If goats are milked in clean quarters and away from bucks, their milk will not have any unpleasant flavor or odor. The odor of the buck is quickly absorbed by warm milk (Ensminger, 1970).

2.12 Management of goats

The survival of goats depends largely on its management even before birth. The management of a pregnant doe influences its survival and that of its offspring after birth. Management encompasses total care given to an animal or a group of them in order to enhance its productivity and survival. This entails sanitation, feeding, healthcare, record keeping and reproductive management. Losses in productivity and through mortality can be averted or controlled by good management. This results in higher returns and greater asset. There are three management systems for goat production and these are; Extensive management system, semi-intensive management system and intensive management system. In all these three (3) major management systems, there are management practices that are exclusive and others that are common to them, such as feeding, sanitation, healthcare and reproduction (Lakpini, 2002^a).

Female on heat are isolated in to a breeding pen and breeding bucks introduced to them in ratio of one male two females on heat. After breeding, the pregnant animals should be kept together and fed accordingly until they are delivered of their offspring. Lactating and nursing dams are also reared together. Orphan offspring can be reared by foster mother or artificially by bottle feeding. The breeding males should be reared together separately and introduced to the females on heat when breeding is desirable. The dry non-pregnant does should also be reared separately (Lakpini, 2002^a).

The gestation period of goats is 21weeks. If the care of the doe had been adequate, kidding should present no difficulty and the animals should be left undisturbed. Any kid in birth labour that is not showing progress in delivering its offspring should be promptly attended to, after birth, the doe normally licks her offspring to stimulate breathing and circulation. When milk let-down is obstructed a few drops can be manually expressed out to ensure that milk channels are open. Kids can be encouraged to suckle by tickling it under the base of its tail using a finger. If the doe fails to lick-clean its kid, straws should be used to clean it. If after birth the kid is not breathing, it can be induced by cleaning its mouth and nostrils, blowing down the nose smacking and moving the ribs. The naval cord should be disinfected to avoid entry of pathogens (Abolude, 2002).

Goats require much more care than sheep at the time the newborn are arriving. Young kids are more delicate than young Lambs-being able neither to endure so much cold or damp or damp weather nor to follow their mothers to the range so early in life. An 80% kid crop is considered excellent for range bands, does with extra large teats may have to be hand milked until the kids have learned to nurse the abnormally large teats (Ensminger, 1970).

2.12.0 Pre-weaning

Kids are left with their dams for at least Three (3) days to suckle colostrum. For the first few weeks the offspring is completely depend on its dams milk. The doe should be well. Between 3 and 6 weeks of age, the offspring stomach develops enough to enable it begin to nibble on the other feeds (Devendra and McLeoroy, 1982).

2.12.1 Weaning and post weaning

Weaning is done by taking the entire flock to well fenced field with good water supply. After 2-3days the does are removed to another pen far away. The kids should be

left in familiar pens. Rear male and female kids separately to avoid indiscriminate breeding. After about 40 days of lactation, milk production in the dam declines rapidly. Kids are therefore weaned at about 3 months. It is done gradually by daily separating the offspring from their dams a few hours over the last two weeks of the weaning age.

When a kid is weaned, the immediate factor to performance is usually the level and quality of feed intake. The feed for early weaned kids must not only supply the essential nutrients in adequate amounts but also ensure the maximum voluntary intake. Cereals are required for maximum weight gain. The diet should contain energy, protein, non-protein nitrogen, minerals and vitamins in amounts required for them to attain the required live-weight in desired time period. Young animals with rumen not fully developed cannot utilize non-protein-nitrogen, but should be fed animals or vegetables protein to sustain high growth rate. Early weaned kids grow well on cereal diets supplemented to provide 16% crude protein in the ration. Older kids can utilize non-protein-nitrogen sources because the rumen microbes can use them to synthesize protein. Routine deworming and deticking should be done at time of weaning. Well fed animals are better able to resist the effects of parasitic infestation (Abolude, 2002).

2.12.2 Milking

It is important to note that the more frequently the doe is milked, the more the milk is produced. Twice daily milking is ideal, morning and evening under commercial setting, but if the kids are left with the dams, once daily milking can be practiced. At each milking time, it is good to empty the udder completely so that subsequent yield of milk is not depressed or affected. Before milking the doe should be placed on raised platform provided with a concentrate. The milker should wash his hands and also use a clean bucket. Since milk spoils quickly, and could be source of spreading infectious diseases, high standard of hygiene is required during milking. After milking, wash all milking utensils (Otaru, 2002).

2.12.3 Processing of goats milk

Immediately after milking the milk collected should be transferred to separate room, and filtered through a clean and very fine cloth or muslin. Known quantity of the filtered milk can be measured into a sachet and cooled immediately. It can be kept in a refrigerator for some time, whatever the milk is intended for, whether it is to be

consumed fresh (as liquid milk) or processed into other products such as yoghurt butter, cream or cheese, it must be pasteurized first (Otaru, 2002).

2.13 Nutritional problems of goat milk

Animal disease is one of the most important factor to increasing the productivity of food animals in sub-saharan Africa. Knowledge of the types and extents of common health problems and their association with different risk factors in dairy farms is important to livestock owners. Reproductive diseases and clinical mastitis were the most frequent diseases of dairy herds (Lema *et al.*, 2001).

Marketing of fresh milk raises new problems of public health, humans can contract zoonotic diseases such as tuberculoses and brucellosis. Children and senior citizens are particularly susceptible as their immune systems are deficient for various reasons. Mode of infection is usually by handling diseased animals or infected carcasses or through consumption of raw milk, yoghurt and cheese. In addition to tuberculoses and brucellosis it has a considerable impact on the livestock economy, the loss of meat and milk, the reduced kidding rate and restrictions on international livestock trade (Weinhaulp *et al.*, 2000).

Caprine brucellosis cause serious losses by way of abortion and stillbirths, besides being potentially hazardous to the animal handlers. Infected parturition (normal birth or abortion) and infected males play an important role in the spread of infection in the herds. It is reported 11.5% loss embryos (2.8% abortions and 1% born death) in an intensively managed herd of milk goats (Singh *et al.*, 2000).

Much of the milk consumed in Tanzania is from the traditional communally grazed livestock sector. Cattle-derived in man is attributed to *Mycobacterium bovis* and *Mycobacterium tuberculosis* and is mainly transmitted through milk. Therefore, habits, such as consumption of raw milk and sour milk prepared by fermentation, may predispose people to such infections. Out of 805 milk samples screen in a study, 31, (3.9%) were positive for *Mycobacterium* species. Public health implication of *Mycobacterium bovis* infections, which were acquired mainly through consumption of infected milk and account for 30% of the disease in children, up to 10% of the extra-pulmonary form of tuberculosis in man, should be taken seriously, despite its low isolation rate in the study. It has been indicated that one cow can excrete enough viable

bacilli to contaminate the milk of up to 100 cows, when their milk is pooled. Mixing of milk is practiced in rural communities in Tanzania, thereby increasing the chances of gross contamination of milk. The habit of drinking raw milk and /or mixing raw milk with other raw animals products, exacerbates the chances of acquiring zoonotic conditions such as tuberculosis. Furthermore, there is a tendency by many pastoralists to prepare yoghurt by fermentation of raw milk. Although fermentation results in formation of lactic acid when the milk is soured, and hence lowers the PH which is detrimental to many pathogenic microbes, *Mycobacterium* species are known to survive in this soured milk for up to 14 days. Therefore, milk from such animals may be a potential source of *Mycobacterial* infection to man. In summary, the isolation of *Mycobacterium bovis* and *M. fortuitum* in milk, pastoral animals indicates the potential dangers of acquiring infection through consumption of raw milk and other animal products, a practice which is common in many pastoral communities in Africa (Kazwala *et al.*, 1998).

Nearly all changes which take place in the flavor and appearance of milk after it is drawn are the results of activities of micro-organisms. The most important are the bacteria, mould, yeast and virus. Few are desirable while most caused undesirable changes. Small proportion of them are disease causing. The greater the bacteria count in milk, the lower is its bacteriological quality. It is well established that milk can be a potential carrier of disease causing organisms unless proper precautions are taken especially if raw milk is consumed (Sukumar, 1991).

World medical literature reported that there is occurrence of low intestinal lactose activity in some people. It is concluded that taking milk by these people may lead to gastro-intestinal disturbances described as milk “intolerance” and these may interfere with the proper utilization of milk nutrients (Loosli *et al.*, 1999).

Hair on flanks and around the udder should be trimmed as milk can smell if goat hair falls to the buckets or if the male goat has been in close contact with the female. Goats can be deodorized before the animal is one month old (MacDonald and Low, 1985).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experiment 1

3.1.0 Assessment of milk production potentials of dairy goats in Adamawa state

3.1.1 Introduction

Milk is very important in human diet as a source of protein for body growth, repair of tissues and other vital functions of the body. Despite the knowledge of its importance, it is still absent in the diets of most Nigerians, because the quantity produced and supplied to the market is grossly inadequate. The cost of milk and milk products imported to augment local supply is often very high. Thus most Nigerians cannot afford to buy them. Apart from cattle which is the predominant source of milk available in the market, goats also produce some considerable quantities of milk which vary from 1.02-3.8kg/animal/day amongst some of the foreign dairy breeds. The indigenous breeds (Red Sokoto, Sahel and Dwarf goats) yield much less milk with a range of 0.40-1.00kg/animal/day. The population of goats in Nigeria has been estimated at 34.45 million with 5.7 goats per compound. The indigenous breeds that constitute the population have not been selected and developed for dairy production, hence their characteristic low milk yield and shorter lactation length (Otaru, 2002).

3.1.2 Specific objectives

Thirty (30) questionnaires were distributed randomly in each of the local government areas of the study area. A total of two hundred and forty (240) structured questionnaires were used. Information required included the age, sex, marital status, years of experience, whether goats are milked, use of the milk, reason for non consumption of milk, breed of goats reared, reason for keeping goats, education level of respondents, system of management, source of labour, frequency of milking, mode of processing and problems of goats production. The experiment lasted for one year.

3.1.3 Location of the study

The research was carried out in the Benue trough block of the state. Adamawa state is located at the North Eastern part of Nigeria. It lies between latitude 7⁰ and 11⁰N of the equator and between longitude 11⁰ and 14⁰E of the Greenwich meridian. It shares boundaries with Taraba State in the South and West, Gombe State in its Northwest and

Borno to the North. Adamawa State has an international boundary with the Cameroon Republic along its eastern border. The state covers a land area of about 38,741km. The amount of sunshine hours ranges from 2500 in the south to 3000 hours per annum in the extreme north of the state. Maximum temperature is 40⁰c particularly in April while minimum temperature is 18⁰c between December and January. Rainy season begins in April and ends in October with a mean annual rainfall of 1150mm. Relative humidity ranges from 20-80% (Adebayo and Tukur, 1999).

3.1.4 Design/data collection

A survey was conducted to identify small holders and pastoral dairy goat farmers in the state.

Adamawa is one of the states with high concentration of livestock. A number of factors combine to dictate the types, population and spatial distribution of livestock over the state. The state is divided into four pastoral blocks based largely on similarities in ecological conditions (i.e. Toungo block, Jada-Mayobelwa block, Benue Trough block and Hong – Michika Block) (Adebayo and Tukur, 1999). The survey was carried out in the Benue trough block. It is the largest block covering about 11,000km² making up to 31.8% and contains 50.5% of the total goat population of the state. It is a grassland area characterized by the flood plains of the Benue and that of its tributaries such as rivers Gongola, Kilange and Ine. The study covers Fufore, Yola South, Yola North, Girei, Song, Demsa, Lamorde and Gombi Local Government areas of the state.

3.1.5 Statistical analyses

Simple percentages were used to analyze the data generated

3.2 Experiment 2

3.2.0 Effects of different supplements on milk production of sokoto red goats.

3.2.1 Introduction

The Sokoto red goats are the most numerous (about 17 million) and widely distributed breed of goats in Nigeria. It is the only Nigerian goat breed for which there is a record of systematic attempts to stabilize a particular type. It is characterized by its uniformly dark red coat color, short and horizontal ears and horn in both sexes. The mature body weight varies between 30-35kg in males and 25-30kg in females. The Kano

brown and Borno white are believed to be strains of the Sokoto red. The skin of the Sokoto red goat, known as “Morocco” leather is used in leather Industries locally and abroad and commands a very high premium in world markets. Also their milk is consumed in some areas (Oni, 2002). Average height at withers is 65cm, it is very well adapted to the arid zones, in the male bearded is common (Devendra and McLerory, 1982). The breed is more cosmopolitan in distribution and an average flock size of small holder farmers is between 3-5 goats (Makun *et al.*, 2008).

3.2.2 Location of the study

The study was conducted at the teaching and research farm of the Department of Animal Science and Range Management, Modibbo Adama University of Technology, Yola, located in the northeastern part of the country, it is situated within the Guinea savanna region and lies between latitude 09.14°N and longitude 12.8°E and an altitude of 152m above sea level. Average temperature is 29°C and an annual mean rainfall of 1150mm (Adebayo and Tukur, 1999).

3.2.3 Experimental animals and management

Twenty two (22) Sokoto red goats were purchased from the identified local farmers known to milk goats which proved to be good milkers in experiment one (1) (twenty does and two bucks). The animals were ear tagged and weighed at the beginning of the experiment. They were dewormed with ivomec super, a broad spectrum dewormer and reared for two weeks adaptation period. The experiment lasted for fourteen (14) months. Semi-intensive system of management was adopted in managing the animals. They were taken out for grazing in the morning during dry season and in the afternoon during rainy season while supplements (maize bran, cotton seed cake and groundnut hay) was provided in the evening and during milking. Salt lick and portable drinking water was provided *ad-libitum*. The animals were divided into four groups of five animals each. Group one (1) was the control and receives no supplement, while group two (2) was supplemented with maize bran, group three (3) with cotton seed cake and group four (4) with groundnut hay in a complete randomized block design. The animals were vaccinated against PPR. The pens were made up of concrete floor and well ventilated. Routine management practices were carried out (sweeping of Pens daily, washing the drinkers and

changing the water and cleaning the feeders daily). Any sick animal was transferred to a sick pen, diagnosed and treated.

3.2.4 Experimental diets

Maize bran was purchased from small scale mills in Yola metropolis and sundried to avoid molding. Cotton seed cake was purchased from stores in Yola. It was milled to reduce the size for feeding. Similarly, groundnut haulms were purchased on-farm. They were crushed and bulk in bags prior to the study period and ensured that sufficient quantity was made available for the animals up to when new ones were available.

3.2.5 Treatments and experimental design

Animals were randomly divided into four (4) treatment groups. Five animals were assigned to a particular diet in a complete Randomized Block design (Steel and Torrie, 1980).

Daily grazing was used. The ingredients used as supplements were maize bran, cotton seed cake and groundnut hay. The animals were divided into four treatment groups. Treatment one (1) which was made up of five animals, received no supplement after grazing, treatment two (2) was supplemented with maize bran after grazing, treatment three ((3) with cotton seed cake and treatment (4) with groundnut haulms after grazing. Semi-intensive management system was used in managing the animals. The animals were managed up to kidding and lactation periods.

3.2.6 Data collection

Data was collected on the following parameters

3.2.6.1 Feed intake

The Daily feed intake of the supplemental diets was obtained by subtracting the left over from the total feed supplied for the day. The supplement was given to the animals after grazing.

3.2.6.2 Body weight changes

Initial body weights of the experimental animals were measured before the onset of the experiment while subsequent body weight measurements were done weekly. The weight gain per animal was determined by subtracting the weight before the beginning of the experiment from the final weigh divided by the number of days the experiment lasted.

3.2.6.3 Reproduction parameters

3.2.6.4 Gestation length

This was measured from the date of mating up to kidding period for each of the animals in all the treatments.

3.2.6.5 Birth weight

Birth weight was measured using a weighing balance immediately after birth. Subsequently the weighing of the kids was done weekly up to weaning period. This was done using a sensitive weighing balance.

3.2.6.6 Twinning rate and mortality

The number of kids reproduced per each animal in single pregnancy was recorded. Also recorded was the mortality of the kids.

3.2.6.7 Kidding interval

This refers to the number of days between two successive kiddings.

3.2.6.8 Milk production

After kidding the does were milked daily in the morning to determine the partial daily milk yield of the does. Milking was done for up to three months by hand milking. Does were separated from their kids at 6:00pm till after milk collection the next morning at 6:00 – 7:00am. Milk yield were measured using a weighing balance immediately after collection. The milk collected was defined as the partial daily milk yield (PDM) which is a combination of milk off-take and 12hr milk yield. Milking was done for first and second parities for three months each. Portion of milk which was used from each doe per collection were quickly transported and stored in a deep freezer at -5⁰c till required for analyses. Before analyses each sample was thawed at 40⁰c to melt the fat and then cool to 20⁰c. The entire content was then thoroughly mixed without any preservative and evaluated for gross composition (PH, crude protein, fat, lactose and ash). The proximate composition of the milk was done in three different stages. At early lactation, mid lactation and late lactation. Fat was estimated by gerber methods (A.O.A.C, 1995). Protein was determined by kjeldahl method (IDF, 1995). Ash content was determined by igniting the dry sample at 500⁰c (A.O.A.C, 1995). While lactose content was assessed by Barnett and Tawab (1957) methods.

3.2.6.9 Chemical analyses

The proximate composition of the of the milk was done at three different stages. At early lactations, mid lactation and at the end of lactation. The proximate compositions of the different supplements were also determined

3.2.7 Statistical analyses

The data collected from the four treatment groups were analysed for variance using a complete randomized block design procedure (Steel and Torrie, 1980). While significant differences between treatment means were determined using LSD.

3.3 Experiment 3

3.3.0 Effects of supplements on milk yield and composition of red sokoto goats.

3.3.1 Introduction

Goats play an important role in the socio-economic life of people of Nigeria and also make a significant contribution to the national economy. Sheep and goats constitute about 35% of national meat supply. These figures may be higher if animals not processed in slaughter houses, for which records are not available, are included. The different goats breeds in Nigeria posses unique traits of adaptability, and breeds perform best in the particular vegetation zone (s) where they are commonly found. Such adaptability traits include ability to survive seasonal fluctuation in availability of feeds, drought resistance and increased tolerance to diseases prevalent in the areas in which they live, also some are known to exhibit economically advantageous traits such as prolificacy and fast growth rate. Consequently, effort to improve the genetic worth of these animals with regards to increased productivity and efficiency should also take cognizance of preserving the much desired traits of adaptability, genetic improvement and nutritional improvement must complement each other for the animal to express its genetic potentials to the full (Oni, 2002).

3.3.2 Experimental animals and management

The offsprings of the best milkers (does and bucks) in experiment two (2) were used in this experiment. Sixteen (16) animals were used in a complete randomized block design experiment (Steel and Torrie, 1980). They were dewormed using ivomec, a broad spectrum dewormer, vaccinated against PPR, ear tagged and weighted before the onset of the experiment. Semi-intensive management system was adopted as in experiment two

with the same supplements. The animals were taken out for grazing in the morning and in the evening supplements were given to them and during milking. Treatment one (1) as the control, treatment two supplemented with maize bran, treatment three supplemented with cotton seed cake and treatment four with groundnut hay (Harawa).

3.3.3 Data collection

3.3.3.1 Feed intake

The daily feed intake of the supplemental diet was obtained by subtracting the left over from the quantity of feed provided for the day. After grazing a known quantity of the supplemental diet (Maize bran, Cotton seed cake and Groundnut hay) was given to the animals and the left over was measured in the morning and the quantity subtracted from the quantity supplied and is referred to as the daily supplement feed in take. No supplement was given to the control group.

3.3.3.2 Body weight changes

Initial body weight of the experimental animals was measured at the beginning of the experiment and thereafter at weekly interval.

3.3.3.3 Reproduction parameters

3.3.3.4 Gestation period

This refers to number of days from conception to kidding. This was recorded for each animal in all the treatment groups.

3.3.3.5 Birth weight

The birth weight of the kids were recorded for each kid immediately after kidding. This was done using a sensitive weighing balance.

3.3.3.6 Twinning rate and mortality

The number of kids reproduced per each animal in a single pregnancy was recorded. Also recorded was the mortality of the kids. The number of days from birth up to the onset of puberty was also recorded for each of the animals.

3.3.3.7 Milk production

The does were milked daily in the morning to determine the partial daily milk yield. It was done by separating the does from their kids over the night. Milking commences after the colostoral period. The animals were hand milked. The does were separated from the kids at 6:00pm until after milking the following morning at 6:00 –

7:00am. Milk yield was measured using a weighing balance. The collected sample was given out to the people in order to induce its consumption. Portions of the milk at second week eight week and twelve weeks were collected from each animal for nutrient composition determination (PH, fat, lactose and ash) as was done in the previous experiment.

3.3.3.8 Chemical analysis of feed

Chemical analysis of the different supplements was carried out to determine the nutrient composition of the different supplements. The supplements were taken to the laboratory for proximate composition to determine dry matter, crude protein, ether extract, crude fibre and ash content, according to A.O.A.C. (1995).

3.3.3.9 Statistical analysis

The data generated were analyzed using analysis of variance and where significant differences exist, least significant difference was used to separate the means. SPSS version 13 statistical software was used to analyse the data.

CHAPTER FOUR

RESULTS

4.1 Experiment 1: Assessment of milk production potential of dairy goats in Adamawa state.

The result of the investigation revealed that in Song Local Government Area of the state, dairy goats farmers formed 36.67% of the respondents. Dairy goats farmers were also located in Gombi Local Government Area and constituted 26.67%. The result also revealed that in Fufore, Lamorde and Demsa Local Government Areas dairy goat farmers were 10, 10 and 6.67% respectively as indicated in Table 1. Respondents in Girei, Yola North and Yola South formed 6.67, 0 and 0% respectively of dairy goats farmers in the study area.

The result of the investigation revealed that of the thirty (30) questionnaires distributed in Yola North and Yola South Local Government Areas of Adamawa State shows that the respondents did not use goats milk for any purpose. In Demsa local government 93.3% of the respondent did not use goat milk. The data obtained from Girei, Fufore and Lamurde Local Government areas showed that 93.3, 90 and 90% of respondents respectively had never use goat as a dairy animal, while in Gombi and Song only 73.3 and 63.3% of the respondents respectively did not use goat milk for any purpose as shown in Table 2.

The result of the investigation from the 240 questionnaires distributed among the eight (8) local government areas of the study area showed that only 12.08% of the respondents have preference for goat milk. This shows that preference for cow milk was 87.92%. However, one of the major reasons for non-consumption of goat milk in the study area revealed by the investigation was that the tradition of the respondents do not allow them to consume goat milk and it accounted for 82.46%. Low milk yield from the goats as one of the reasons for non-consumption of goats milk accounted for 15.17%. Some of the respondents in the study area stated that the odour of the milk could not allow them to take goat milk and it accounted for 1.42%. The data obtained from the experiment revealed that 0.94% of the respondents used to encounter health problems after consumption of goat milk as indicated in Table 3. The above mentioned reasons

Table: 1 Distribution of dairy Goat Farmers in the Study

L. G. A.	Farmers interviewed	Goat Milkers	% of Farmers
Song	30	11	36.67
Gombi	30	8	26.67
Fufore	30	3	10
Lamorde	30	3	10
Demsa	30	2	6.67
Girei	30	2	6.67
Yola North	30	0	0
Yola South	30	0	0

Table: 2 Distribution of Non-dairy Goat Farmers in the Study Area

L. G. A.	Farmers interviewed	Non- Milkers	% of Farmers
Yola North	30	30	100
Yola South	30	30	100
Demsa	30	28	93.3
Girei	30	28	93.3
Fufore	30	27	90
Lamorde	30	27	90
Gombi	30	22	73.3
Song	30	19	63.3
Total	240	211	

Table: 3 Distribution of Respondents According to Reasons for Non-Consumption of Goat Milk

Reason	No. of Farmers	% of farmers
Tradition	174	82.46
Low milk yield	32	15.16
Odour	3	1.42
Health	2	0.94
Total	211	100

combined together accounted for 87.92% of the respondents in the study area that did not consume goats milk or did not consider goats as a dairy animal.

The outcome of the survey carried out in the study area revealed that majority of the farmers kept Sokoto red goats, it accounted for 67.9% from the respondents. Sahel goats were the other breed of goats found in the study area. The number of respondents that keep Sahel goats accounted for 6.25%. These were the two distinct breeds of goats found in the study area, the remaining were the combination of the different breeds of goats. They were the result of cross breeding between Sokoto red, Sahel and West African dwarf goats which were brought to the study area by travelers who went to the South to sell cattle long time ago. These groups of animals constituted 25.83% of the breed of goats found in the study area as indicated in Table 4.

As indicated in Table 5, the study revealed that majority of the goat keepers in the study area kept goats for income generation especially for taking care of the educational needs of their children, for purchase of drugs of cattle and for buying food items for the family especially when crop fails, and it constituted 64.58%. Farmers that kept goats for the purpose of milking them constituted 12.08% and was the second largest group after income. Others kept goats for their meat and it constituted 8.75% of the farmers in the study area. Some farmers in the study area reared goats in order to use them during ceremonies and they constituted 2.5%. The rest of the farmers in the study area kept goats for some reasons other than those mentioned above and constituted 12.08% of the farmers in the study area.

Gender and marital status of the respondents in the study area are shown in Table 6. The result shows that majority of farmers in the area were males, 87.92%, while 12.08% of the respondents were females. However, the marital status of the respondents showed that 77.50% of them were married men and women, 13.33% of them were unmarried. The result of the study also revealed that 3.75% of the farmers in the study area were divorced men and women, while 5.42% were widows.

The result of the analysis of age of respondents and number of goats per house hold showed that 13.30% were between the ages of 18-23 years and the number of goats/house hold of respondents of these age group was between 2-10 goats. As shown in Table 7, 10.42% of the respondents were between the ages of 24 – 29 years and they

Table: 4. Breeds of Goats reared in the Study Area

Breed	Number	Percentage (%)
Sokoto Red	163	67.9
Sahel	15	6.25
Mixed breeds	62	25.83
Total	240	100

Table: 5. Distribution of Respondents According to Reason for Keeping Goats

Purpose	No. of Farmers	% of farmers
Income	155	64.58
Milk	29	12.08
Meat	21	8.75
Ceremonies	6	2.5
Others	29	12.08

Table: 6. Gender and Marital Status of Respondents in the study

Respondents	No. of Farmers	Percentage (%)
Males	211	87.92
Females	29	12.08
Married	216	77.50
Singles	12	13.33
Divorced	6	3.75
Widows	6	5.42

Table: 7. Age of Respondents that Reared Goats in the Study Area

Age	No. of Farmers	% of Farmers	No. of Goats
18-23	32	13.30	2-10
24-29	25	10.42	5-20
30-35	73	30.42	5-35
36-41	30	12.50	10-60
42-47	16	6.67	15-90
48-53	17	7.08	10-25
54-59	21	8.75	10-30
>60	26	10.83	15-30
Total	240	100	

possessed 5 – 20 goats/house hold. Farmers of the age 30-35 years make up 30.42% and the number of goats/ household were 5-35 goats. People of the age of 36-41 years were 12.50% of the farmers in the study area and they possessed 10-60 goats/household. The result also shows that 6.67% of the respondents in the study area were between the ages of 42-47 years and they possessed the highest number of goats/household i.e 15-90 goats. However, 7.08% of the farmers in the study area were between the ages of 48-53 years and they possessed 10-25 goats/household. While respondents between the ages 54 – 59 years made up 8.75% and the number of goats/house hold of this group was 10-30 goats. Those above 60 years reared between 15-30 goats/household and they made up 10.83% of the people interviewed in the study area as shown in Table 7.

The educational level of the respondents in the study area as shown in Table 8 indicated that 42.9% of them were illiterates. The result also shows that 23.3% of them attended primary school only. However, 15% of the farmers in the study area progressed their educational career to secondary school level. Farmers in the study area that attended other tertiary institutions apart from the University made up to 13.3% while 5.4% of the respondents attended the University.

The different systems of managing goats adopted by farmers in the study area shows 40.24% of the respondents kept their goats under the free range method. Tethering system of managing animals was adopted by 14.17% of the respondents in the study area. However, the village herding system ranked the second largest after free range system and accounted for 30.0% of the respondents in the study area. While cut and carry system made up of 15.42% of the farmers in the study area as shown in Table 9.

The respondents level of experience and sources of labour indicated that 10.83% of them possessed a level of experience in goats rearing between 1-5 years. Farmers that reared goats between 6-10 years made up 29.58%. While majority of the farmers i.e. 35.83% possessed a level of experience in goats farming of between 11-16 years. The result of the analysis also shows that farmers that have an experience level of between 17-26 years made up 14.17%. While 9.58% of the respondents reared goats for more than 26 years as indicated in Table 10. However, the result of the analysis also indicated that 39.17% of the farmers in the study area used hired labour especially by children in

Table: 8. Educational Level of Respondents in the Study Area

Level of Education	No. of farmers	Percentage (%)
Illiterate	103	42.9
Primary School	56	23.3
Secondary School	36	15.0
Tertiary Institutions	32	13.3
University	13	5.4
Total	240	100

Table: 9. Systems of Managing Goats by Respondents in the study

Management System	No. of farmers	Percentage (%)
Free range	97	40.42
Tethering	34	14.17
Village herding system	72	30.00
Cut and Carry	37	15.42
Total	240	100

Table: 10. Respondents Level of Experience and Source of Labour

Years	No. of farmers	% of Farmers
1-5	26	10.83
6-10	71	29.58
11-16	86	35.83
17-26	34	14.17
> 26	23	9.58
Hired	94	39.17
Family	146	60.83

keeping their animals, while majority of the farmers in the study area used family labour in managing their goats and it made up 60.83% as shown in Table 10.

The result of the analysis of the data obtained from the questionnaires distributed to the respondents in study area shows that 20.69% milked their goats only once in a day for assurance of the survival of the kids. However, majority of the farmers i.e 51.73% milked their goats twice in a day (morning and evening). While 17.24% of the farmers milked their animals three times in a day (morning, afternoon and evening). The questionnaire also shows that only 10.34% of the farmers milked their animals more than three times in a day as shown in Table 11. The result also shows that 65.52% of the farmers that milked their animals were processing the milk after milking for easy storage and sell, while 34.48% of them were not processing the milk. They consumed or sell the milk without processing it. The result also shows that 57.89% of the dairy goat farmers that processed their milk were processing it to kindirmu (yoghurt), while 42.10% of them were processing it to butter fat as indicated in Table 11.

The result of the analysis of problems of goat farming in the study area shows that 12.50% of the respondents indicated that conflict with crop farmers and households was the major problem they were facing during their years of experience in goats farming. Lack of extension workers that will enlighten the farmers on new innovations, veterinary services and importance of goat milk as the other problems they faced in goat farming and they accounted for 14.58% of farmers in the study area. Some farmers indicated automobile accidents as the problem they faced in goat farming and it made up 9.17% of the respondents in the study area. The results of the analysis shows that 40.42% of the farmers indicated that lack of feed materials especially during the dry season as the problem they encountered during their years of experience in goat farming and these served as the major problem of farmers in the study area. Disease problem accounted for 23.33% of the problems of goat farming as indicated by the respondents in the study area as shown in Table 12.

The result also shows that of the common diseases encountered by goat farmers in the study area, ectoparasite infestation accounted for 19.64%, while endoparasite infestation accounted for 10.71% of the respondents in the study area. Mastitis as the disease of dairy animals accounted for 17.86% of goat farmers in the area investigated.

Table: 11. Frequency of Milking, processing and Mode of Processing of Milk by Respondents

Frequency of Milking	No. of Farmers	% of Farmers
Once	6	20.69
Twice	15	51.73
Thrice	5	17.24
> Thrice	3	10.34
Processing Milk	19	65.52
Not Processing Milk	10	34.48
Processing to Kindirmu	11	57.89
Processing to Butter fat	8	42.10

Table: 12. Problems of Goat Production in the Study Area

Source	No. of farmers	%
Conflict with farmers and House holds	30	12.50
Lack of Extension Services	35	14.58
Automobiles	22	9.17
Lack of Feed	97	40.42
Disease	56	23.33
Total	240	100

The result of the analysis of the common diseases of goats in the study area also shows that pes des petit ruminant (P. P. R.) accounted for 51.78% of the diseases of goat in the study area, it also indicated that it was the major disease encountered by farmers in the area investigated as shown in Table 13.

4.2.0 *Experiment 2: Effects of different supplements on milk production of sokoto red goats*

4.2.1 *Chemical composition of the supplemental feeds*

The chemical composition of the supplemental feeds are presented in Table 14. The animals were taken out for grazing in the morning and taken back in to the pens in the evening for supplemental feeding in their various treatment groups. At the beginning of the experiment the different supplements were taken to the laboratory for proximate analysis to determine dry matter, crude protein, crude fibre, ash and ether extract. The result obtained from the analysis indicated that the dry matter content of the supplements were higher in the groundnut haulms, followed by cotton seed cake while least was in maize bran. Crude protein values were higher in cotton seed cake than groundnut haulms and maize bran while the crude fibre records were higher in groundnut haulms than cotton seed cake and maize bran. The mineral (ash) content were high in groundnut haulms, followed by cotton seed cake and the least was in maize bran. Ether extract values were high in cotton seed cake, then groundnut haulms while the least value was recorded in maize bran.

The initial weight, total weight gain, supplement feed intake, gestation length, twinning rate, birth weight, milk yield, mortality and total weight gain of kids are summarized in Table 15.

4.2.2 *Initial weight*

The initial weight of the animals across the different treatment groups ranged between 16.25 and 16.75kg. The differences between all the treatment groups were not significant.

4.2.3 *Total weight gain*

The total weight gain was significantly affected ($p < 0.001$) by the dietary treatments. The total weight gain values were 4.750, 5.750, 6.775 and 3.750kg for

Table: 13. Common Diseases of Goats in the Study Area

Diseases of Goats	No. of Farmers	Percentage of Farmers
Ectoparasite	11	19.64
Endo parasite	6	10.71
Mastitis	10	17.86
P. P. R	29	51.78
Total	56	100

Table: 14. Chemical Composition of the Supplemental Feeds (% DM basis)

Diets	DM	CP	CF	ASH	EE
Maize bran	92.23	10.53	10.53	1.16	1.89
Cotton seed cake	93.60	29.94	23.50	5.16	5.76
Groundnut haulms	93.65	15.63	23.26	7.67	2.06

Table: 15. Performance and milk Production of does (Parent stock, First Parity) in the study

Parameters	Treatments				SEM
	1	2	3	4	
Initial Weight (kg)	16.500	16.500	16.250	16.750	0.289NS
Total Weight gain (kg)	4.750 ^c	5.750 ^b	6.775 ^a	3.750 ^d	0.356***
Supplement Feed intake (kg)	0.000 ^c	30.235 ^b	30.550 ^b	34.275 ^a	0.042***
Gestation Length (days)	152.000 ^a	150.500 ^b	150.500 ^b	150.750 ^b	0.315*
Twinning Rate	0.000	0.500	0.500	0.000	0.204NS
Birth Weight of Kids (kg)	2.050 ^a	1.613 ^c	1.763 ^b	1.700 ^{ab}	0.039***
Milk yield (kg)	35.530	32.218	39.623	28.433	5.505NS
Mortality of Kids	0.250 ^{ab}	0.750 ^a	0.000 ^b	0.000 ^b	0.204*
Total Weight gain of Kids (kg)	3.333 ^d	4.900 ^b	5.050 ^a	4.325 ^c	0.042***

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

treatments 1, 2, 3 and 4 respectively. The total weight gain was low in treatment four (4), those supplemented with groundnut haulms and the highest value was attained in treatment three (3) those supplemented with cotton seed cake followed by treatment two (2), those supplemented with maize bran and then the control group.

4.2.4 Supplement intake

The total supplement feed intake was significantly ($p < 0.001$) influenced by the different dietary treatments. Treatment 1, which was the control group did not receive any supplement. The highest supplement feed intake was recorded in treatment four 4 those supplemented with groundnut haulms, (34.27kg). This is followed by treatment three 3, those supplemented with cotton seed cake (30.550kg) and the least is obtained in treatment two 2, those supplemented with maize bran (30.235kg).

4.2.5 Gestation length

The length of the gestation period was also significantly affected by the dietary treatments ($p < 0.05$). The gestation length values were 152.00, 150.50, 150.50 and 150.75days for treatments 1, 2, 3 and 4 respectively. The highest value of 152.00days was recorded in treatment one (1), this was followed by treatment four (4), with 150.75days and then treatment two (2), and three (3) with 150.50 days each respectively.

4.2.6 Twinning rate

The twinning rate was not significantly affected by the different dietary treatment groups. The values were 0.00, 0.50, 0.05 and 0.00 for treatments 1,2,3 and 4 respectively. The result shows that twinning was not recorded in treatment one (1) (control) and treatment four (4). However, it was recorded in treatment two (2) (0.50) and three (3) (0.50) respectively.

4.2.7. Birth weight

The different supplements showed a significant ($p < 0.001$) difference on birth weight of kids. The average birth weight of kids were 2.050, 1.613, 1.763 and 1.700kg for treatments 1,2,3 and 4 respectively. The highest birth weight was recorded in the control group (1). It was followed by kids on treatment three (3) and four (4). The least birth weight was recorded in treatment two (2).

4.2.8 Milk yield

The milk yield values were 35.530, 32.218, 39.263 and 28.433kg for the different treatment groups with no significant difference among the treatment groups. The values were higher in the group supplemented with cotton seed cake, followed by the control group. Treatment two (2) which is supplemented with maize bran is the next and the least values were recorded in the group supplemented with groundnut haulms.

4.2.9 Mortality of kids

Kids mortality was recorded only in experiment one (1) and two (2) and there is a significant ($p < 0.05$) difference between the treatment groups. The values recorded are 0.250 and 0.750 for treatments one (1) and two (2) while none was recorded in treatments three (3) and four (4). This shows that mortality of kids were higher in treatment two (2) followed by treatment one (1).

4.2.10 Total weight gain of kids

The values recorded for total weight gain of kids across the different treatment groups showed that there were significant ($p < 0.001$) differences. The values were 3.33, 4.90, 5.05 and 4.325kg for treatments 1, 2, 3 and 4 respectively. The highest weight gain was recorded in treatment three (3) which was supplemented with cotton seed cake which was followed by treatment two (2) and then four (4). The least values of kids growth was recorded in the control group.

4.2.11 Proximate analysis of milk (first parity parent stock)

The result of the proximate composition of milk obtained from the parent stock during early lactation first parity did not show any significant difference between all the treatment groups for PH, total solids, crude protein, fats, lactose and ash. However, the result recorded from the proximate analysis of milk during mid-lactation also did not show any significant difference between all the treatment groups for PH, total solids, crude protein, fats and lactose. But the values recorded for ash showed a significant ($p < 0.05$) difference between the treatment groups. The highest value was recorded in treatment two (2) (1.145) which was followed by treatment four (4) (1.138), then treatment three (3) (1.100) while the least value was recorded in the control group (0.958) as shown in Table 16.

Table: 16. Proximate Composition of Milk from Does During First Parity in the study

Parameters	Treatments				SEM
	1	2	3	4	
Early Lactation					
PH	6.213	6.320	6.253	6.288	0.047Ns
Total Solids	12.635	12.698	12.723	12.638	0.039Ns
Crude Protein	3.923	3.718	3.473	3.580	0.136Ns
Fat	3.665	3.698	3.640	3.780	0.061Ns
Lactose	3.878	3.948	3.935	3.873	0.085Ns
Ash	0.808	0.790	0.715	0.748	0.063Ns
Mid-Lactation					
PH	6.293	6.303	6.295	6.350	0.22Ns
Total Solids	11.553	11.495	11.480	11.568	0.047Ns
Crude Protein	3.368	3.353	3.333	3.375	0.016Ns
Fat	4.625	4.588	4.600	4.563	0.22Ns
Lactose	4.405	4.400	4.373	4.405	0.016Ns
Ash	0.958 ^b	1.145 ^a	1.100 ^a	1.138 ^a	0.039*
Late Lactation					
PH	6.113	6.138	6.135	6.158	0.022Ns
Total Solids	11.553	11.670	11.595	11.645	0.027Ns
Crude Protein	3.693	3.208	3.185	3.198	0.136Ns
Fat	4.153 ^{ab}	4.155 ^{ab}	4.173 ^{ab}	4.145 ^b	0.000*
Lactose	4.085 ^b	4.115 ^b	4.148 ^a	4.105 ^b	0.000**
Ash	0.803 ^b	0.968 ^a	0.993 ^a	0.855 ^b	0.016***

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

The proximate analysis of milk obtained during late-lactation also did not show any significant difference between the treatment groups for PH, total solids and crude protein. Values recorded for fats showed significant ($p<0.05$) difference between the treatment groups. The highest value was recorded in treatment three (3) (4.173), these was followed by treatment two (2) (4.155), then the control group (4.153) and the least was recorded in treatment four (4) (4.145). The values recorded for lactose also showed a significant ($p<0.01$) difference between the treatment groups. The least value was recorded in the control group (4.085) while the highest value was recorded in treatment three (3) (4.148). The results for ash also showed a significant ($p<0.001$) difference between the treatment groups. The highest value was recorded in treatment three (3) with 0.993, this was followed by treatment two (2) and four (4) with 0.968 and 0.855 respectively while the least value of 0.803 was recorded in the control group.

4.2.12 *Second parity*

The supplement feed intake, birth weight, gestation lengths kidding interval, twinning rate, milk yield, total weight gain and mortality of kids were summarized in Table 17.

4.2.12.1 *Supplement intake*

The supplement feed intake was significantly affected ($p<0.001$) by the dietary treatments. The supplement was not provided to the control group (1), while the values for treatment 2, 3 and 4 were 31.090, 30.798 and 32.228kg respectively. Animals on treatment four (4) had the highest supplement feed intake while the lowest was recorded for animals on treatment three (3).

4.2.12.2 *Birth weight*

The birth weight of kids vary significantly ($p<0.05$) between the different treatment groups. The least birth weight was recorded in the control group which indicates that kids reproduced by goats in supplemented groups tended to be higher in weight than those in the control group. The highest birth weight was recorded in treatment three (3), followed by treatment two (2) and four (4) respectively.

4.2.12.3 *Kidding interval*

The number of days between two successive kiddings vary significantly ($p<0.01$) between the various treatment groups. The highest was recorded in the control group with 203.75 days. This was followed by treatment four (4) with 187.50 days and then

Table: 17. Performance and Milk Production of Does (second parity, parent stock) in the study

Parameters	Treatments				SEM
	1	2	3	4	
Supplement Feed intake (kg)	0.000 ^d	31.090 ^b	30.798 ^c	32.228 ^a	0.000***
Birth Weight of Kids (kg)	1.850 ^b	1.950 ^{ab}	1.988 ^a	1.913 ^{ab}	0.035*
Kidding Interval (days)	203.750 ^a	185.000 ^b	182.500 ^b	187.500 ^b	3.011**
Gestation Length (days)	148.500 ^b	149.250 ^b	149.250 ^b	150.250 ^a	0.239**
Twinning Rate	0.750	1.000	1.000	0.750	0.186Ns
Milk yield (kg)	42.588	38.758	46.708	33.605	6.975Ns
Total Weight gain of Kids (kg)	5.850 ^c	6.038 ^b	6.813 ^a	6.013 ^b	0.035***
Mortality of Kids	0.500	0.250	0.250	0.250	0.266Ns

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

treatment two (2) with 185.00 days while the least was recorded on treatment three (3) with 182.50 days.

4.2.12.4 Gestation length

The length of pregnancy also vary significantly ($p < 0.01$) among the different treatment groups. The least number of days was recorded in the control group, which was followed by treatment two (2) (149.25) and three (3) (149.25), while the highest gestation length was recorded in treatment 4 (150.25).

4.2.12.5 Twinning rate

The number of kids reproduced in a single pregnancy was not affected by supplementation. The records for twinning rate across the different treatment groups were 0.75, 1.00, 1.00 and 0.75 for treatment 1, 2, 3 and 4 respectively.

4.2.12.6 Milk yield

The milk production of does during the second parity also did not show any significant difference among the different treatment groups. The records were 42.588, 38.758, 46.708 and 33.605kg for treatments 1, 2, 3 and 4 respectively. This result shows that the highest milk yield was recorded in the group supplemented with cotton seed cake and this was followed by the control group. Next in the ranking was treatment two (2) which was supplemented with maize bran while the least record was obtained from the treatment receiving groundnut haulms as a supplement.

4.2.12.7 Total weight gain of kids

The total weight gain of kids reproduced during the second parity of the parent stock showed that the different supplements given to the does in different treatment groups shows that there was a significant difference ($p < 0.001$) between the treatment groups. The least weight gain was recorded in the control group while the highest weight gain was recorded in the group supplemented with cotton seed cake. Treatment two (2) and four (4) were intermediate between the two treatment groups.

4.2.12.8 Mortality of kids

Mortality of the kids reproduced during second parity did not show any significant difference between the different treatment groups. The values recorded were 0.500, 0.250, 0.250 and 0.250 for treatments 1, 2, 3 and 4 respectively. The control group

recorded the highest mortality rate followed by the three treatment groups which recorded the same values (i.e 2, 3 and 4).

4.2.13 Proximate composition of milk (second parity parent stock)

The proximate analysis of milk obtained from parent stock goats during second parity early lactation shows that differences exist between the different treatment groups for PH, total solids, crude protein, fats, lactose and ash as indicated in Table 18.

4.2.13.1 PH values

The records for PH from the milk shows that there is a significant ($p < 0.05$) difference between the treatment groups. The highest value was obtained from treatment three (3), this was followed by treatment two (2) and four (4) respectively, while the least value was recorded in the control group.

4.2.13.2 Total solids

The result of the analysis shows that there is a significant ($p < 0.05$) difference between the different treatment groups for total solids. The least value was recorded from the control group while the highest value was recorded from the group that was supplemented by cotton seed cake (treatment 3).

4.2.13.3 Crude protein

The recorded values for crude protein indicated that there is a significant ($p < 0.05$) difference between the various treatment groups. This shows that supplementation affects the protein level of milk from the does. The least value was recorded from the control group while the highest value was recorded from treatment three (3).

4.2.13.4 Fats

The proximate analysis of milk shows that supplementation affects ($p < 0.001$) significantly the fat content of milk obtained from the does. The highest fat content was recorded from treatment 3, this is followed by the control group and then treatment two (2) and four (4) respectively.

4.2.13.5 Lactose

The lactose content of milk shows that there were significant differences ($P < 0.001$) between treatments 1, 2, 3 and 4. The least value was recorded from the animals from the control group while the highest values were recorded from the group supplemented with cotton seed cake.

Table: 18. Proximate Composition of Milk of Parent Stock, Second Parity in the study

Parameters	Treatments				SEM
	1	2	3	4	
Early – Lactation					
PH	6.328 ^b	6.378 ^{ab}	6.410 ^a	6.355 ^b	0.016*
Total Solids	11.598 ^b	11.725 ^b	11.885 ^a	11.658 ^a	0.045*
Crude Protein	3.403 ^b	3.508 ^a	3.548 ^a	3.405 ^b	0.022*
Fat	4.680 ^b	4.658 ^b	4.728 ^a	4.600 ^c	0.016***
Lactose	4.423 ^c	4.523 ^b	4.793 ^a	4.490 ^{bc}	0.022***
Ash	1.103 ^b	1.215 ^a	1.263 ^a	1.113 ^b	0.027**
Mid - Lactation					
PH	6.365	6.383	6.395	6.360	0.27Ns
Total Solids	11.640 ^b	11.908 ^a	11.845 ^a	11.645 ^b	0.047**
Crude Protein	3.423 ^b	3.533 ^a	3.425 ^b	3.405 ^b	0.022*
Fat	4.663	4.750	4.723	4.674	0.027Ns
Lactose	4.398 ^c	4.515 ^{bc}	4.705 ^a	4.583 ^{ab}	0.039**
Ash	1.230 ^{ab}	1.225 ^{ab}	1.308 ^a	1.143 ^b	0.035*
Late - Lactation					
PH	6.328 ^b	6.378 ^{ab}	6.410 ^a	6.355 ^b	0.016*
Total Solids	11.598 ^b	11.705 ^b	11.885 ^a	11.668 ^b	0.045*
Crude Protein	3.463 ^b	3.568 ^a	3.598 ^a	3.405 ^b	0.022**
Fat	4.670 ^b	4.658 ^b	4.708 ^a	4.606 ^c	0.016***
Lactose	4.423 ^c	4.503 ^b	4.798 ^a	4.496 ^{bc}	0.022***
Ash	1.108 ^b	1.216 ^{ba}	1.263 ^a	1.173 ^b	0.027**

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

4.2.13.6 Ash

The ash content of the milk obtained from analysis of milk showed a significant ($p < 0.01$) difference between the treatment groups. The highest value was recorded from treatment three (3), followed by treatment two (2) and four (4) respectively while the least value was recorded from the control group.

The proximate analysis of milk obtained during mid-lactation indicates that differences exist between the treatments for total solids, crude protein, lactose and ash while no differences existed between the treatments for PH and fats.

4.2.13.7 PH values

The proximate values of PH during mid-lactation did not show any significant difference between the different treatments. The highest values was recorded from treatment three (3), this was followed by treatment two (2) and then the control group while the least value was recorded in treatment four (4).

4.2.13.8 Total solids

The analysis produced records for total solids that show significant ($p < 0.01$) differences between the different treatment groups. The highest was recorded in treatment two (2) while the least value was recorded in the control group.

4.2.13.9 Crude protein

The values for crude protein showed significant ($p < 0.05$) differences between the various treatment groups. The highest value was obtained from treatment two (2) while the least value was recorded from animals from treatment four (4).

4.2.13.10 Fats

The highest fat value was obtained from treatment two (2), this was followed by animals from treatment three (3) and four (4), while the least value was recorded from the control group. The result indicated that there is no significant difference between the different treatment groups.

4.2.13.11 Lactose

Lactose recorded from the proximate composition showed a significant ($p < 0.01$) difference between the treatments. The highest record was obtained from the group receiving cotton seed cake, this was followed by the group supplemented with groundnut

haulms and then those receiving maize bran while the least was recorded from the control group.

4.2.13.12 Ash

The ash records showed significant ($p < 0.05$) difference between the treatment groups. The highest records were obtained from treatment three (3) while the least value was recorded from treatment four (4).

The proximate composition of milk from goats during late-lactation second parity showed that differences exist between treatment groups for PH, total solids, crude protein, fat, lactose and ash.

4.2.13.13 PH values

The records of proximate analysis of milk from goats for PH values showed significant ($p < 0.05$) differences between the treatment groups. The least value was recorded from the control group while the highest value was obtained from treatment three (3).

4.2.13.14 Total solids

These records also showed significant ($p < 0.05$) differences between the various treatment groups. They revealed that there were influences of supplementation on total solid values. The highest value was recorded from treatment three (3) while the least value was obtained from the control group.

4.2.13.15 Crude protein

The values for crude protein showed that there is a significant ($p < 0.01$) difference between the different treatment groups. The least crude protein record was obtained from the control group while the highest record was obtained from treatment three (3).

4.2.13.16 Fats

The values obtained from analysis of milk revealed that there is a significant ($p < 0.001$) difference for fat between the different treatment groups. The highest value was recorded from treatment three (3), this was followed by the control group and those from treatment two (2) while the least value was recorded from treatment four (4).

4.2.13.17 Lactose

Lactose values from the proximate composition showed a significant ($p < 0.001$) difference between the treatment groups. The highest was obtained from treatment three (3), then treatments two (2) and four (4) while the least value was obtained from the control group.

4.2.13.18 Ash

Total ash also showed a significant ($p < 0.01$) difference between the various treatment groups. The least record was obtained from the control group while the highest value was from treatment three (3).

4.3 Experiment 3: Effects of supplementation on milk yield and composition of sokoto red goats

The initial weight, total weight gain, supplement feed intake, gestation length, maturity age, twinning rate and milk yield of the F_1 generation does were summarized while birth weight, total weight gain and mortality of the F_2 generation kids were also summarized in Table 19.

4.3.1 Initial weight

The initial weight of the F_1 generation before the onset of the experiment was recorded. The data were 18.50, 18.30, 18.00 and 18.40kg for treatments 1, 2, 3, and 4 respectively. The result did not show any significant differences between the treatment groups for initial weight.

4.3.2 Total weight gain

The recorded data for total weight gain indicated that there were significant ($p < 0.001$) differences between the various treatment groups. The highest weight gain was recorded in treatment three (3), this was followed by treatment two (2) and four (4) respectively while the least value was recorded in the control group.

4.3.3 Supplement intake

The result of supplement feed intake which was given only to treatments 2, 3 and 4 showed a significant ($p < 0.001$) differences between the treatment groups. The highest intake was recorded in treatment four (4) followed by treatment two (2) and three (3) respectively while no supplement was provided to the control group.

Table: 19. Growth Performance and Milk Production of Does (F₁ generation) in the study

Parameters	Treatments				SEM
	1	2	3	4	
Initial Weight (kg)	18.500	18.300	18.000	18.400	0.197Ns
Total weight Gain F ₁ (kg)	5.000 ^d	6.825 ^b	8.375 ^a	6.000 ^c	0.174***
Supplement Feed Intake F ₁ (kg)	0.000 ^d	30.923 ^b	30.705 ^c	33.137 ^a	0.022***
Gestation Length (days)	151.500 ^a	151.250 ^{ab}	151.750 ^a	150.750 ^b	0.209*
Puberty Age (days)	255.000 ^a	220.000 ^c	213.750 ^c	240.000 ^b	2.894***
Birth weight F ₂ (kg)	2.500 ^a	2.275 ^b	2.475 ^a	2.013 ^b	0.092**
Twinning rate	0.250	0.750	1.000	0.500	0.220Ns
Milk Yield F ₁ (kg)	46.770	46.680	47.525	43.755	5.290Ns
Total Weight Gain F ₂ (kg)	5.413 ^c	6.150 ^b	7.525 ^a	6.188 ^b	0.05***
Mortality of Kids F ₂	0.250	0.500	0.250	0.000	0.235Ns

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

4.3.4 Gestation length

The number of days it took during pregnancy showed significant ($p < 0.05$) differences between the various treatment groups. The highest number of days was recorded in treatment three (3), this was followed by the control group while the least number of days was recorded in treatment four (4).

4.3.5 Puberty age

The number of days it takes the does to reach maturity age showed that supplementation affected ($p < 0.001$) significantly the different treatment groups. Treatment one (1) or the control group recorded the highest number of days before they mature while the least number of days was recorded in treatment three (3).

4.3.6 Twinning rate

The result obtained from the experiment showed that supplementation does not have any influence on twinning rate. No significant difference was recorded between the different treatment groups. The least rate was recorded in the control group while the highest was recorded in treatment three (3).

4.3.7 Milk yield

The result of these experiment showed that supplementation does not have any influence on milk yield. The highest yield was recorded in treatment three (3), this was followed by the control group and those in treatment two (2) while the least yield was recorded in treatment four (4). It shows that there is no significant difference between the different treatment groups.

4.3.8 Birth weight

The birth weight of F_2 generation showed that there were significant ($p < 0.01$) differences between treatment groups. These indicated that supplementation had effect on birth weight. The highest was recorded in the control group, it was followed by treatment three (3) and two (2) respectively, while the least was recorded in treatment four (4).

4.3.9 Total weight gain of kids

The total weight gain recorded in the F_2 generation showed that there is a significant ($p < 0.001$) difference between the various treatment groups. The highest total weight gain was recorded in treatment three (3), then treatment four (4) and two (2) respectively, while the least value was recorded in the control group.

4.3.10 Mortality of kids

The record of mortality in F₂ generation showed no significant difference between the different treatment groups. The highest mortality rate was recorded in treatment two (2) while this was followed by the control group and treatment three (3) which recorded the same value while the least was recorded in treatment four (4).

4.3.11 Proximate analysis of milk of F₁ generation

The data obtained from the proximate composition of milk of the F₁ generation does during early lactation did not show any significant difference between the treatment groups for PH, total solids, crude protein, fat, lactose and ash as indicated in Table 20.

4.3.11.1 PH values

The total PH recorded were 6.160, 6.178, 6.166 and 6.178 for treatments 1, 2, 3 and 4 respectively. The record did not show any significant difference between the treatment groups during early lactation. The highest value was recorded in treatment two (2) and four (4) respectively and this was followed by treatment three (3) while the least was in treatment one (1).

4.3.11.2 Total solids

This record also did not show any significant difference between the treatment groups. The highest value was recorded in the control group, followed by treatments two (2) and four (4) while the least value was recorded in treatment three (3).

4.3.11.3 Crude protein

The highest crude protein value was recorded in treatment three (3), which was followed by treatment four (4) and then the control group, while the least value were recorded in treatment two (2). The values did not show any significant difference between the treatment groups.

4.3.11.4 Fats

The least fat record was recorded in the control group, while the highest was recorded in treatment 2. The values were 4.105, 4.123, 4.115 and 4.110 for treatments 1, 2, 3 and 4 respectively. The values did not show any significant difference between the treatment means.

Table: 20. Proximate Composition of Milk of F₁ Generation

Parameters	Treatments				SEM
	1	2	3	4	
Early - Lactation					
PH	6.160	6.178	6.166	6.178	0.022Ns
Total Solids	11.685	11.683	11.665	11.675	0.022Ns
Crude Protein	3.220	3.208	3.253	3.240	0.022Ns
Fat	4.105	4.123	4.115	4.110	0.016Ns
Lactose	4.113	4.110	4.123	4.113	0.016Ns
Ash	0.940	0.973	1.020	0.998	0.022Ns
Mid - Lactation					
PH	6.320	6.357	6.330	6.333	0.016Ns
Total Solids	11.570	11.580	11.573	11.603	0.040Ns
Crude Protein	3.410	3.327	3.380 ^{ab}	3.360 ^{ab}	0.018*
Fat	4.610	4.587	4.573	4.600	0.032Ns
Lactose	4.410	4.437	4.393	4.393	0.018Ns
Ash	1.143	1.157	1.217	1.133	0.091Ns
Late - Lactation					
PH	6.200 ^b	6.537 ^a	6.330 ^a	6.333 ^a	0.032*
Total Solids	11.687	11.673	11.677	11.687	0.032Ns
Crude Protein	3.223	3.213	3.247	3.237	0.026Ns
Fat	4.103	4.117	4.120	4.113	0.026Ns
Lactose	4.110	4.117	4.130	4.117	0.026Ns
Ash	0.953	0.963	1.010	0.997	0.026Ns

Means with different superscripts within a row are significantly different

NS – Not Significant

SEM – Standard error of mean

* (P<0.05)

** (P<0.01)

*** (P<0.001)

4.3.11.5 Lactose

Lactose values did not show any significant difference between the various treatment groups. The control group and treatment four (4) had same and intermediate records. The least value was recorded in treatment two (2) while the highest was in treatment three (3).

4.3.11.6 Ash

The ash records were 0.940, 0.973, 1.020 and 0.998 for treatments 1, 2, 3 and 4 respectively. The values did not show any significant difference between the treatment groups. The highest value was recorded in treatment three (3) while the least was recorded in treatment one (1) (control).

Mid-lactation proximate composition showed that significant differences existed only in crude protein level among the treatment groups. While the values for PH, total solids, fat, lactose and ash did not show any significant difference between the treatment groups as shown in Table 20.

4.3.11.7 PH records

The PH values were 6.320, 6.357, 6.330 and 6.333 for treatments 1, 2, 3 and 4 respectively. The values did not show any significant difference between the treatment groups. The highest record was obtained in treatment two (2), while the least value was recorded in the control group.

4.3.11.8 Total solids

The record for total solids also did not show any significant difference between the treatment groups. The highest data was recorded in treatment four (4), followed by treatment two (2) and three (3) while the least was recorded in the control group.

4.3.11.9 Crude protein

Crude protein record showed a significant ($p < 0.05$) difference between the treatment groups. The highest value was recorded in the control group, followed by those in treatment three (3) and four (4) while the least value was recorded in treatment two (2).

4.3.11.10 Fats

Total fat records were 4.610, 4.587, 4.393 and 4.600 for treatments 1, 2, 3 and 4 respectively. The recorded data showed that the different supplements did not have

significant influence on the animals. The highest value was recorded in the control group while the least was recorded in treatment three (3).

4.3.11.11 Lactose

The least lactose value was recorded in treatment three (3) and four (4) while the highest was recorded in treatment two (2). The values did not show any significant difference between the treatment groups.

4.3.11.12 Ash

Ash records during mid-lactation did not show any significant difference between the treatment groups. The highest value was recorded in treatment three (3), followed by treatment 2 and control group while the least was recorded in treatment four (4).

Proximate analysis of milk obtained during late - lactation of F₁ generation does showed a significant difference in PH values only, while the records for total solids, crude protein, fat, lactose and ash did not show any significant difference between the treatment groups.

4.3.11.13 PH Record

The PH values showed a significant ($p < 0.05$) difference between the various treatment groups. The highest value was recorded in treatment two (2), this was followed by treatment four (4) and three (3) while the least was recorded in the control group.

4.3.11.14 Total solids

The recorded data for total solids showed that the different supplements did not show any significant impact on the animals. The least value was recorded in treatment two (2) while the highest value was recorded in treatment four (4) and the control group.

4.3.11.15 Crude protein

The values for crude protein did not show any significant difference between the different treatment groups. the values were 3.223, 3.213, 3.247 and 3.237 for treatments 1, 2, 3 and 4 respectively. The least value was recorded in treatment two (2) while the highest was recorded in treatment three (3).

4.3.11.16 Fats

The fat values also did not show any significant difference between the different treatment groups. The highest value was recorded in treatment three (3), followed by

treatment two (2) and four (4) while the least value was recorded in the control group.

4.3.11.17 *Lactose*

The lactose records were 4.110, 4.117, 4.130 and 4.117 for treatments 1, 2, 3 and 4 respectively. The record did not show any significant difference between the treatment groups. The highest value was recorded in treatment three (3) while the least value was recorded in the control group.

4.3.11.18 *Ash*

Ash values did not show any significant difference between the treatment groups. The highest value was recorded in treatment three (3), followed by treatment four (4) and two (2) while the least value was recorded in the control group.

CHAPTER FIVE

DISCUSSION

5.1 Assessment of milk production potential of dairy goats in Adamawa state

5.1.1 Socio-economic characteristics of respondents in the study area

Some percentage of farmers in the study area used goat milk for feeding infants and also for treating some diseases is in agreement with the earlier report of Eniolorunda and Apata (2012) that milk is a complete food for infants, good supplementing food for people of all ages and essentially protective for the sick and invalids. Goats play an important role in improving the existing low level of protein supply in many developing countries. *Tubercle bacilli* are rare in goats milk and there is also a proportion of smaller fat globules facilitating easy digestion. Goat milk also possess antiallergic properties (Butswat *et al.*, 2002). As an infant food, it is nearly as high in vitamin B₄ and twice vitamin B₁₂ as human milk (Zahraddeen *et al.*, 2007^a). Goat and cow infant formula had a very high digestibility for minerals. Goats milk infant formula provided a pattern of mineral retention very similar to that of the adopted cow milk infant formula (Rutherford *et al.*, 2006). However, Malau-Aduli-*et al.*, (2003) reported that between 40 and 100% patients allergic to cow milk tolerate goats milk, therefore, goat milk have been recommended as a substitute for those who suffer from allergies to cow milk or other food sources. Yoghurt have been associated with tremendous health benefits such as improvement of gastrointestinal functions and disease risk reduction (Olorunnisomo and Odesanmi, 2012). Olorunmisomo and Salau (2012) also observed that consumption of probiotic bacteria via dairy products is a way to re-establish the intestinal micro flora balance. Mohammad (2012) also reported that goat milk is nutritious, has therapeutic value and has been reported to be consumed in a lot of places around the world.

5.1.2 Reasons for the dislike of goats milk

Respondent reasons for non-consumption of goats milk are tradition of the responded in the study area (58.29%), low milk yield from the goats (15.17%), odour of the milk (17.54%) and general body discomfort or ill-health (9.00%). As reported by Otaru (2002) milk is very important in human diets as a source of protein, but it is still absent in the diets of most Nigerians, because the quantity produced and supplied to the

market is grossly inadequate due to the fact that cattle are the predominant source of milk available in the market. However, goats also produce some considerable quantities of milk which vary from 1.02-3.8kg/animal/day among some foreign breeds and 0.4 – 1.0kg/animal/day among the indigenous breeds. Despite the low yield it can still provide the populace with cheap source of milk, but one problem to content with is the lingering apathy towards consuming goat milk. Mohammad (2012) also observed that, goat milk despite being nutritious and has therapeutic values, is still yet to be nationally acceptable for consumption in Nigeria, the milk which is produced over the lactating period of 120 days is rarely consumed. He reported that 89% of respondents interviewed in Minna (Nigeria) did not consume goat milk. While most people who consumed it (92%) did so occasionally. Unavailability and unawareness were the most important factors affecting goats milk consumption in the study area. This report also agrees with the report of Butswat *et al.*, (2002) which states that goats in Nigeria are kept mainly for meat production, their milk is rarely consumed by humans. They also reported that countries like Iraq and Libya obtained half of their milk requirement from goats. It also tallies with the report of Zaraddeen *et al.*, (2007^a) that in Nigeria, the indigenous cattle have been the major source of domestic meat and milk supply while milk supply from sheep, goats and camels is negligible.

5.1.3. Breeds of goats reared in the study area and reasons of goat keeping

The outcome of the experiment shows that 67.9% of the farmers in the study area kept Sokoto red goats, while 6.25% of them kept Sahel goats. Other breeds which comprises the crosses between the different breeds found in the study area made up 25.83%. This agrees with the report of Okonkwo *et al.*, (2011) which stated that three distinct groups of goats are found in Nigeria and each has its unique utility. The west African Dwarf goats is known for her resistance to trypanosomiasis and tolerance to harsh environmental conditions, the red Sokoto breed is distinct for her excellent meat and milk yields, high quality skin and twinning ability while the Sahel breed is characterized by high prolificacy, multiple births and good meat quality but poor meat yield. It also tallies with the report of Oni (2002) and Malau-Aduli *et al.*, (2005) which stated that in Nigeria, the Red Sokoto goats is the most wide-spread and well known breed of goats with the largest population of approximately 50% of the total goat

population of the country. Environmental factors have little influence on the body weight of Sahel goat and the breed is generally preferred by pastoralist.

Makun *et al.*, (2008) also reported that in Nigeria goat population is predominantly made up of the Sokoto Red, West African Dwarf and Sahelian breeds of goats. Butswat *et al.*, (2002) also stated that the most commonly used breeds of goats in Nigeria for both milk and meat productions are the red Sokoto and Sahel goats. This report also agrees with the report of Malau-Aduli *et al.*, (2003) which states that the red Sokoto goat is found throughout the sub-humid and semi-arid zones of Nigeria.

Respondents reason for keeping goats in the study area shows that 64.58% of them keep goats for income generation, 12.08% for milk production, 8.75% for meat production, 2.5% for ceremonies and 12.08% for other purposes other than those mentioned above. This agrees with the report of Aina *et al.*, (2012) which reported that more than 80% of sheep and goats in Nigeria are generally raised by poor farmers and that goats have become popular in recent years as a pathway out of poverty. Keeping these animals serve as a means of improving the income and nutrition of rural communities and a way of bringing the rural communities in to commercial marketing system. Gefu, (2002) also stated that goats can be a source of income for the household as well as serve to strengthen social relationship between household and individuals in the community apart from fulfilling the nutrients requirements of household from their milk. But not in conformity with the report of Zahraddeen *et al.*, (2007^a) that goats in the country are kept mainly for meat production. The report of Olafur (2004) also stated that in Europe, in the goat sector the milk has been and still is the main product while meat is secondary in most cases followed by skin and hair. Goats are fewer in Greenland and in Faroe Islands there are no goats at all while there is a strong tradition of goat keeping mainly for milk production in Norway, Switzerland and Austria. However, in South Africa the main reason for keeping goats were for milk, meat and social functions as stated by Collins (2000).

5.1.4 Gender and marital status of respondents

The high percentage of males among the respondents keeping goats in the study area (87.92%) did not compare favourably with the earlier report (Luka, 2012) that more goats were reared as backyard farming by women and children. Otaru (2002) also

reported that goats being friendly animals can be kept and managed by all categories of people including women. CTA (2006) in their report stated that most dairy goats are owned by women thus supplementing their income. Also Spore magazine (2013) reported that countries are beginning to put programmes into place to reverse the decline in indigenous livestock breeds but a new FAO study suggest that initiatives will not be successful if the role of women as keepers of indigenous livestock is ignored. Women are the guardians of livestock diversity. Devendra and McLeroy (1987) in their report also stated that young animals and does in milk that are kept in the village are milked twice a day by women. However, Zahraddeen (2006) reported that majority (92.6%) of goat farmers in Bauchi state were males which compares favourably with this report. The report also showed that majority of the respondents (77.50%) were married while few were divorced (3.75%) and widowed (5.42%). This compares favourably with the findings of Umar and Kazaure (2012^a) that most 90.0% of the respondents in the study area were married. In another report they (Umar and Kazaure, 2012^b) also reported that 95.3% of goat traders in Hadejia were married while widows comprised 1.7% and no divorcee (0.0%). Also Aboki and Alu (2013) reported that among small scale pig farmers in Nassarwa state 60% of them were married while 25% of them were widows/divorced.

5.1.5 Age of respondents and number of goats/household

The high percentage of respondents keeping goats 30.42% were within the age group of 30-35 years which compares favourably with the report of Luka (2012) that people within the age group of 20-40 years could be strong enough to carry out the necessary routine practices required for the healthy growth of animals. It also corresponds with the report of Zahraddeen (2006) which stated that 66.1% of goat farmers in Bauchi were within the ages of 40 years and above. Umar and Kazaure (2012^a) in their report of Yankasa traders in Hadejia stated that respondents within the age of 36-45 years constituted the majority (48.3%) which implied that most of the respondents were in their active stage of life. While in another report of goat traders Umar and Kazaure (2012^b) reported that respondents within the ages of 46-55 years constituted the majority. Aboki and Alu (2013) also reported that majority (55%) of pig farmers in Nassarawa state were within the age of 41-50 years. Respondents within the age of 30-35 years which constitute the majority (30.42%) kept from 5-35 goats/household while those from 42-47

years kept the highest (15-90) goats/household. This is not in agreement with the report of Aboki and Alu (2013) which stated that majority of pig farmers had 6-15 pigs/household. Luka (2012) reported that mean herd structure varied according to location, in Darazo 66.7% of female respondents kept milking goats in the range of 1-5 while male respondents (53.2%) also kept these goats within the same range/household, while in Gamawa female respondents had a flock size of 11-15 goats/household. However, Makun *et al.*, (2008) reported that the flock size of small holder goat farmers in Nigeria was between 3-5 goats/household.

5.1.6 Educational level of respondents

The educational level of respondents in the study area showed that majority (42.9%) of them were illiterates. This report agrees with the findings of Luka (2012) that bulk of goat farmers (59.6%) in Bauchi had no formal education, Zahraddeen (2006) stated that (70.87%) of goat farmers in Bauchi had Quranic education, Umar and Kazaure (2012^a) reported a 65.0% sheep traders in Jigawa state without formal education and 78.3% of goats traders in same state without formal education, while Aboki and Alu (2013) stated that 27.5% of pig farmers in Nasarawa state were illiterates and 35% had primary education, 22.5% had secondary education and 15% had tertiary education.

5.1.7 Systems of goats management

The different management systems adopted by most of the farmers in the study area showed that majority (40.24%) of the respondents used the free range system which was followed by village herding (30%) system, cut and carry (15.42%) and tethering (14.17%). This compares favourably with the report of Makun *et al.*, (2008) who reported that in West Africa, traditional goat production is characterized by free roaming in the day and tethering at night or during cropping season. Aganga *et al.*, (2005) also reported that goat rearing was an integral part of the extensive farming system in Botswana, where 70% of goat farmers relied solely on natural range as a source of feed for their goats. Also in another report Malau-Aduli *et al.*, (2004) stated that majority of small ruminant farmers in Nigeria practiced the extensive system of management which does not make provision for adequate feeding. However, Zahraddeen *et al.*, (2010) stated that in traditional husbandry system no special care is given to breeding stock and this has resulted in reduced productivity. While the report of Akhmad *et al.*, (2003) did not

tally with this report, where they stated that in Indonesia, the common production system for small ruminants are cut and carry where forage and other feeds are brought to a continuously housed animals and grazing under tree crops, along road sides in temporarily idle crop lands. Olafur (2004) also reported that goat production in northern European countries are under strong climatic influence (low temperature and high precipitation). Housing and indoor feeding is required throughout the winter in all Nordic and Alpine regions due to snow and frost for several months of the year.

5.1.8 Respondents level of experience and source of labour

The level of experience of respondents rearing goats in the study area shows that those that kept goats for 11-16 years (35.83) constituted the majority, followed by those that Kept goats between 6-10 years (29.58%), then 17-26 years (14.17%), 1-5 years (10.83%) and above 26 years (9.58%). This did not correspond with the findings of Mahanjana and Cronje (2000) who reported that in Eastern cape region of south Africa majority of goat owners had either been farming with goats for more than 20 years (41%) or less than 10 years (43%) while only 16% of respondents fell in to the intermediate 10-20 years category. However, it corresponds with report of Umar and Kazaure (2012^b) who stated that in Hadejia, most (65.0%) of the respondents had goat trading experience of more than 11 years, while in another report, Umar and Kajaure (2012^a) reported that 45% of sheep marketers in the same area had about 4-7 years of experience and constituted the majority. Family labour constituted the majority (60.84%) source of labour in the study area, while hired labour made up 39.17% of the respondents. This compares favourably with the report of Devendra and McLeroy (1987) who reported that in India goats were taken from the camps by young boys to graze by the day and brought at dusk to the shelter to protect them from predators or to hired shepherds when the herds were larger. Eniolorunda *et al.*, (2012) also reported that goats can be managed effectively on small scale by members of the family. Similarly in a report of Collins (2000), 80% of goat farmers in the North west province of south Africa did not reserve particular pasture for goats and goats were not herded but were allowed to roam freely with no or little cost of labour. Devendra (1980^a) also reported that goats were cared for by women and children and required only limited resources for labour. Makun *et al.*, (2008) reported that in West Africa traditional goat production is characterized by free

roaming in the day and tethering at night or during cropping season. Devendra and Burns (1995) also reported that labour and supervision cost for goats amounted to 40-48% of the total cost of goat production. Thus, labour is a major cost in all systems if family labour is counted. Extensive system are most appropriate where large areas of pasture can provide grazing and browse for goats with minimum labour by using family labour and no problem of milk distribution.

5.1.9 Frequency of milking, processing and mode of processing by respondents

The daily milking frequency of dairy goat farmers in the study area showed that majority (51.73%) of the farmers milked their animals twice (morning and evening) a day. This was followed by once (20.69%) a day, thrice (17.24%) and more than three times (10.34%) a day. This correspond with the report of Malau-Aduli *et al.*, (2003) who stated that the two halves of the udder of lactating doe were hand-milked early in the morning and in the evenings. Also Alphonsus *et al.*, (2012) reported that milking was done twice daily and the milk yield was recorded at every milking in cows. While Sanusi *et al.*, (2012) in their findings stated that cattle were hand milked twice daily in Gujba, Yobe state. However, the report of Eniolorunda and Apata (2012) is that milking was done only once in the morning after calves were used to stimulate milk let down in Ogun state. Ajibola *et al.*, (2012) also stated that milking of Zebu cows in Vom is done once between the hours of 7:00a.m. – 8:00a.m. Findings of Mahanjana and Cronje (2000) also revealed that goat farmers in south Africa milked their goats only once daily. Butswat *et al.*, (2002) and Zahraddeen *et al.*, (2008^a) stated that milking in does is done once in the morning daily. The result of the analysis showed that 65.52% of the farmers processed the milk after milking, while 57.89 of them processed the milk in to yoghurt (kindirmo). This conform with the findings of Otaru (2002) who stated that after milking, the milk must be pasteurized first before being processed into other milk products such as yoghurt, butter and cream or cheese. Luka (2012) also reported that milk is processed into yoghurt, butter and cream in Bauchi. Olorunnisomo and Salau (2012) in their report stated that fermentation (yoghurt) of milk ensures not only increased shelf life and microbial safety but also makes food more digestible. In another report Olorunnisomo and Odesanmi (2012) stated that yoghurt contains the essential nutrients for humans of all ages, ensure shelf life of milk, improve gastrointestinal functions, reduce disease risk while

sweeteners are also added to improve flavor of the soured milk. Thomas and Robert (2012) reported that goat's milk can be processed into numerous value-added cheeses and the amount of milk needed to produce each product depends primarily on the fat content of the milk. However, Devendra and McLeroy (1987) stated that there is limited processing of goat milk in the tropics, goats are milked by hand and the milk is used for domestic consumption or distributed for sale locally. Cheese making is conducted in Mexico and India, in Venezuela goat milk is mixed with cow milk to produce mixed cheese, while occasionally butter and ghee are produced from goat's milk in India and Bangladesh.

5.1.10. Problems of goat farming

Majority (40.42%) of farmers in the study area indicated that lack of feed had impeded goat production, this was followed by diseases (23.33%), lack of extension service (14.58%), conflict (12.50%) and lastly automobiles accidents (9.17%). This conforms with the reports of Ahemen *et al.*, (2012) who stated that feeding cost constituted about 80% of the total cost of intensive livestock production. Agbanah *et al.*, (2012) reported that feed is an important component in livestock production and its high cost is a major constraint to animal production in Nigeria. Yusuf *et al.*, (2012) stated that the constraint to livestock production in Nigeria are unavailability of adequate quantity and quality feed as roughages do not support optimal growth due to low protein and energy levels. Malau-Aduli *et al.*, (2003) also stated that supplementary feeding in the dry season is likely to have great impact on nutritional deficiencies observed in tropical animals which improve its growth rate and enable it to produce optimum level of good quality semen at the earliest possible age since onset of puberty is more closely related to body weight than age. Lakpini (2002^a) stated that feeding forms the largest component of cost of livestock production and the skill in increasing the profit margin depends on how well nutrient requirements are met at least cost. The report of Devendra (1980^a) also stated that inadequate nutrition is by far the most important factor responsible for low productivity of dairy goats in the caribbean, another problem of continuing concern is that of animal health and disease. In Bangladesh, mortality was 82% in kids and 48% in adults, of the causes 36-44% of the deaths were due to respiratory diseases and 25-44% due to gastrointestinal parasites, while in Sri Lanka kid mortality from 2340 pregnancies

was 28%, and in West Indies, internal parasites and infectious agalactic diseases have been identified as major problem with Alpine goats. Aganga *et al.*, (2005) reported that in Botswana the quality and quantity of forage intake by grazing animals were potential constraints of an efficient production of livestock on range lands and low intake was the most common factor. Non-availability of feed was stated by 50% of respondents as a limiting factor for Tswana goat production, while diseases and parasites accounted for 44.6% of losses, Predators, unknown causes and snake bites accounted for 26.8%, 25.0% and 3.6% respectively. This report also tallies with the findings of Gefu (2002) that many social problems have arisen from the fact that small ruminants, especially goats, have broken into neighbours compounds to eat farm produce or grains left within the compound, in some instances it assumed large proportions to the extent that local community laws are made to restrict animals from within certain limits of the community.

5.1.11 Common diseases of goats encountered in the study area

Most farmers in the study area reported that peste-des-petes ruminant (P.P.R) was the major (51.78%) disease encountered by goat farmers, this was followed by ectoparasites (19.64%), mastitis (17.86%) and endoparasites (10.71%). This compares favourably with the report of Gefu (2002) that there is high morbidity and mortality of goats especially during rainy season where high incidence of PPR and FMD is experienced. Devendra and McLeroy (1987) also stated that diseases and parasites form one of the main constraints to goat production in many parts of the tropics and PPR sometimes called pseudo-rinderpest is a serious virus infection of goats in all parts of the tropics. Mohammed (2002) in his studies on the prevalence and seasonality of diseases of ruminants indicated that helminthiasis, ectoparasitism, PPR, foot rot and polythene bag induced rumen impaction were the major causes of mortality of sheep and goats under traditional agropastoral management in northern and southern Nigeria. Eniolorunda *et al.*, (2012) also reported that mastitis is one of the major disease that affect livestock production, usually affecting lactating animals leading to low milk yield. In another report, Makun *et al.*, (2008) stated that helminthiasis in small ruminants and goats in particular is of considerable importance because it affects production through losses due to mortality and reduced weight gain. Aganga *et al.*, (2005) also reported that diseases are

a limiting factor in goat production in the humid tropics, he reported a 49.2% disease related deaths in Black Bangal kids and adult goats in Bangladesh, while one third of kids died before weaning in Gaborone region in Botswana.

5.2 Effects of different supplements on milk production of sokoto red goats

The proximate analyses of the supplemental feed used in the study indicated that maize offal contained the least dry matter, crude protein, crude fibre, ash and ether extract than cotton seed cake and groundnut haulms. Cotton seed cake has moderate (93.60) dry matter content, the crude protein (29.94), crude fibre (23.50) and ether extract (5.76) content were higher than that of maize bran (1.89) and groundnut haulms (2.06) while the ash content (5.16) was higher than that of maize bran (1.16) but lower than groundnut haulms (2.06). The protein content of maize offal in this study is lower than that by Aduku (1993) who reported 11.9% crude protein but higher (10.08) than that reported by Malau-Aduli *et al.*, (2003), who reported a lower (1.50) crude fibre content, ash (0.80) and ether extract (1.70). Ogundipe (2002) also reported a higher (11.0) crude protein content and a higher ether extract (8.99) content but a lower crude fibre (6.67) content. However Nyako *et al.*, (2012) reported a lower (8.30) crude protein content in maize bran and also a lower crude fibre content (23.9) in cotton seed cake. Yohanna and Halilu (2012) also reported a higher crude protein (14.45) content in maize bran and cotton seed cake (43.3). In another report by Tamburawa and Duru (2012), they reported a lower crude protein and a higher crude fibre content (33.4) in groundnut shell. Aduku (1993) reported a lower crude protein (15.13) content in groundnut hay. The crude protein content of groundnut hay in this study tallies with the report of Malau-Aduli *et al.*, (2003). However, Ogundipe (2002) reported a lower crude protein (7.7) content than in this finding, a lower (0.6) ether extract and a higher (46.2) crude fibre content. Those supplemented with cotton seed cake performed better as a result of better nutritional quality.

5.2.1 Initial weight

The initial weight of the animals in all the different treatment groups did not indicate any variability. The range of values 16.25-16.75kg obtained in the present study compares favourably with the report of Malau-Aduli, (2003) where red Sokoto weaner

bucks of approximately four (4) months were balanced for weight and blocked into seven (7) treatments. In another reported Malau-Aduli (2004) also reported an initial live weight of adult red Sokoto does ranging between 24.6 and 26.4kg were used. Jalo *et al.*, (2009) and Nyako (2009) in their reports, stated that animals were weighed at the beginning of the experiment and subsequently at weekly intervals. Njoku *et al.*, (2012) also reported a similar finding where forty eight (48) weaner large white pigs of eight weeks old with mean body weight of 7.16 ± 0.45 kg were assigned to two treatment groups. This uniformity in age and weight help in producing better results rather than using animals of different ages and weight with different consumption pattern, growth and susceptibility to diseases.

5.2.2 Total weight gain

The average total weight gain of animals across the treatment groups was affected significantly ($p < 0.001$) by the dietary supplements, the weight gain values were 4.750, 5.750, 6.775 and 3.750kg for the different groups 1, 2, 3 and 4 respectively. This observation agreed with the findings of Yahaya *et al.*, (1999) which stated that supplemented animals tended to increase weight compared to non-supplemented animals. Malau-Aduli *et al.*, (2005) also revealed that supplementation had a significant effect ($p < 0.01$) on weight at puberty of weaner does. This finding is also similar to the report of Fajemisin *et al.*, (2012) who observed that average weight gain values varied ($p < 0.05$) from 4.79 to 36.03g when west African Dwarf rams were fed untreated and treated corn cobs. Nyako *et al.*, (2012) also produced a similar report when Yankasa rams were fed Pangola grass supplemented with cotton seed cake, maize bran and brewers waste, the highest weight gain was recorded in the group supplemented with cotton seed cake and the lowest gain was recorded in the control group where only pangola grass was fed. However, the findings of Finangwai *et al.*, (2012) is not similar with this finding where the initial and final weight of West African Dwarf goats fed Acha straw supplemented with ensiled poultry litter in concentrate mixture did not show ($p < 0.05$) any significant difference among the treatment groups and also when groundnut haulms were supplemented to Kano brown bucks. Animals on cotton seed cake supplement recorded the highest weight gain (6.775kg). This might be because cotton seed cake provided the best balance nutrient for growth (Luka, 2012). The lower performance of animals in

group (4) might be due to previous establishment that higher feed intake resulted in a faster rate of passage of digester from the reticulo-rumen which does not allow for effective degradation, hence lowering the digestibility of feed. Increasing the level of crop residue in the diet also increased the amount of lignin which depressed the digestibility of feed, because the rate of microbial colonization of a feed with high fibre content is comparatively lower (Malau-Aduli, *et al.*, 2003). The high total weight gain recorded in the control group is due to the fact that they graze longer than the supplemented groups which either rest under shed or run back to the pen in the afternoon.

5.2.3 Supplement intake

The highest supplement feed intake was recorded in treatment four (4) (34.27kg) which was followed by treatment three (3) and then treatment two (2). It indicated some variability among the different treatment groups ($P < 0.001$). The range of values 30.235kg to 34.27kg reported in this study is lower than the one reported by Malau-Aduli *et al.*, (2003) when Sokoto red bucks were fed natural pasture and *Digitaria smutsii* hay supplemented by crop residue (470g/day). It is also lower than the report of Nyako *et al.*, (2012) when Yankasa rams were fed pangola grass supplemented with cotton seed cake, maize bran and brewers waste where the dry matter intake ranged from 801.77 to 942.6g/day ($P < 0.05$), the high intake of cotton seed cake provided essential nutrients to maintain optimal rumen activity. Areegbe *et al.*, (2012) also reported a lower feed intake that ranged between 130.74-210.37/day when West African Dwarf goats were fed *panicum maximum* as basal diet and four concentrate diets were compounded with cassava hay at different levels to serve as a supplement. However, Finangwai *et al.*, (2012) fed ensiled poultrywaste to West African Dwarf bucks at different levels and Acha straw as a basal diet was used.

5.2.4 Gestation length

The range of gestation (150.50-152.00) recorded in the present study fall within the normal gestation length of goats. This confirms the report of Luka (2012) who reported a gestation length of 145-152 days in Sokoto red goats, and also of Devendra and Marca (1995) who reported a range of 143 to 153 days. However, Devendra and McLeroy (1987) reported a lower gestation length of 146 days. Thomas and Robert (2012) reported an average gestation length in sheep and goats to be 147 days, they also

reported that medium-wooled and meat breeds have shorter gestation length whereas fine-wooled breeds have longer gestation periods. In another finding Zahraddeen *et al.*, (2007^b) reported a gestation length of 145-155 days. Short gestations may be characteristic of small breeds of goats. The causes of variation in gestation length is not known in detail, but on analogy with other species it is probably affected by sex of foetus, parity and other environmental variations especially nutrition and by genetic factors (Devendra and Burns, 1995).

5.2.5 Twinning rate

The values recorded for twinning rate in this study were 0.00, 0.50, 0.500 and 0.00. This shows that the influence of dietary supplements did not have any significant difference on the animals. This report tallies with the report of Collins (2000) who reported that twins comprised 11% and 18% of kids born from village and Boer goats respectively while the remainder were single births. Devendra and Burns (1995) reported that of 338 pregnant goats in India, the incidence of single, twin, triplet and quadruplet pregnancies were 54.8, 39.8, 5.1 and 0.3% respectively. Twinning also occurred in 10-15% of births in East Africa and 30% in Mubende goats in Uganda. Saka *et al.*, (2013) observed that the weaners of single birth had ($p < 0.05$) significantly higher body weight than the twin and triplet weaners. Devendra and McLeroy (1987) also reported that in Malabar goats the proportion of twins and triplet birth increased from 19% in first kidding to 79% in the second and later kiddings. Akhmad *et al.*, (2003) found that litter size increased with parity with largest litter at the fifth parity on goats and sheep in central Mali. Sextuplet is a rare occurrence but has been reported in sheep, cattle, goats and human beings, in humans it has been reported in all continents of the world with the most recent in Afghanistan. In Nigeria it occurred in 2009 (Adeyeye *et al.*, 2012).

5.2.6 Birth weight

The average birth weight recorded in this study were 2.050, 1.613, 1.763 and 1.700kg for treatments 1, 2, 3, and 4 respectively. The differences in birth weight were ($p < 0.001$) significant. This suggests that the lower birth weight recorded is due to the multiple birth recorded in some of the treatment groups. The birth weight recorded in this study compares favourably with the findings of Eniolorunda *et al.*, (2012) who reported a birth weight of 1-4kg in goats. Aganga *et al.*, (2005) also reported an average birth

weight of $3.9 \pm 0.1\text{kg}$ for males and $3.2 \pm 0.2\text{kg}$ for females in Bostwana. Aina *et al.*, (2012) also reported a higher birth weight of 2.20 and 2.92kg in kids and lambs respectively. However, Malau-Aduli *et al.*, (2004) reported a lower birth weight that ranges between 1.07 – 1.4kg when residues were supplemented to pregnant does. Zahraddeen *et al.*, (2008^a) reported that parameters such as litter size, birth weight and growth rate of offsprings from birth to weaning are indices of reproductive performance.

5.2.7 Milk yield

The average values recorded for milk yield in the present study were 35.530, 32.218, 39.263 and 28.433kg for the different treatment groups, which signified no significant differences between the treatment groups. This finding is lower than the report of Otaru (2002) who reported a 0.5 – 1.0kg milk/day in red Sokoto goats, 0.8 – 1.0kg/day for Sahel goats and 0.40kg for West African dwarf goats, and 0.7 – 1.60, 1.2 – 3.20 and 1.02 - 3.80kg for Sudanese Nubia, Angolo-Nubia and Saanen goats. Malau-Aduli *et al.*, (2003) reported a similar finding with the present study (38.4 and 54.5kg) when Sokoto red goats were supplemented with crop residues. In another report Malau-Aduli *et al.*, (2004) recorded a milk yield which ranged between 0.25 – 0.62kg in Sokoto red goats. Zahraddeen *et al.*, (2009) reported a 207.74, 188.27 and 168.63ml partial daily milk yield in Sahel goats, red Sokoto goats and West African dwarf goats respectively and milk yield increases with increased in parity number and was highest in the third parity and does with single birth had lower milk than does that kidded twins. In another report Butswat *et al.*, (2002) recorded a mean milk yield of 46.97 and 75.83ml for Sahel and red Sokoto goats respectively and the highest yield was recorded at 4th and 2nd weeks for Sahel and red Sokoto goats respectively. Devendra (1980^a) reported a higher milk yield of 200.1kg in 208 days in Beetal goats in India, 204.5kg in 130 days in Dera Deen Panah goats in Pakistan and 227.3 in 120 days in Kamori goats also of Pakistan. While Devendra and Mcleroy (1987) reported an average milk yield of 160kg over a lactation period of 120 days in Boer goats of South Africa. Mahanjana and Cronje (2000) found out that it is not possible to accurately determine milk yield but gave an estimate of 500ml per day in Eastern cape region of south Africa and the milk was consumed by elderly or by infants and goats milk represent an underutilized source of nutrients that could improve the nutritional and health status of the community. Olafur, (2004) found

out that in northern Europe the milk has been and still is the main product from goats while meat is secondary in most cases, however, goats are much fewer than sheep in all cases and in Greenland and the Faroe Islands there are no goats at all, but in some countries there is a strong tradition of goats kept mainly for milk production in Norway, Switzerland and Austria. Collins, (2000) also reported that the main reasons for keeping goats in the North West province of South Africa were for milk, meat and social functions. In another report by Aganga *et al.*, (2005) who confirmed that although goats are able to produce relatively high milk yield per unit of live weight only 5% of goat farmers milked their goats in the Gaborone Agricultural region in Botswana. According to Morand-Fehr and Sauvant (1980) the addition of hay to a diet of green forages did not improve milk production. This could be the reason for low milk yield in the group supplemented with groundnut hay.

5.2.8. Mortality of kids

Mortality was recorded only in treatments one (1) and two (2). The values recorded were 0.0250 and 0.750 for the two treatment groups respectively. The record showed a significant difference ($p < 0.05$) between the groups while none was recorded in treatment three (3) and four (4). Devendra and Burns (1995) reported that the percentage mortality from birth to three months of age was 55%, thereafter declining rapidly with increasing age. The heaviest mortality occurred during the first 14 days of life. Mortality up to six months old was higher in the colder seasons. Kids mortality was at least twice that of adults. Aganga *et al.*, (2005) found out that one third of Tswana goats in Botswana died before weaning. Most kids that had low birth weights ($< 3.0\text{kg}$) died before weaning, diseases and parasites accounted for 44.6% of deaths while predators, unknown causes and snake bites accounted for 26.8, 25.0 and 3.6% respectively. Singles accounted for 66.1% while twins constituted 33.9% of the kids which died, while more male kids (60.77) died than females (39.3). Mahanjana and Cronje (2000) also reported an annual mortality rate of 7% in the Eastern Cape region of South African goats, adult does accounted for 47% of the deaths and abortions 29%, they opined that the high incidence of abortions may be indicative of inadequate nutrition during the last trimester in pregnancy. In another report, Zahraddeen *et al.*, (2010) in their assessment of reproductive problems in Bauchi among small ruminants that higher cases of abortions

(26%) was recorded in goats as compared to sheep (7.6%) and cattle (19.0%). Akhmad *et al.*, (2003) in their study of reproduction rate of Kacang and Peranakan Etawah goats in Indonesia found out that mortality rate decreased with increasing parity, this may be due to physiological maturity of older does and their ability to provide enough milk for the kids. They also reported an increase in the mortality rate with parity due to an increased rate of twinning as parity increased, but survivability increased gradually with the increase in parity number having the highest survival rate in the 5th parity.

5.2.9. Total weight gain of kids

The values recorded for total weight gain of kids among the different treatment groups were 3.33, 4.90, 5.05 and 4.32kg for treatment 1, 2, 3 and 4 respectively. The highest was recorded in treatment three (3), followed by treatments two (2) and four (4) while the least was recorded in the control group. The findings showed significant ($P < 0.001$) differences between the treatment groups. These findings are higher than those reported by Oduguwa *et al.*, (2012) when West African Dwarf goats were fed varying levels of Pineapple and cassava peels, the values were 1.9, 1.8, 1.1 and 0.7kg for treatments 1, 2, 3 and 4 respectively. The present finding is also higher than the findings of Aina *et al.*, (2012) when unsupplemented West African Dwarf kids had an average daily weight gain of 41.19g. Aduku (1993) also reported a daily weight gain of 170g for Nigerian goats. Malau Aduli *et al.*, 2003 in their findings on Sokoto red goats when fed crop residue based supplements recorded the highest weight gain of 2.75kg. In another finding Adedeji *et al.*, (2013) recorded a total weight gain of 2.08, 2.79, 3.29 and 3.02kg when West African Dwarf goats were fed diets containing processed wild cocoyam urea meal. The findings from the present study proves that the animals were well selected and cared for.

5.2.10. Proximate composition of milk (first parity)

The proximate analysis of the milk obtained from the does during early lactation of first parity did not show any significant difference between the treatment groups for all the parameters measured. During mid lactation also there was no significant difference between all the treatment groups for most of the parameters measured except for ash ($P < 0.05$). The least value was recorded in the control group while the highest value was recorded in treatment two (2). However, the result of the proximate analysis of the milk

during late lactation did not show any significant difference for pH, total solids and crude protein only. Values for fats showed a significant difference ($P < 0.05$) between the groups. The highest values were recorded in treatment three (3), while the least value was recorded in treatment four (4). Lactose values also showed a significant difference ($P < 0.01$) among the treatment groups. The least value was obtained from the control group while the highest value was recorded in group three (3). The result for ash also showed a significant difference ($P < 0.001$) between the treatment groups, the highest value was recorded also in treatment three (3) while the least value was recorded in the control group. According to the report of Chillard *et al.*, (2003) milk fat content is high after parturition and then declines during the major part of lactation in goats, which is due to dilution effect as a result of increase in the volume of milk until peak lactation.

In four early lactation trials, lipid supplementation tended to increase milk yield from + 0.1 to + 0.4kg/day and fat content from +2 to +7/g/kg. They also found that feeding fat supplements to mid or late lactation goats did not increase milk yield while milk fat content always increased sharply. Zahraddeen *et al.*, (2007^a) also reported that crude protein in goat milk was significantly ($P < 0.001$) affected by stage of lactation, it decreases with advancing lactation which does not agree with the present finding. Like crude protein, fat content also decreases as lactation progressed, while it increases with increase in parity level. There is no significant effect of stage of lactation and parity level on total solids, ash and pH of the milk. They also reported a significant ($P < 0.001$) decrease in lactose as lactation progressed, while it increases significantly ($p < 0.001$) with increase in the parity number. In another finding by Malau-Aduli *et al.*, (2003) when they fed crop residue based supplements to Sokoto red goats, found out that milk from does fed crop residue supplements contained the highest percentage of fat, protein, total solids and solid not fat while milk from does on the unsupplemented group ranked the least with respect to all parameters studied. Rutherford *et al.*, (2006) in their study on piglets fed cow and goat milk infant formula found out that the largest differences were observed for calcium which was 30% higher in the goat milk and for iron which was approximately 23% higher in cow milk. Morand-Fehr and Sauvant, (1980) found out that milk production was improved by 20% by the diet high in concentrate, milk fat content were slightly lower while protein and lactose contents higher. When energy concentrations of

concentrate mixtures were raised during mid-lactation by replacing feeds high in crude fibre with feeds higher in starch, milk production and composition (milk fat, protein and fatty acid composition) changed a little, but fat reserves increased.

5.2.11 Second parity

5.2.12 Supplementary feed intake

The supplementary feed intakes were 31.090, 30.798 and 32.228kg for treatment 2, 3 and 4 respectively, while no supplement was provided to the control group. Feed intake was significantly affected ($p < 0.001$) by the dietary treatments. Aduku, (1993) reported that goats should consume 1.53% of their live weight per day. Lakpini (2002^b) also observed that pregnant or lactating does can be fed roughage as in breeding males and dry females and be supplemented with 300-500g of cereal by products or sundried deep liter poultry waste. The present study is similar with the finding of Devendra and Burns, (1995) who reported that in the tropics goats fed to appetite have daily dry matter intake of 1.8 – 4.7% of their body weight, equivalent to 40.5 – 131.1g/kg body weight daily. The dry matter intake also depends on whether the forage is fed alone or with concentrates and supplementation of low protein forages with high protein concentrates has a greater effect on intake than on digestibility. Yashim *et al.*, (2013) reported a lower supplement feed intake that ranged between 12.08 – 16.62kg when different levels of sundried *Gmelina arborea* leaves were supplemented to red Sokoto bucks. Oloche *et al.*, (2013) also reported a lower concentrate feed intake of 191.17 – 191.60g/day when west African Dwarf goats were fed shea butter leaves supplemented with varying levels of sweet orange peel meal.

5.2.13 Birth weight

The birth weight of kids in the second parity vary significantly ($p < 0.05$) between the different supplemental groups. The least birth weight was recorded in the control group which is due to twinning rate and lack of supplementation, while the highest birth weight was recorded in treatment three (3) which was the best supplement. This report is similar with the findings of Luka (2012) who reported a birth weight that ranges between 1.58 – 1.90kg in Sokoto red goats. Eniolorunda *et al.*, (2012) also produced a similar report of 1 - 5kg birth weight in sheep and 1 – 4kg as birth weight in goats. However, Devendra and Burns (1995) reported a higher birth weight of 3.7 and 3.3kg in singles and

twins birth of male Alpine goats in India and 3.6 and 3.0 in single and twins female goats respectively.

5.2.14 Kidding interval

Kidding interval vary significantly ($p < 0.01$) between the various treatment groups. The highest was recorded in the control group, followed by treatments four (4), two (2) and the least was recorded in treatment 3. This is because, inadequate nutrient intake delays the onset of puberty and return of estrous cycle after kidding. Kidding interval composed of the service period and the gestation periods since gestation length differences are small, the service period is the most important determinant of kidding interval. Akhmad *et al.*, (2003) observed that kidding interval was responsible for a decrease in productivity of goats, they reported that parity significantly affected kidding interval of Kacang and Peranakan Etawah goats in Indonesia which generally decreased with parity till the 4th parity. The kidding interval of Kachang goats in the 1st, 2nd, 3rd, 4th, 5th and 6th parities were 271, 262, 243, 217, 223 and 239 days respectively, while the kidding interval of Peranakan Etawah goats in the 1st, 2nd, 3rd, 4th and 5th parities were 334, 312, 301, 278 and 291 days respectively, both proved to be higher than the present study. Zahraddeen *et al.*, (2007^b) in their study of kidding interval of goats in Bauchi also recorded a higher kidding interval of 253.7, 294.5 and 251.9 days for Red Sokoto, Sahel and West African Dwarf goats respectively and a kidding interval of 262.7 and 270.7 days in dry and wet seasons respectively. However, Devendra and McLeroy, (1987) reported a kidding interval for indigenous breeds of goats in the tropics to be 90 – 150 days while for European breeds imported into the same hot environment to be 169 – 327 days. The findings from the tropical breeds are shorter than the one obtained from the present study. Devendra and Burns (1995) also reported a higher kidding interval of 335 days in Anglo Nubian goats in India, 332.4 days in Maradi goats in Niger and 365 days in Zairaiby goats in Egypt than in the present study.

5.2.15 Gestation length

The lengths of gestation were 148.50, 149.25, 149.24 and 150.25 days for treatment 1, 2, 3 and 4 respectively. This shows that it varied significantly ($p < 0.01$) among the different treatment groups. The present finding conforms favourably with the report of Eniolorunda *et al.*, (2012) who reported a gestation length of 145 -150 days for

goats. Zahraddeen *et al.*, (2007^b) also reported a gestation length of 149.4, 148.6 and 147.30 days for Sahel goats, Red Sokoto goats and west African dwarf goats respectively. While Devendra and Burns (1995) observed an average gestation length of 145 days in Black Bengal goats in India and a lower gestation length of 141.3 days in west African Dwarf goats. The differences in gestation length is probably affected by the sex of foetus, parity and other environmental variations, particularly nutrition and by genetic factors.

5.2.16 Twinning rate

The records for twinning are 0.75, 1.00, 1.00 and 0.75 in treatments 1, 2, 3 and 4 respectively. This shows that supplementation does not affect twinning in second parity. Devendra and McLeroy (1987) reported in an Egyptian study of Angora does born as single or twin showed a difference in the age of first estrous; single kids started at 194.4 days and 13.1kg live weight and twin kids started at 296.5 days and 13.5kg live weight. This shows that single kids matures earlier as a result of lack of competition during breast feeding. In another report by Eniolorunda *et al.*, (2012) stated that the feeding regime in does should be improved in order to induce super ovulation that lead to multiple births since litter size in goats ranges from 1 - 4 kids. Devendra and Burns (1995) reported that twinning occurred in 30% of Mubende goats birth in Uganda, small goats of the lower Congo usually produce twins twice a year, in Ghana the west African Dwarf goats in their annual kiddings produced 32.1% singles, 55.9% twins, 13.1% triplet and 1.3% quadruplets and in local goats in Ethiopia 14 does produced twins and 7 had single kids in a group of 21 does.

5.2.17 Milk yield

In the second parity also milk yield is not affected by supplementation. The yields were 42.588, 38.758, 46.708 and 33.605kg for treatments 1, 2, 3 and 4 respectively. The finding is higher than that of Luka (2012) who reported a milk yield of 0.1, 0.5, 0.2 and 0.3kg for treatments 1, 2, 3 and 4 respectively when Sokoto red goats were supplemented with different protein and energy levels. The present study is lower than the findings of Malau-Aduli *et al.*, (2003) who reported a daily milk yield which ranged between 0.25 - 0.62kg when Sokoto Red goats were fed crop residue based supplements in Nigeria. This showed that apart from feeding, selection also play a role in improving milk production.

5.2.18 Weight gain of kids

The total weight gain of kids reproduced in the second parity showed a significant difference ($p < 0.001$) between the different treatment groups. The least weight gain of the kids was recorded in the control group while the highest value was observed in treatment three (3). This shows that lack of supplementation affect kids growth while supplementation support kids growth. The records obtained were 5.85, 6.03, 6.81 and 6.01kg for treatments 1, 2, 3 and 4 respectively. This is higher than the findings of Jalo *et al.*, (2009) when Sokoto Red goats were fed *Ficus sycomorus* supplemented with graded levels of sugar cane peels, they recorded weight changes of 2.09, 2.37, 2.15 and 3.97kg for the different treatment groups. Malau-Aduli *et al.*, (2003) also reported a growth rate that ranged between 5.90 – 6.75, 6.20 – 8.00 and 7.50 – 10.20kg at 5, 6 and 7 months respectively when Sokoto Red bucks were supplemented with crop residues. While in another finding Malau-Aduli *et al.*, (2005) observed a daily growth rate that ranged between 20.0 ± 10.2 – 120 ± 10.2 g in Sokoto Red goats.

5.2.19 Mortality of kids

The mortality recorded in the second parity were 0.050, 0.25, 0.25 and 0.25 for treatments 1, 2, 3 and 4 respectively and it did not show any significant difference between the treatment groups. The control group recorded the highest mortality rate possibly due to poor nutrition. This report is higher than the findings of Adedeji *et al.*, (2013) when West African Dwarf goats were fed diets containing processed wild cocoyam ureal meal where they recorded no mortality in all the treatment groups. Aganga *et al.*, (2005) reported poor mothering ability as a cause of kid mortality within 24-48h of birth. Deaths due to poor mothering ability and hypothermia were recorded on East African kids while 49.2% disease related deaths were recorded in Black Bengal kids and adult goats in Bangladesh. Akhmad *et al.*, (2003) in their study on Kacang and Peranakan Etawah goats under village production system in Indonesia reported that mortality rate decreased with increasing parity which may be due to physiological maturity of older does and their ability to produce enough milk for the kids. However, they also reported an increase in mortality rate with parity due to an increased rate of twinning as parity increased and concluded that the effect of parity was significant but survivability

increased gradually with the increase in parity number having the highest survival rate in the 5th parity.

5.2.20 Proximate composition of milk (second parity)

The result obtained from analysis of milk from goats during second parity during early lactation showed that there was a significant differences between the treatment groups for PH, total solids, crude protein, fats, lactose and ash.

5.2.21 PH values

The highest value for PH was recorded on treatment three (3), followed by treatment two (2) and four (4) while the least value was recorded from the control group. The treatment groups vary ($p < 0.05$) significantly. Morand-Fehr and Sauvart (1980) stated that in early lactation, supply of concentrates improve milk production as during mid-lactation and the effects of concentrates are marked during early lactation and it decreased during late lactation. Zahraddeen *et al.*, (2007^a) reported a PH level of 6.36 during early lactation in goats, which is almost similar with the present finding. However, Eniolorunda and Apata, (2012) reported a higher value of 6.4-6.8 PH on milk from white Fulani cattle in Ogun state.

5.2.22 Total solids

The result for total solids were 11.59, 11.72, 11.88 and 11.68 for treatments 1,2,3 and 4 respectively and it varied significantly among the treatment groups. The least value was recorded from the control group while the highest value was recorded in treatment three (3). The present finding proved that supplementation affects total solid content of the milk. Otaru (2002) reported a higher value of 15.85 and 18.18 total solids in Red Sokoto and West African Dwarf goats. However, Malau-Aduli *et al.*, (2003) observed a value that ranged between 12.33-21.85 when Sokoto Red goats were fed crop residue-based supplements.

5.2.23 Crude protein

The record for crude protein vary significantly ($p < 0.05$) among the treatment groups. It also followed the same trend that the least value was recorded in the control group while the highest value was recorded in treatment three (3). The values were 3.40, 3.50, 3.54 and 3.40 for treatments 1,2,3 and 4 respectively. The result showed that supplementation especially with good supplements affects milk protein. This finding is

lower than the findings of Otaru (2002) who reported a protein level of 4.74 and 5.30 for Red Sokoto and West African Dwarf goat milk. While the findings of Zahraddeen *et al.*, (2007^b) is almost similar with the present finding. They reported a milk protein level of 3.66 during early lactation in goat milk.

5.2.24 Fats

Observed values for fats in the present study were 4.68, 4.65, 4.72 and 4.60 for treatments 1,2,3 and 4 respectively, and it showed that supplementation affects significantly ($p<0.001$) the fat content of goats milk during early lactation. The least value was recorded in treatment four (4) while the highest value was recorded in treatment three (3). Morand-Fehr and Sauvant (1980) reported that lipid contents of concentrates may influence milk production and milk fat content may be influenced by lipid contents of concentrates. Low lipid contents ($<1\%$ dry matter) in the total ration reduced milk production and milk fat percentages and they reported a lower fat content of 2.99 and 2.78 for low energy and high energy concentration on goats milk. While Zahraddeen *et al.*, (2007^a) reported a higher value of 4.97% fats in goats milk during early lactation.

5.2.25 Lactose

The result of milk analysis showed that lactose contents of the milk during early lactation showed a significant ($p<0.001$) difference between the treatment groups. The highest value was recorded in treatment three (3) while the least value was recorded in the control group. Devendra (1980^a) recorded a similar finding of 4.77% lactose in Sokoto Red goats milk and 4.76% for Barbari goats in India. Otaru, (2002) also reported a similar lactose value of 4.77, in Sokoto Red goats milk and a higher value of 5.19% in West African Dwarf goats. Zahraddeen *et al.*, (2007^a) also observed a similar value of 4.72% lactose during early lactation in indigenous goats in Nigeria.

5.2.26 Ash

The values for ash were 1.10,1.21.1.26 and 1.11 for treatment 1,2,3 and 4 respectively. They vary significantly ($p<0.01$) among the treatment groups. The highest value was recorded in treatment three (3) while the least was recorded from the control group. Malau-Aduli *et al.*, (2003) reported a lower ash value that ranges between 0.75-0.83% from goats milk supplemented with crop residue. Morand-Fehr and Sauvant

(1980) observed that no information seems available on effects of minerals and vitamins on composition of goat milk and its mineral and vitamin contents. Devendra (1980^b) also found out that mineral information on goat milk is limited, he reported that sodium and potassium content appear to be higher in goat milk than in buffalo milk but are comparable to cow milk and reported a lower ash content of 0.85% in goats milk. Rutherford *et al.*, (2006) observed an apparent absorption of minerals present in goats milk when fed to three week old piglets is 96.2%.

5.2.27. Mid lactation

Differences exist between the treatment groups for total solids, crude protein lactose and ash while no difference existed between the treatments for PH and fats.

5.2.28. PH values

The PH values during mid-lactation were 6.36, 6.38, 6.39 and 6.36 for treatments 1, 2, 3 and 4 respectively. The result did not show any significant difference between the treatment groups. Morand-Fehr and Sauvant (1980) observed that like during late gestation, feeding during early lactation affects milk production during the first weeks of lactation and during mid lactation. Olorunnisomo and Salau (2012) reported a lower PH value of 5.275 and 5.243 for sweetened and 10% banana enhanced yogurt.

5.2.29. Total solids

The result showed that there is a significant ($p < 0.01$) difference between the treatment groups for total solids. The least value was recorded in the control group while the highest was recorded in treatment two (2). The values were 11.64, 11.90, 11.84 and 11.64 for treatments 1, 2, 3 and 4 respectively. This compares favourably with the findings of Zahraddeen *et al.*, (2007^a) who reported a value of 11.51 for goats milk during mid lactation. While Otaru (2002) observed a higher total solid value of 15.85 for Red Sokoto goats milk. Devendra (1980^a) also observed a higher value of 15.71 for south African Boer goats and similar value with present finding of 11.50m in British Alpine in west indies.

5.2.30. Crude protein

The crude protein values showed a significant ($p < 0.05$) difference between the treatment groups. The values obtained were 3.42, 3.53, 3.42 and 3.40 for treatments 1, 2, 3 and 4 respectively. These findings were lower than the report of Alphonsus *et al.*,

(2012) who reported a crude protein content from Friesian crossed with Bunaji cows to be 4.38 during 31 – 60 days lactation period. Zahraddeen *et al.*, (2007^a) reported a lower value of 3.38 during mid-lactation in goats. While Malau-Aduli *et al.*, (2003) reported a protein level that ranged between 3.25 – 6.67 on Sokoto Red goats that received different crop residue based supplements. Devendra (1980^a) also observed a higher finding of 4.74 protein in milk of Sokoto Red goats in Nigeria and a lower value of 2.89 in British Alpine goats in west indies.

5.2.31 Fats

The findings did not show any significant difference between the treatment groups for fat level in goats milk during mid-lactation. The highest value of 4.75 was obtained from treatment two (2) while the least value of 4.66 was obtained from the control group. Alphonsus *et al.*, (2012) reported a lower fat level of 4.50 during mid-lactation in cattle. While Zahraddeen *et al.*, (2007^a) recorded a similar finding with the present study, they reported a fat level of 4.62 during mid-lactation in goats. Otaru (2002) reported a fat level of 5.32 and 7.78 in Sokoto Red goats and west African Dwarf goats respectively. While Morand-Fehr and Sauvant (1980) observed a fat content of milk of 4.10 and 4.44 when goats were fed high and low feed respectively before parturition. Devendra (1980^b) also observed a similar finding with the present study of 4.60 fat level in Jamnapari goats in India. Chilliard *et al.*, (2003) stated that lipid composition of milk is one of the most important components of the technological and nutritional quality of milk, it is involved in chesse yield, firmness, colour and flavour of caprine dairy products. They also stated that milk fat content is high after parturition and then decreases during the major part of lactation in goats which is due to dilution effect as a result of increase in milk volume and decrease in fat mobilization for mammary lipid synthesis.

5.2.32 Lactose

The record for lactose during mid-lactation showed a significant difference ($p < 0.01$) between the treatment groups. The records were 4.39, 4.51, 4.70 and 4.58 for treatment 1, 2, 3 and 4 respectively. This is similar to findings of Otaru (2002) who reported a lactose contents of 4.77 in the milk of Red Sokoto goats. Devendra (1980^a) also reported a similar finding of 4.56 in Saanen goats milk in Nigeria and a higher

values of 6.12 lactose content in Boer goats in South Africa. Alphonsus *et al.*, (2012) in their findings reported a lactose level of 4.49 which also tallies with the present finding during mid-lactation in cows.

5.2.33. Ash

The ash record obtained from milk during mid-lactation were 1.23, 1.22, 1.30 and 1.14 for treatment 1, 2, 3 and 4 respectively. The records showed a significant ($p < 0.05$) difference between the treatment groups. These results are higher than the findings of Malau-Aduli *et al.*, (2003) who reported ash content values that ranged between 0.76-0.83 in Red Sokoto goats in Nigeria. Zahraddeen *et al.*, (2007^a) recorded a lower ash content of 1.12 than the present study during mid-lactation in goats milk. While Olorunnisomo and Odesanmi (2012) reported a mineral content of 4.77 magnesium, and 131.67 calcium (mg/100g) in plain yogurt. Devendra (1980^b) also reported an ash content of 0.78 in Red Sokoto goats in Nigeria and is lower than the present findings.

5.2.34 Late lactation

The result of milk analysis showed that significant differences existed between treatment groups for PH, total solids, crude protein, fat, lactose and ash during late lactation.

5.2.35 PH values

The records for PH values were 6.32, 6.37, 6.41 and 6.35 for treatments 1, 2, 3 and 4 respectively. The result showed a significant difference ($p < 0.05$) between the treatment groups. Zahraddeen *et al.*, (2006) reported a lower value of 6.11 in goats milk during late lactation. However, Olorunnisomo and Salau (2012) reported a lower PH value of 5.27 in yoghurt and 5.18 in 10% sweet orange enhanced yoghurt. Eniolorunda and Apata (2012) stated that these attribute of milk can be altered by the type and number of micro-organisms in the milk and are affected by specie, equipment, cleanliness, season, feed and health status of the animal.

5.2.36 Total solids

The record for total solids showed that supplementation affect it and there is a significant difference ($p < 0.05$) between the treatment groups. The least value of 11.59 was recorded from the control group while the highest value of 11.88 was recorded in treatment three (3). These compares favourably with the findings of Zahraddeen *et al.*,

(2007^a) who recorded a value of 11.61 total solids during late lactation in goats. While Devendra (1980^b) reported a lower value of 7.39 in Malabar goats in India and 11.00 in British Alpine in west Indies. While Devendra and Burns (1995) observed a higher value of 19.8 in west African Dwarf goats in Nigeria, they further stated that there appears to be the tendency for the milk of tropical goat breeds to be higher in total solids, mainly due to higher fat and protein contents while within a breed and also within lactations, total solids tend to be inversely related to milk yield.

5.2.37 Crude protein

The crude protein level in the milk of goats in this study during late lactation showed a significant difference between the treatment groups. The values were 3.40, 3.50, 3.54 and 3.40 for treatments 1, 2, 3 and 4 respectively. The finding is lower than the report of Ensminger (1983) who reported a protein content of 4.4 in goats. While Malau-Aduli *et al.*, (2003) recorded a protein level that ranged between 3.25 – 6.67 in Sokoto Red goats receiving different crop residue supplements. Devendra and Burns (1995) reported a higher value of 5.8 protein level in Black Bengal goats in India and a lower value of 2.79 protein in Black Bedouin in Israel. They also reported that Saanen goats in Nigeria produced milk lower in protein content than is characteristic of these breed in temperate countries and they pointed out that the low value may be due to nutritional deficiencies arising from an insufficient intake of dry matter.

5.2.38 Fats

The fat value also vary significantly ($p < 0.001$) between the different groups. The values were 4.68, 4.52, 4.79 and 4.49 for treatments 1, 2, 3 and 4 respectively. This study is higher than the findings of Alphonsus *et al.*, (2012) who reported a fat level of 4.22 during late lactation in cattle. While Ensminger (1983) recorded a similar fat value with the present study when he reported a fat value of 4.6 in goats milk. Devendra and Burns (1995) reported a higher value of 7.78 fat in west African Dwarf goats in Nigeria and they also reported that percentage of fat, protein, lactose and energy tended to rise with advancing lactation particularly in west African Dwarf goats while in Black Bengals, Barbaris and cross breeds, fat level decreased in the third month of lactation.

5.2.39 Lactose

The result showed that lactose values varied significantly ($p < 0.001$) between the different treatment groups. The highest value of 4.79 was obtained from treatment three (3) while the least value (4.42) was recorded in the control group. This study compares favourably with the findings of Alphonsus *et al.*, (2012) who reported a lactose level of 4.41 during second parity and 4.22 lactose during late lactation in cattle. While a higher value of 7.49 lactose was reported in sweetened yoghurt as reported by Olorunnisomo and Salau (2012). Otaru (2002) also reported a similar value with the present finding of 4.77 and a higher lactose value of 5.19 in Red Sokoto goats and west African Dwarf goats respectively.

5.2.40. Ash

The result of the analysis showed that there is a significant difference ($p < 0.01$) between the treatment groups. The values are 1.10, 1.21, 1.26 and 1.11 for treatments 1, 2, 3 and 4 respectively. This finding is lower than the report of Ensminger (1983) who reported an ash content of 0.8 in goat milk. It is also lower than the findings of Malau-Aduli *et al.*, (2003) who observed an ash value that ranged between 0.76 – 0.83 in Sokoto Red goats. However, Olorunnisomo and Salau (2012) recorded 4.77 and 131.6mg/100g magnesium and calcium in plain yoghurt and also reported that magnesium, calcium and phosphorus were all increased by the inclusion of Amaranthus, garden egg, scent leaf and moringa during storage period. Devendra (1980^b) also reported a lower ash content of 0.89 in South African Boer and 0.78 in red Sokoto goats. He observed that considerable variation occurred in the mineral content of milk from West African Dwarf goats and Sokoto Red which was as a result of variation in stage of lactation and observed a calcium level of 141.8mg/100g and 62.2mg/100g magnesium in the milk of Red Sokoto goats during late lactation.

5.3 Effects of supplementation on milk yield and composition of sokoto red goats

5.3.1 Initial weight of F_1 generation

Before the onset of the experiment, the initial weight of the does intended to be used during the study were recorded. The result of the statistical analysis of the initial weight of the does did not show any significant difference between the treatment groups. The values were 18.30, 18.00 and 18.40kg for treatments 1,2,3 and 4 respectively. Lack of much differences in the initial weight of animals in an experiment will ensure uniform result. Adedeji *et al.*, (2013) recorded an initial weight of 7.24, 7.26, 7.26 and 7.23kg in an experiment to study the growth performance of West African Dwarf goats. Oloche *et al.*, (2013) in their study of performance of West African Dwarf goats using graded levels of sweet orange peels also recorded an initial weight of 6.80, 6.81, 6.77 and 6.77 for treatments 1,2,3 and 4 respectively.

5.3.2 Total weight gain

The result of study showed a significant difference ($p < 0.001$) between the treatment groups. The variation in weight gain occur as a result of supplementation. The highest total weight gain was recorded in treatment three (3) while the least was recorded in the control group. The values recorded were 5.00, 6.82, 8.37 and 6.00 for treatments 1, 2, 3 and 4 respectively. The present study is higher than the findings of Nyako *et al.*, (2012) who reported a live weight gain of 1.8, 3.7, 2.7 and 3.2kg for treatments 1,2,3 and 4 respectively when Yankasa rams were fed pangola grass with different supplements, the highest weight gain was recorded where cotton seed cake was supplemented, because supplementation of protein based supplement improved intake and growth performance. Yashim *et al.*, (2013) also reported a lower weight gain that ranged between 2.35 – 4.87kg on Sokoto Red bucks when *Gmelina arborea* was included in their diet. They observed that the increase in weight gain may be as a result of increased feed intake. Devendra and Burns (1995) reported that nutritional status was found to have a considerable effect on live weight gain, a high plane of nutrition had a significant effect on growth rate with kids on high plane of nutrition reaching 15kg at approximately 20 weeks of age while kids on low plane did not reach this weight until 48 weeks.

5.3.3 Supplement intake

The supplemental feed given showed a significant ($P < 0.001$) difference on intake between the treatment groups. The records were 0.00, 30.92, 30.70 and 33.13kg for treatments 1,2,3 and 4 respectively. The dry matter intake recorded in this study is lower than the findings of Finangwai *et al.*, (2012) who reported a dry matter intake of 410,610 and 470 when West African Dwarf goats were supplemented with different levels, of ensiled poultry litter. Iwuanyanwu *et al.*, (2012) also reported a higher concentrate intake which ranged between 1.74-1.97kg on cattle weaners when they were supplemented with diets containing urea and blood meal. However, Yashim *et al.*, (2013) recorded a lower feed intake of 16.55, 14.70, 16.62 and 12.08kg for treatments 1,2,3 and 4 respectively when different levels of dried *Gmelina arborea* leaves were supplemented to Sokoto Red bucks. Malau-Aduli *et al.*, (2003) reported that supplemented groups had significantly higher dry matter and crude protein intake and digestibility than the unsupplemented group and they also observed that supplementation increased the digestibility of all nutrients. While Devendra and Burns (1995) observed that indigenous goats in the tropics fed to appetite have a daily dry matter intake which ranged between 1.8-4.7% of body weight and lactation increases dry matter intake while high ambient temperatures depress both appetite and productivity.

5.3.4 Gestation length

The length of gestation showed a significant ($p < 0.05$) difference between the different treatment groups. The highest number of days (151.75) was recorded in treatment three (3) while the least was recorded (150.75) in treatment four (4). Devendra and McLeroy (1987) reported a lower gestation length of 146 days in Barbari goats in India, a similar value of 151 days in Toggenburg goats in Brazil and a higher figure of 153 days in Anglo-Nubian goats in Malaysia. They reported that, this variations relate to environmental factors such as ambient temperature, time of the year, breed, size of the goat, sex of kids, litter size and order of birth. While Luka (2012) also reported a similar gestation length that ranged between 145-152 days in Sokoto Red goats.

5.3.5. Puberty age

The result showed that supplementation significantly ($p < 0.001$) affects the maturity period. The records were 255.0, 220.0, 213.75 and 240.0 days. As reported by

Eniolorunda *et al.*, (2012) puberty which is the period of sexual development at which the animal becomes capable of reproduction is influenced by both genetic and environmental factors and ranges between 150-230 days depending on nutrition, location and season of birth. Devendra and Burns (1995) reported that does which had been born as singles had their first heat period at an average age of 194.38 days while those born as twins at 296.50 days and at an average weight of 13.13 and 13.50kg respectively and concluded that age at puberty depended mainly on age and body weight. However, Malau-Aduli *et al.*, (2005) reported a lower puberty age than the present study when they recorded that weaner does attained puberty at an average age of 201 days in Sokoto Red does and also reported that age at puberty depended more on body weight rather than age because the unsupplemented does were oldest and highest at puberty and had the lowest growth rate. Devendra and McLeroy (1987) observed that in goats sexual maturity is reached at an early age and age is not as good a criteria as live weight by which to determine the right time for mating. They also reported that in South Africa, puberty in male boer was reached at 157.5 days old and first ejaculation were recorded at 509 days.

5.3.6 Twinning rate

The result indicated that no significant difference existed between the various treatment groups for twinning rate. The least was recorded (0.25) in the control group while the highest (1.00) was recorded in treatment three (3). According to Saka *et al.*, (2013) single birth weaners performed better than multiple birth weaners in growth rate. Ensminger (1983) reported that the tendency to produce twins is inherited to some extent; thus more twins are produced in some breeds and in some families than in others and he also observed that most cattlemen prefer single birth due to high incidence of free martins in twins of opposite sexes, increased mortality rate and the tendency of cows that have produced twins to have a lowered conception rate following twinning. In another finding Devendra and Burns (1995) stated that the most fertile breed in the Indian subcontinent is the Black Bengal which was reported to produce 85% multiple births with 22% singles, 54% twins, 21% triplets and 3% quadruplets in 175 observations. They also reported that 66% of Katjang goats in Malaysia produce twins, 4% of criollo goats in Venezuela produce single kids and 66% multiple births while MaTou goats of Central China had 21.7% single birth, 70% twins or triplets and 8.3% quadruplets.

5.3.7. Milk yield of F₁ generation

The result of analysis of the data generated from milk yield showed that supplementation does not have any significant influence. The highest yield of 47.525kg was recorded in treatment three (3) while the least (43.755kg) yield was recorded in treatment four (4). This result is higher than the findings of Luka (2012) who recorded a lactation yield of 40.75kg in Sokoto Red goats. Devendra and McLeroy (1987) observed that goats have flatter lactation curve and peak yield are reached between 8 – 12 weeks of lactation while in cows and buffaloes it is recorded between 4 – 6 weeks and goats produce relatively higher milk yield per unit of live weight compared to cows. Devendra and Burns, (1995) reported a lower milk yield of 40kg in Chegu breed in India, and a higher value 500 – 560kg in Damascus breed in Cyprus, they also reported a study in which children aged 6- 13years were given the same basic diet supplemented with 0.946 litres of either goat or cow milk made an excellent growth, but the children on goats milk surpassed the cow milk group in skeletal mineralization, blood plasma vitamin A and serum calcium and slightly greater concentration of hemoglobin.

5.3.8. Birth weight of F₂ generation

The result of analysis of birth weight of the F₂ generation showed that supplementation had significant effects ($p < 0.01$) on birth weight of kids. The highest was recorded (2.50kg) in the control group possibly as a result of single kidding while the least value (2.01kg) was recorded in treatment four (4). This result compared favourably with the findings of Eniolorunda *et al.*, (2012) who reported a birth weight that ranged between 1 – 4kg in goats. Devendra and Burns, (1995) reported a similar birth weight of 2.01kg in Barbari goats in India and a higher birth weight of 3.50kg in Jamnapari goats of the same nation. However, Zahraddeen *et al.*, (2008^a) reported a lower birth weight of 1.91kg in sahel goats, 1.76kg in Sokoto Red goats and 1.65kg in west African Dwarf goats. While Malau-Aduli *et al.*, (2004) also recorded a lower birth weight value that ranged between 1.07 – 1.40kg in Sokoto Red goats. They also reported that supplementation especially during the last lap of pregnancy had an effect of producing the heaviest kids at parturition compared to the unsupplemented does.

5.3.9. Total weight gain of kids

The result of the total weight gain of kids recorded in the F₂ generation showed a significant ($p < 0.001$) difference between the different treatment groups. The values are 5.41, 6.15, 7.52 and 6.18 for treatments 1, 2, 3 and 4 respectively. This is lower than the findings of Saka *et al.*, (2013) who reported a growth rate of 9.98, 8.24 and 8.16kg on single, twins and triplet kids respectively and also a growth rate of 9.30 and 8.29kg in male and female kids respectively in Nigerian goats under traditional management system. Finangwai *et al.*, (2012) also reported a lower value than the present finding which ranged between 3.3 – 3.8kg when growing west African Dwarf goats were fed Acha straw supplemented with ensiled poultry litter. While Malau-Aduli *et al.*, (2003) recorded a higher value that ranged between 6.00 – 6.80, 6.70 – 8.00 and 8.20 – 10.20kg at 5, 6 and 7 months respectively when Sokoto Red weaner bucks were supplemented with crop residues. The high growth rate recorded might be as a result of proper management of the parent stock and the kids produced.

5.3.10. Mortality of kids

The record of mortality of kids in the F₂ generation did not show any significant difference between the various treatment groups. The highest mortality (0.50) was recorded in treatment two (2) while the least (0.00) was recorded in treatment four (4). The low mortality recorded could be as a result of supplementation and management. The survival rate recorded tallies with that observed by Zahraddeen (2006) when he recorded a survival rate of 0.50%, 0.39% and 0.33% in Sokoto Red, Sahel and West African Dwarf goats respectively. Reasonable estimate for mortality are 5% for does and 10% for kids, when sufficient nutrients are provided low mortality of kids at birth is achieved and the kids have a good basis for subsequent growth and productivity is supported (Devendra and McLeroy 1987). However, Devendra and Burns, (1995) also observed that the death rate among kids is a major factor in determining the productivity of a herd and is a sensitive index of management efficiency and reported a kid mortality in 275 Barbari and 30 Jamnapari kids in India as 18.1% in Barbari and 16.6% in Jamnaparis.

5.3.11 Proximate analysis of milk of F_1 generation

The result of the proximate analysis of milk obtained from F_1 generation does during early lactation did not show any significant differences between the treatment groups for PH, total solids, crude protein, fat, lactose and ash.

The data recorded for PH were .16, 6.17, 6.16 and 6.17 for treatments 1,2,3 and 4 respectively. The result did not show any significant difference between the different groups. The present finding is lower than the findings of Zahraddeen (2006) who reported a PH value of 6.5 during early lactation, he also stated that goat milk had distinct alkalinity. Olorunnisomo and Salau (2012) reported a PH of 5.15 in 10% mango enhanced yoghurt.

The result of data analysis for total solids did not show any significant difference between the treatment groups. The highest value (11.68) was recorded in the control group while the least value (11.66) was recorded in treatment four (3). Thomas and Robert (2012) reported a value higher than the present finding of 12.4 total solids in goat milk. Zahraddeen (2006) also reported a much higher value of 15.6 total solids during early lactation. However, Devendra and Burns (1995) reported a lower value of 10.67 total solids in Toggengburg goats in Malaysia and much higher value of 18.18 in West African Dwarf goats in Nigeria. They also reported that there is a tendency for milk from tropical breeds to be higher in total solids, mainly due to higher fat and protein contents. Within a breed and also within lactations, total solids tends to be inversely related to milk yield.

The values for crude protein also did not show any significant difference between the treatment groups. The records were 3.22, 3.20, 3.25 and 3.24 for treatments 1,2,3 and 4 respectively. This is lower than the findings of Wuanor *et al.*, (2013) who reported a milk protein level of 3.54, 3.38, 3.44 and 3.45 for Bunaji, Bororo, N'dama and crosses breeds of cattle respectively. Alphonsus *et al.*, (2012) also reported a higher crude protein value of 4.01 during early lactation in Friesian crossed by Bunaji cows. However, Thomas and Robert (2012) reported a similar protein content of 3.3 in goats, they also observed that milk from cows or goats is much higher in protein than human milk and varying the protein content of the ration has little change on the protein content of the milk. While Devendra and Burns (1995) reported a lower protein content of 2.9 in British

Alpine in Trinidad and that protein content of West African Dwarf goats declined slightly with advancing lactation despite a significant fall in milk yield.

The recorded fat value in the present study were 4.10, 4.12, 4.11 and 4.11 for treatments 1, 2, 3 and 4 respectively. The value did not show any significant difference between the treatment groups. This result is higher than the findings of Luka (2012) who reported a fat level in that order of 3.57, 3.89, 4.09 and 3.79 when Sokoto Red goats were fed different energy and protein levels. While Zahraddeen (2006) reported a fat content of 5.16 and 4.38 in Sahel and Red Sokoto goats and also observed that fat content decreased as lactation progressed. Devendra and Burns (1995) also observed that differences in milk fat composition occur between breeds and between individuals within the same breed as well as due to stage of lactation. They also reported that Saanen goats in Nigeria produced milk lower in fat than is characteristic of this breed in temperate countries and pointed out that the low values may be due to nutritional deficiency arising from insufficient intake of dry matter.

The values for lactose during early lactation are 4.11, 4.11, 4.12 and 4.11 for treatments 1,2,3 and 4 respectively. The values did not show any significant difference between the treatment groups. This is lower than the findings of Zahraddeen (2006) who reported a lactose content of 4.72 during early lactation in Nigerian goats. Thomas and Robert (2012) also observed a lactose content of 4.7 in goats and that lactose contents remain relatively constant even with dietary fluctuations. Devendra and Burns (1995) reported a lactose content of 4.8 in colostrum and 4.77 in Red Sokoto goats in Nigeria, and they also observed that lactose content decreased in the second month of lactation in Black Bengal goat.

The records for ash were 0.84, 0.97, 1.02 and 0.99 for treatments 1,2,3 and 4 respectively. The records did not show any significant difference between the different treatment groups. This study compares favourably with the findings of Ensminger (1983) who reported an ash content of goat milk as 0.8. Devendra and McLeroy (1987) also reported a similar value of 0.85 ash in goat milk. While Olorunnisomo and Salau (2012) recorded an ash value of 1.40 in sweetened yoghurt. However, Devendra and Burns (1995) reported a lower ash value of 0.44 in Saanen goats in Malaysia and a higher value of 1.15 in African Dwarf goat in South Africa and also observed that ash content

decreased in Black Bengal goat during second month of lactation while the concentration of calcium increased with advancing lactation.

During mid-lactation, the proximate composition of milk showed significant difference between the treatment groups only in crude protein level while the remaining parameters did not show any difference.

The PH values recorded were 6.32, 6.35, 6.33 and 6.33 for treatments 1,2,3 and 4 respectively. The values did not show any significant difference between the treatment groups. This result compares favourably with the findings of Eniolorunda and Apata (2012) who reported a PH value which ranged between 6.4-6.8 in milk obtained from white Fulani cattle in Ogun state, Nigeria. While Olorunnisomo and Odesanmi (2012) reported a lower PH value of 4.13 in plain yoghurt. This indicated that yoghurt is more acidic than milk possibly due to the action of bacteria on the milk

The record for total solids during mid-lactation did not show any significant difference between the treatment groups. The highest value (11.60) was recorded in treatment four (4) while the least (11.57) was recorded in the control group. The records obtained from the present study compares favourably with the findings of Zahraddeen (2006) who reported total solids value of 11.51 during mid-lactation in goats. However the present finding is lower than the result obtained by Wuanor *et al.*, (2013) who reported a total solid value of 12.02 and 12.20 in the milk of Bunaji and Bororo breeds of cattle.

The result obtained from the analysis of goats milk obtained during mid-lactation for crude protein level showed a significant difference between the treatment groups ($p < 0.05$). The records were 3.41, 3.32, 3.38 and 3.36 for treatment 1, 2, 3 and 4 respectively. The present study tallies with the findings of Wuanor *et al.*, (2013) who reported a protein value of 3.44 in milk of Ndama cattle. While Devendra and Burns (1995) reported a similar value of 3.4 protein in Anglo-Nubian goats in Trinidad and a higher record of 5.06 in pigmy goats in U.S.A.

The records for fats showed that the different supplements did not have significant influence on milk fats during mid-lactation. The highest value of 4.61 was recorded in the control group while the least value of 4.39 was recorded in treatment three (3). The present study conforms with the findings of Alphonsus *et al.*, (2012) who reported a fat

value of 4.50 during mid-lactation in cattle. They also reported a fat value of 4.46, 4.41 and 4.47 during 1st, 2nd and 3rd parities respectively. Devendra (1980^b) observed that the high concentration of small fat globules is an advantage, but for butter making, milk fat from goats milk is more difficult to separate than cow or buffalo milk and they reported a similar fat content of 4.60 in milk of Jamnapari goat in India and a lower fat value of 3.88 in Barbari goats milk in India.

The lactose value during mid-lactation did not show any significant difference between the treatment groups. The highest value (4.43) was recorded in treatment two (2) while the least value was recorded (4.39) in treatment three (3) and four (4). The present study is lower than the findings of Thomas and Robert (2012) who reported a lactose value of 4.7 in goats milk. While Zahraddeen (2006) reported a similar lactose value of 4.40 during mid-lactation in goats. Alphonsus *et al.*, (2012) also reported a similar lactose content of 4.49 during mid-lactation in cattle.

The result of the milk analysis for ash did not show any significant difference between the different supplementation groups. The values recorded were 1.14, 1.15, 1.21 and 1.13 for treatments 1, 2, 3 and 4 respectively. The value obtained from the present study compares favourably with the findings of Devendra and Burns (1995) who reported an ash content of 1.15 in the milk of African Dwarf goats in South Africa and a lower ash value of 0.30 in Toggenburg goats in Malaysia, and also observed that the colostrum of West African Dwarf goats contained higher percentages of all minerals except calcium, than milk secreted later while the concentration of calcium increased with advancing lactation, but that of all other minerals except zinc fell.

The result of the proximate analysis of milk obtained from the F₁ generation goats during late-lactation showed a significant difference in PH records only while the records for the other parameters measured did not show any significant difference between the treatment groups.

The P^H values recorded during late-lactation of the F₁ generation does showed a significant ($p < 0.05$) difference between the treatment groups. The records were 6.20, 6.53, 6.33 and 6.33 for treatments 1, 2, 3 and 4 respectively. The present study is higher than the findings of Olorunmisomo and Salau (2012) who reported a PH value of 5.24, 5.22 and 5.15 in 10% banana, pineapple and mango enhanced yogurts respectively. It is

also higher than the report of Olorunmisomo and Odesanmi (2012) who observed a PH record of 4.13, 4.30 and 4.30 for vegetable enhanced yogurt stored for 10, 20 and 30 days respectively, which indicated that yoghurt is more acidic than milk.

The records for total solids during late-lactation showed that supplementation did not have any significant effect on the milk total solids. The values were 11.68, 11.67, 11.67 and 11.68 for treatments 1, 2, 3 and 4 respectively. This conforms with the report of Zahraddeen (2006) who observed a total solid record of 11.61 during late-lactation in does. While Luka (2012) observed a higher value of 12.33, 12.59, 12.73 and 12.63 total solids in milk of Red Sokoto does fed different protein and energy levels. He also observed no significant difference in total solids content of goat milk with advancing stage of lactation.

The crude protein record did not show any significant difference between the treatment groups. The highest value was recorded in treatment three (3) (3.24) while the least was recorded (3.21) in treatment two (2). This findings are lower than the report of Otaru (2002), Devendra (1980^b) and Thomas and Robert (2012). Goat milk is a valuable source of amino acids, rich in histidine, aspartic acid and tyrosine compared with cows milk and has a larger amount of non-protein nitrogen (Devendra and McLeroy, 1987).

The recorded value for fat also did not show any significant difference between the different treatment groups. The values were 4.10, 4.11, 4.12 and 4.11 for the four treatment groups. The findings of the present study is higher than the findings of Eniolorunda *et al.*, (2012) who reported a fat record of 3.8 in goat milk. While the present findings is lower than the report of Devendra and McLeroy (1987) and Wuanor *et al.*, (2013) who reported a fat value of 3.91, 3.87 and 3.85 in Bunaji, Bororo and Ndama cattle in Nigeria.

The lactose content of the milk during late lactation ranged between 4.11 - 4.13. The values showed that supplementation did not have any significant influence between the different treatment groups. The findings are higher than the findings of Zahraddeen (2006). Devendra and Burns (1995) also reported a higher lactose content of 4.77, 4.76 and 6.3 in Sokoto Red goats in Nigeria, Barbari and Jamnapari goats in India and West African Dwarf goats in Nigeria respectively.

The ash record also did not show any significant difference between the treatment groups. The highest value of 1.01 was recorded in treatment three (3) while the least record of 0.95 was recorded in the control group. This is higher than the findings of Devendra and McLeoroy (1987), Malau-Aduli *et al.*, (2003) and Zahraddeen *et al.*, (2007^a). Devendra and McLeroy (1987) also reported that sodium, iron and cupper contents of goats milk are relatively high.

CHAPTER SIX

SUMMARY, CONCLUSION, RECOMMENDATION AND CONTRIBUTION TO KNOWLEDGE

6.1. Summary

Studies were carried out in 2007 and 2008 to investigate dairy goat farmers and constraints of goat production in Adamawa state. The study was conducted in the Benue trough block where more than 50% of the goat population of the state were found. Dairy goat farmers were found only in Girei, Song and Gombi local Governments.

Tradition was one of the reasons of non-consumption of goats milk in the study area. Breeds of goats reared in the study were Sokoto Red (67.9%), Sahel (6.25%) while other breeds and their crosses made up 25.83%.

Farmers reasons for keeping goats showed that 64.58% kept goats for income generation, 12.08% of them kept goats for milk production, 8.75% of people kept goats for their meat. While 2.5% of the people kept goats for using them during ceremonies. Other purposes apart from those mentioned above were 12.08% of the people in the study area.

Male farmers formed the majority (87.92%) in the study area. Married men and women constitute 77.50%, 13.33% unmarried, 3.75% of them were divorced while 5.42% were widowed. Respondents that were between the ages of 30 – 35 years formed the majority, while the least group were those between ages of 42 – 47 years. Those that were between the ages of 42 – 47 years possessed the highest number of goats per household, while the least group of farmers in possession of goats were between the ages of 18 – 23 years.

Illiterates formed the largest group among farmers interviewed and was followed by those that had only primary education, while the least group constituted those that had University knowledge. Free range constituted the largest form of goat management system in the study area and was followed by village herding system while the least was the tethering system.

Farmers that had goats rearing experience between 11 – 16 years forms the largest group, followed by those whose level of experience in goat keeping was between 6 – 10

years while the least group were those that kept goats for more than 26 years. Farmers that used family labour formed the majority.

Respondents that milked their goats twice in a day formed the majority, while the least were those that milked their animals more than three times a day. Dairy goat farmers that processed their milk constituted the majority. Majority of those that processed the milk, processed it in to kindirmo.

Most farmers in the study area indicated inadequate feed as one of the major problems of goat keeping followed by diseases and parasites while the least problem was that of automobile accidents.

Among the common diseases experienced by farmers in the study area were P. P. R. which constituted 51.78%, followed by ectoparasites 19.64% while the least is that of endoparasites as indicated by farmers interviewed in the study area.

The proximate composition of the supplemental diet showed that groundnut haulms had the highest dry matter content of 93.65% while the least was obtained from maize bran with 92.23%. Cotton seed cake exhibited the highest crude protein content of 29.94%, followed by groundnut haulms 15.63% while the least crude protein content of 10.53% was obtained from maize bran. The highest crude fibre content was obtained from cotton seed cake (23.50%) while the least was obtained from maize bran (10.53%). Groundnut haulms contained the highest ash content of 7.67% while the least was obtained from maize bran and it constituted 1.16% The analysis showed that the highest ether extract was obtained from cotton seed cake which made up to 5.76%, followed by groundnut cake 2.06% while the least value was obtained from maize bran (1.89%).

The initial weight of the parent stock did not show any significant differences between the different treatment groups. Significant difference ($p < 0.001$) existed between the treatment groups for total weight gained by the does, the highest weight gain was recorded in the group supplemented with cotton seed cake while the least was in the group supplemented with groundnut haulms. The highest supplement feed intake was recorded in groundnut haulms while the least was in maize bran and it also showed a significant ($p < 0.001$) difference between the groups.

Gestation length was short in groups receiving maize bran and cotton seed cake but longer in the control group and significant differences ($p < 0.05$) existed between the

different groups. Twinning was recorded only in the groups receiving maize bran and cotton seed cake and no significant differences existed. The birth weight of the F1 kids showed significant ($p < 0.001$) differences between the groups, the highest was recorded in the control group while the least was recorded in the group receiving maize bran due to incidence of twinning.

Milk yield did not show any significant difference between the different groups and highest was recorded in the group receiving cotton seed cake while the least was recorded in the group receiving groundnut haulms. Mortality of kids also showed significant ($p < 0.05$) differences between the treatment groups and highest was recorded in the group receiving maize bran while non was recorded in the group receiving cotton seed cake and groundnut haulms. Total weight gain of kids during weaning showed a significant difference ($p < 0.001$) between the groups and the highest was recorded in the group receiving cotton seed cake while the least was recorded in the control group.

The proximate composition of milk of the parent stock during first parity showed no significant difference between the treatment groups for PH during early, mid and late lactations respectively. The values increased during mid lactation and declined during late lactation. Total solids showed no difference between the treatment means during the three stages of lactation. The values declined during mid lactation and then increases at late-lactation. The records for crude protein also did not show any significant difference during the three stages of lactation of first parity and the values decreased as lactation progresses .

Fats record did not show any significant difference between groups during early and mid-lactation while differences ($p < 0.05$) existed during late lactation. The values increased and reached peak during mid-lactation and then declined during late-lactation. Lactose record also did not show any significant difference between groups during early and mid-lactations while differences ($p < 0.01$) existed during late-lactation and was highest in the group supplemented with cotton seed cake and least in the control group, lactose values also reached peak during mid-lactation and started declining. Ash values were similar during early lactation while differences existed between groups during mid-lactation ($p < 0.05$) and late lactation ($p < 0.001$). The ash also reached peak during mid-lactation and then declined during late-lactation.

Supplement feed intake during second parity in the parent stock also showed significant ($p < 0.001$) differences between groups with the highest intake recorded in the group receiving groundnut haulms and the least in the group receiving cotton seed cake. Birth weight of kids during second parity also showed significant ($p < 0.05$) difference between groups and the highest was recorded in the group receiving cotton seed cake. Kidding interval was highest in the control group and the least in the group receiving cotton seed cake while differences existed ($p < 0.01$) between the groups. Gestation length was highest in the group receiving groundnut haulms and differences ($p < 0.01$) existed between the treatment groups.

Twinning was recorded in all the treatment groups and no significant difference existed between the treatment groups. Milk yield also did not show any difference between the treatment groups but the highest was recorded in the group receiving cotton seed cake and the least in groundnut haulms receiving group. The total weight gain of kids was highest in the group receiving cotton seed cake and the least in the control group and significant differences ($p < 0.001$) existed between the groups. Mortality of the kids was recorded in all the treatment groups and no difference existed between the groups.

The proximate composition of milk from does during second parity showed that the PH level showed significant ($p < 0.05$) differences among treatment groups and the level increased during mid-lactation and then declined. Total solids also showed differences ($p < 0.05$) between treatment groups, the values were similar during early and late-lactations. Crude protein records also showed significant difference ($p < 0.05$) between groups, the values increased as lactation progressed.

The fat values also showed differences ($p < 0.001$) during early and late lactations and it decreased as lactation progressed. Lactose content of milk also showed significant ($p < 0.001$) differences between treatment groups during second parity in all the three lactation stages. While ash values are almost similar during early, mid and late-lactations and showed significant ($p < 0.01$) differences between groups during the three stages of lactation.

The initial weight of the F_1 generation does during the study period did not show any difference between the treatments. The total weight gained by the does showed significant ($p < 0.001$) differences between the groups and the highest was recorded in the

group supplemented with cotton seed cake. Feed intake was highest in the group receiving groundnut haulms and there was a significant ($p < 0.001$) differences between the groups. Pregnancy period was highest in the group receiving cotton seed cake and it showed a significant ($p < 0.05$) differences between the groups. The number of days it took the does to attain puberty varied significantly ($p < 0.001$) among the different groups and was highest in the control group and least in the group receiving cotton seed cake.

The birth weight of the F_2 generation kids showed highly significant differences ($p < 0.01$) between treatment groups and was highest in the control group and least in the group receiving groundnut haulms. Twinning occurred in all the groups and no significant differences appeared. Milk yield did not show any difference among the groups and was highest in the group receiving cotton seed cake as a supplement and least in the group receiving groundnut haulms. The total weight gained by the F_2 generation kids was highest in cotton seed cake receiving group and least in the control group and it showed a significant difference ($p < 0.001$) between the groups. Mortality of the kids occurred in all the treatment groups except treatment four (4) and no significant differences appeared between the treatment groups.

The result of the proximate analysis of milk obtained from F_1 generation does showed no significant difference existed between all parameters measured during early lactation. During mid-lactation, PH, total solids, fat, lactose and ash did not show any significant differences between treatment groups, but the crude protein content of the milk showed significant ($p < 0.05$) differences between the groups. Late – lactation analysis also showed no significant difference between groups for all the parameters measured except PH which recorded differences ($p < 0.05$) between treatment groups and the least value was obtained from the control group while the highest was from the group receiving maize bran as a supplement.

6.2. Conclusions

Based on the findings of this study, the following conclusions were drawn.

1. Goats are rarely used as dairy animals as only 10% of respondents in the study area used goats for dairy production. The dairy products were mostly consumed in rural areas. Tradition appears to be the major reason for non-consumption of goats milk.

2. Sokoto red goats appear to be the major goat breed found in the state which accounted for 67.9% of goats population. Most farmers in the state keep goats for income generation.
3. Adult farmers that were between the ages 30 – 35 years formed the majority group in the state. While most of the goat farmers in the state were illiterates.
4. Goats management system in the state was mainly free range, village herding and cut and carry systems, and most of them used family labour in managing their goats. Majority of dairy goat farmers in the state milked their goats twice in a day and processed it into kindirmu.
5. The problem of inadequate feed appeared to be the major constraint of goat production especially during dry season. While P. P. R. appeared to be the most common disease that affects goat production in the state.
6. Cotton seed cake has shown to be the best supplement for goat production.
7. The composition of goat milk observed in this study is comparable to those reported elsewhere.
8. Supplementation reduces kidding interval and milk yield improves as parity level increases. The number of days it takes the does to attain puberty is affected by supplementation.
9. Selection which is sometimes better than cross breeding improves birth weights, twinning rate, total weight gain and milk production of goats.

6.3. Recommendations

Based on the observations of this study, the following recommendations are made;

- (i) Substantial improvement in goat production can be achieved through better management, reduction in goats diseases and mortality and the use of hired labour and better housing to protect them from adverse weather conditions.
- (ii) Goats milk which is believed to contain high concentration of nutrients and is more available in the villages where animal protein is in short supply and also not affordable and should be used as food for adults and

infants especially after weaning. This can be achieved through awareness using trained extension agents.

- (iii) Live weight gain of does and their kids can be enhanced by supplementing with cotton seed cake. Short kidding interval and puberty age can also be achieved.
- (iv) Good selection programme can improve reproductive performance of goats and also its milk production.
- (v) More researches should be conducted on the potentials of dairy goat farming including socio-economic benefits of dairy goat farming. More emphasis should be geared towards within breed selection to achieve optimum milk production.
- (vi) Goats, due to their hardiness, adaptability and low capital investment can be good sources of income generation, source of food, employment and poverty reduction among the poor and jobless Nigerians if reared using appropriate inputs.

6.4 Contribution to knowledge

The study proves that goats milk which contained high concentration of animal protein is poorly consumed in Adamawa State and even the few dairy goat farmers in the state have to mix the goat milk with cow milk for sale to their customers as cow milk. The goat which is more concentrated in the rural areas is underutilized, because their milk can be used to improve animal protein supply especially to the infants who are more vulnerable, and can save the people from buying the much expensive and less nutritious imported powdered milk for feeding the infants especially after weaning. Through good selection programme our indigenous goats can produce milk almost near to that produced by some exotic breeds. Puberty age and kidding intervals are shortened by supplementation while most of the losses of these breeds of goat occur as a result of poor management especially during rainy season.

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APPENDIXCES

1: QUESTIONNAIRES

Dear Sir/Madam,

This is a post Graduate research Questionnaire Schedule on survey of dairy goat farmers in Adamawa Sate. It is intended to collect information that will contribute immediately toward more successful dairy goat production in the state. Your cooperation would be valuable for the success of this research.

Please answer these questions as concise as possible.

- 1. Date:.....
- 2. Sex: Male/Female
- 3. Age:.....
- 4. Marital Status married, Single, Divorced or widow.....
- 5. Level of Education.....
- 6. Location of the Farm.....
- 7. Number of Animals:.....
- 8. Which breed of goats do you rear?.....
- 9. How long have you been rearing goats?.....
- 10. How many kidded last year?.....
- 11. Do you provide supplements? Yes / No
- 12. If yes what supplement do you use:.....
- 13. Which system of management do you use?.....
- 14. Do you milk your animals? Yes / No:.....
- 15. If yes how many times/day: (a) Once (b) Twice (c) Thrice (d) Others
- 16. What is the quantity of milk obtained/day:.....
- 17. What do you do with the milk? Sell / consumed / others
- 18. If none consume what is your reason of non-consumption of milk?
- 19. Do you process the milk? Yes / No
- 20. How do you store the milk?.....
- 21. What other benefits do you obtained from rearing goats?:.....
.....
.....

22. In case of disease outbreak, how do you treat them:.....
23. What are the common diseases:.....
24. What problem(s) do you face on the course of rearing goats:.....
.....
.....
25. Labour system (a) hired labour only (b) family labour only
(c) both hired and family labour:.....
26. How much do you spend on hired labour?.....
27. Do you provide shelter for the goats? Yes / No

ANALYTICAL PROCEDURES FOR MILK COMPONENTS

Milk Protein

The protein contents of the milk samples were determined using Rose-Gottlieb process.

The following procedures are involved.

- Weight out 10ml of the milk sample.
- Add 0.5ml of 0.5% phenol phthalene indicator
- Add 0.4ml of neutral saturated potassium oxalate and mix properly.
- Allow to stand for a few minutes.
- Neutralize with 0.1m sodium hydroxide to standard pink colour.
- Add 2ml of formalin and mix properly.
- Allow to stand for a few minutes.
- Titrate the new acidity produced with 0.1m sodium hydroxide to the same pink colour (titration 'a' ml).
- Titrate separately 2ml of the formalin + 10ml of water with 0.1m alkali ('b' ml) as blank.
- The protein content of the milk (equivalent to $N \times 6.38$ from Kjeldahl method) is $1.7(a-b)$ percent.

Milk Fat

The fat content of the milk samples were determined using formal titration method which involve the following procedures.

- Weight 10ml of milk in to a 100ml beaker.
- Add 1ml of 0.88 ammonia solution and mix properly.
- Add 10ml of alcohol (95%) and mix well.
- Add 25ml peroxide-free diethyl ether.
- Stopper the tube and shake vigorously for 1 minute.
- Add 25ml of light petroleum (b.p.40-60⁰c) and shake vigorously for 30 seconds.
- After separation is complete, transfer fat solution in to suitable flask (previously dried at 100⁰c, cooled and weight).
- Distill off the solvents from the flask.
- Dry the fat for 1 hour at 100⁰c.
- Cool and weight

- Calculation: % fat =
$$\frac{\text{Weight of residue (gm)} \times 100}{\text{Weight of milk (gm)}}$$

Total Solids

The total solids contents of the milk samples were determined by evaporation. This involves the following procedures:

- Spread out 2.0 – 3g of asbestos in the bottom of a porcelain dish.
- Heat, cool in a dessicator and weight.
- Run 10ml of milk sample slowly in to dish from a pipette.
- Weight as rapidly as possible.
- Place on the water bath for 30 minutes until most moisture has driven off.
- Dry for 2 ½ hours in an oven and cover the dish.
- Cool for 30 minutes in a dessicator and weight.
- Heat the material for 1 hour.
- Dry in the steam oven at 100⁰c to constant weight (until the last two readings do not differ by more than 1mg).

Ash

The ash content (minerals and salts) of the milk samples were determined as follows:

- Follow the steps (a – f) in total solids determination in milk.
- Ignite the dish containing the solids at lowered heat.
- Continue step b above until the dish and asbestors are white.
- Turn the dish in the flame to burn off carbon from the edges (avoid overheating to prevent volatilization of chlorides).
- Cool and weight.
- Determined the ash content in % by calculation

Calculation: if the weight of dish = agm
 Weight of dish + sample = bgm
 Weight of dish + ash = cgm

$$\% \text{ Ash} = \frac{C - a \times 100}{b - a}$$

Lactose

The lactose content of the milk samples were determined using standard method.

Three stages are involved:

1. Preparation of 80% phenol solution. This will be prepared as follows:
 - Dissolve 80g of AR phenol in 60 – 70ml of distilled water at 50⁰c.
 - Transfer to 100ml flask and up to the mark.
 - Keep in a dark bottle.
2. Standard curve determination.
 - Dissolve 0.1g lactose crystal in 2 litres water.
 - Pipette in to each 50ml flask 2, 4, 6, 8 and 10ml of standard solution.
 - To each 50ml flask add 20ml AR conc. H₂SO₄ slowly down the side of the flask.
 - Make up to mark with water
 - Mix properly by swirling flask round and round.
 - Leave for 10minutes at room temperature.
 - Read obserbance at 490mm in spectrophotometer
 - Plot obserbance against weight of lactose (mg) in 50ml lactose solution (1ml standard solution = 0.05mg of lactose).
3. Determination of lactose in milk samples:
 - Weight 1ml of lactose well – mixed milk sample in a beaker.
 - Transfer to 1 litre flask and make to mark with distilled water.
 - Shake vigorously well.
 - Pipette 10ml of milk solution in to 50ml flask.
 - Add 20ml AR conc. H₂ SO₄, slowly down the side of the flak.

 - $$\% \text{ Lactose in milk} = Y \times \frac{1000}{10} \times \frac{100}{1000} = 10Y$$
 - Make up the mark with distilled water.
 - Mix properly by swirling flask round and round.
 - Leave for 10 minutes at room temperature.
 - Read absorbance at 490mm in spectrophotometer.
 - Read lactose concentration from the standard curve

Reagents required

- 80% phenol solution.
- Conc. H₂ SO₄.
- Lactose crystals.
- Distilled.

Equipment/ Material

- 50ml, 100ml and 1000ml flasks
- Spectrophotometer
- Electronic weighting scale