SEASONAL CHANGES IN GROWTH AND REPRODUCTIVE PERFORMANCE OF KANO BROWN BUCKS UNDER DIFFERENT FEEDING REGIMES

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A THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (PhD) IN ANIMAL SCIENCE

NOVEMBER, 2017

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Professor S.A. Maigandi and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this thesis and the subsequent write-up (Mudassir Nasir SPS/14/PAS/00001) were carried out under my supervision.

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APPROVAL PAGE

This thesis has been examined and approved for the award of Ph.D in (Animal Science).

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ACKNOWLEDGEMENTS

Praises be to Almighty Allah the Lord of the world, His blessings be upon the beloved Prophet Muhammad (P. B. U. H.), his household and his rightly guided companions. I thank Almighty Allah for providing me with the energy, wisdom and protection to complete this research work.

I wish to thank my supervisor Prof. S.A. Maigandi for the patience, support and encouragement given to me during this study. He was an exceptional supervisor who always listen to my problems and assisted me in solving them. I am grateful to my internal examiner Dr. A.M. Abdussamad for his kind contributions, guidance and encouragement throughout the course of this study, in spite of his tight schedule. I remain grateful to my undergraduate supervisor Dr. A.M. Hassan (Kano University of Science and Technology, Wudil) who was very supportive in all ramifications for the success of this work.

Special thanks go to Prof. I.R. Muhammad, Dr. M. Baba (Head of Department, Animal Science, Bayero University, Kano) who provided the space to undertake the research work, Dr. M.S. Tamburawa (Head of Department, Animal Science, Kano University of Science and Technology, Wudil), Dr. Nuhu Bello and Dr. A. Nasiru. I am grateful to all staff of the Department of Animal Science, Bayero University, Kano.

Finally, I wish to extend my profound gratitude to my colleagues at the Department of Animal Science, Kano University of Science and Technology, Wudil for their contributions, encouragement and prayers toward the success of this work. I am grateful to the management of Kano University of Science and Technology, Wudil for the support to undertake this programme.

However, I appreciate all other people who contribute in all the ramifications of this study and their names are not found written for one reason or the others, I owe you much apology.

DEDICATION

This research work is dedicated to my parents, Late Alhaji Nasir Bindawa and Hajiya Hafsatu Iliyasu.

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ABSTRACT

The study was conducted at University Teaching and Research Farm and the General Laboratory of the Department of Animal Science, Bayero University, Kano between November, 2015 to October, 2016 to evaluate the effect of season and feeding regime on growth performance, reproductive parameters and blood metabolites of Kano Brown bucks. A total of forty eight (48) kids were randomly allotted to four feeding regimes in a 3 x 4 factorial arrangement in a randomized complete block design which comprised sixteen (16) bucks per season. Semen was collected using artificial vagina and evaluated immediately. At the end of this study, twelve (12) bucks, three from each treatment were orchidectomised. Epididymis was carefully separated from the testes using scapel blade and then divided into three parts, (*carput, corpus and cauda epididymides*) weight (g) and length (cm) of each were also measured. Testes (g/testis) and epididymis were used to determine gonadal and extra-gonadal sperm reserves (x 10^6), respectively. At the end of each season blood samples were collected in three bucks (10 ml each) from each treatment. Blood samples were sent for haematology and blood serum chemistry analysis at Aminu Kano Teaching Hospital. The result obtained for growth performance showed that harmattan season had the highest mean values for body weight (18.10 kg) for animals under morning and evening supplementation followed by dry season (16.32 kg) under the same feeding regime whereas rainy season recorded the lowest mean values (16.25 kg). No significant ($P > 0.05$) difference was observed for neck length (cm). However, highest mean value (21.00 cm) was obtained during harmattan season whereas rainy season recorded the lowest values (19.89 cm) in animals offered morning and evening supplementation. No significant ($P > 0.05$) difference was observed for semen color and sperm motility (%) in animals under different feeding regimes. The result of gonadal sperm reserves (x 10^6/g/testis) of Kano Brown bucks differed significantly ($P > 0.05$) among feeding regimes. Dry season recorded the highest mean values (2549.67 x10^6/g/testis) for right testis in animals offered morning and evening supplementation compared to other feeding regime whereas harmattan season had the lowest mean value (2782.67 x10^6)/g/testis. No significant ($P > 0.05$) difference was observed for Hb (g/dl), PCV (%), MCV (fl), MCHC (g/dl) and neutrophils (%). Similarly, no significant ($P > 0.05$) difference was observed for cortisol among feeding regimes, eventhough dry season recorded the highest mean values (361.00 mmol/L) whereas harmattan season had the lowest mean values (351.10 mmol/L) in animals under zero supplementation. Based on the result of this study, it can be concluded that morning and evening supplementation had a significant effect during dry, rainy and harmattan seasons on growth performance, seminal traits, gonadal and extra-gonadal sperm reserves, haematological indices and blood serum chemistry of Kano Brown bucks. Bucks should be raised during rainy and harmattan seasons and should be offered morning and evening supplementation since the level of supplementation promotes growth and other reproductive parameters of Kano Brown bucks.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

The over-riding environmental factor affecting the physiological functions of domestic animals is temperature (Coles, 1986). For most tropical farm animals a mean daily temperature of 28^{o}C is referred to as the "comfort zone" (Benerjee, 2007). In this range, the animal's heat exchange can be regulated solely by physical means such as constriction and dilation of blood vessels in the skin, ruffling up the fur or feather and regulation of the evaporation from lungs as water vapor and carbon dioxide and skin as sweat. At the upper (48^{o}C) and lower (24^{o}C) critical temperatures the physical regulation will not be sufficient to maintain a constant body temperature and the animal must, in addition, decrease or increase its metabolic heat production. A further decrease or increase in temperature will eventually bring the temperature to a point beyond which not even a change in heat production that will be sufficient to maintain homeothermy, the process affect both oogenesis and spermatogenesis and this result to a greater economic loss to farmers (Rashid, 2008).

In tropical and subtropical environments, small and large ruminants may often be under heat stress. When the environmental temperature exceeds the upper critical level of 48°C, depending on the species, there is usually a drop in production or a reduced rate of weight gain. Sivakumar, Singh and Varshney (2010) reported that when the temperature falls outside the comfort zone, other climatic factors assume greater significance. Humidity becomes increasingly important as do solar radiation and wind velocity. In a hot-dry climate evaporation is rapid, but in a hot humid climate the ability of the air to absorb additional moisture is limited and the inadequate cooling may result in heat stress. Too low humidity in the air will cause irritation of the mucous membranes, while too high humidity may promote growth of fungal infections. High humidity

may also contribute to decay in structures. These environmental factors have significant effects on livestock production including goats.

Goats are the most numerous of all livestock species in Nigeria in which the population was estimated to be 57.8 million goats (FAO, 2012). However, Red Sokoto, West African Dwarf and the Sahelian goats are the main breeds (Adu, Buvanendran & Lakpini 1979; Osuga, Abdulrazak, Nishino, Ichinohe & Fujihara, 2006). Among the three breeds of goats in Nigeria, Red Sokoto goat is the predominant and the most widely distributed breed in the Northern guinea savannah of the country (Ngere, Adu & Okobayo 1984; Lombin, 2007). The breed has a uniform dark red color, short haired and with horns on both sexes

One of the major factor limiting the productivity of goats in developing countries is over dependence on low digestible feeds which is uncertain throughout the year and also cannot meet even the maintenance requirements of these animals. Inadequate nutrition particularly during the dry season is a major constraint of livestock producers (Lengarite, Getachew, Akudabweni & Hoag, 2014). Forages during the dry season are highly fibrous, low in digestible protein, energy, minerals and vitamins which do not meet goat nutrient requirements.

Under extensive management, supplementation has frequently been advocated as the main solution to nutritional constraint faced by livestock during the long dry season (Malami, Hicrnaux, Tukur & Steinbach, 2006). Goat is able to consume up to 3 to 5% of its body weight dry matter daily (perhaps more if the forage is highly digestible). The nutrient requirements of goat are determined by age, sex, breed, production (milk or meat), body size, climate and pregnancy. Feeding strategies should be able to meet energy, protein, mineral, and vitamin needs depending on the physiological status of the goats. High ambient temperature depress growth and increases

the level of stress in animals that leads to hormonal secretion of cortisol from adrenal cortex (Silanikove, 2000).

Cortisol is a steroid hormone, known as a glucocorticoid, produced in the cortex of the adrenal gland and then released into the blood which transports it all round the body (Adelokum *et al.,* 2012). However, almost all cells contains receptors for cortisol and so cortisol can have lots of different actions depending on which sort of cells it is acting upon (Addass, Perez, Midau, Lawan & Tizhe, 2010). These effects include controlling the body sugar levels and thus regulating metabolism acting as an anti-inflammatory that influenced memory formation, controlling salt and water balance, influencing blood pressure and helping development of the foetus. In many species cortisol is also responsible for triggering the processes involved in parturition (Bello & Tsado, 2013). Blood levels of cortisol vary, but generally are high in the morning when we wake up, and then fall throughout the day. This is called a diurnal rhythm. In response to stress, extra cortisol is released to help the body to respond appropriately. The secretion of cortisol is mainly controlled by three inter-communicating regions of the body, the hypothalamus in the brain, the pituitary gland and the adrenal gland (Marai, Baghat, Shalaby & Abdel-Hafez, 2007). This is called the hypothalamic-pituitary-adrenal axis. Cortisol levels in the blood may be low, a group of cells in a region of the brain called the hypothalamus release corticotropic-releasing hormone influences the activities in pituitary gland to secrete another hormone known as adrenocorticotropic hormone into the bloodstream. High levels of adrenocorticotropic hormone are detected in the adrenal glands and then stimulate the secretion of cortisol, causing blood levels of cortisol to rise (Marai *et al.,* 2007). As the cortisol levels rise, they start to block the release of corticotropic-releasing hormone from the hypothalamus and in turn adrenocorticotropic hormone from the pituitary. As a result the adrenocorticotropic hormone levels start to drop which then leads to a drop in cortisol levels

(Sandhu, Saini & Randhawa, 2009). This is called a negative feedback loop. Too little cortisol can be due to a condition called Addison's diseases. It has a number of causes, all rare, including damage to the adrenal glands by auto-immune disease. The onset of symptoms is often very gradual. Symptoms may include fatigue, dizziness (especially upon standing), weight loss, muscle weakness, mood changes and the darkening of regions of the skin (Amao, Adejumo & Togun, 2012a).

1.2 PROBLEM STATEMENT

Among the factors limiting goat production in developing countries is over dependence on low digestible feeds, which are uncertain throughout the year. Nutrition influenced growth, sperm production and fertility, particularly in the tropics, where there are seasonal changes in quality and quantity of feeds (Ndama, Entwistle & Lindsay, 1983). Nutrition-reproduction interactions have been known to have important implication for the reproductive performance of farm animals (Bindari, Sulochana, Nabaraj & Gaire, 2013), therefore, nutrient supplementation is required in ruminants to achieved optimal reproductive performance. This usually become more important during prolong and stressful cold-dry season, when grasses and crops residues are dry and fibrous with low digestibility and devoid of most essential nutrients (Osuji, Nsahlai & Khalili, 1993). However, environmental temperature and relative humidity affect the reproductive potentials of farm animal especially when associated with poor nutritional status (Ganong, 2005). Feed consumption could be reduced when the environmental temperature is relatively high (46^{o}C) these simultaneous changes of temperature and humidity (High and low) year in year out, reduced sperm production and fertility. Factors such as nutrition, genetic and environment influenced the reproductive parameters of goats (Ganong, 2005). Animal productivity could be affected when environmental factors are associated with poor nutritional status. Genetic potentials can do very

little when these factors are not favorable and this result to poor conception rate, abortion and other nutritional diseases that has an everlasting effect on reproduction.

Seasonal variation in feed supply, poor feed resource causes progressive weight loss and decreased fertility a well as milk yield for up to 4-5 months of the year. The severity and duration of low quality feed differ from one place to another within the country. Annual burning of native grasslands, further worsen the ecology and its available feed resources thereby drastically reducing the amount of forage for livestock feeding. It has been observed that a combination of these factors, low quality roughage and bush burning significantly reduce the biomass available in quantity and quality that lead to weight losses ranging from 300 to 400g per head per day for cattle (Aregheore, 2001) and up to 15% of body weight in goat.

1.3 JUSTIFICATION FOR THE STUDY

The population of Nigeria is increasing rapidly; thus leading to high demand for animal protein (Gefu, 2002). At present, in sub-Saharan Africa, Nigeria inclusive, the protein consumption from animal origin is lower than 20% of recommended level for adult humans and factors such as availability and cost are adduced for this short fall (FAO, 2012). Therefore, there is the need to devise ways of improving the growth rate and reproductive efficiency of indigenous Kano Brown goats, which are mostly reared by small-holder farmers in rural areas. The animals provide an alternative source of animal protein and serve as a source of income to the rural populace. This could be achieved through disease control, good management and adequate nutrition.

Genetic improvement of Kano Brown bucks can also be achieved through selection of superior breeding stock and artificial insemination. Effect of nutrition on buck fertility before and after puberty is manipulated via the effect of the dietary constituents on the hypothalamic-pituitary axis, which may affect testicular development (Brown, 1994). Malnutrition, particularly low

energy intake in males, can also impair spermatogenesis. Cupps (1991) reported that nutrition play an important role on reproduction. High ambient temperature depressed growth and development as it reduced feed intake. Mann and Lutwak-Mann (1981) reported that reproductive potentials of domestic livestock could be improved by increasing dietary protein in the diets. High ambient temperature depressed growth, reduce production and lower reproductive efficiency (Silanikove, 2000). Season has adverse effect on spermatogenesis and are also detrimental to ova and sperm in the female reproductive tract. The results are lower fertility rates and high embryonic mortality (Land, Gauld, Lee & Webb, 1982).

1.5 OBJECTIVES OF THE STUDY

The broad objective of the study was to investigate the effects of season and feeding regime on growth, reproductive parameters and blood metabolites in Kano Brown bucks. The specific objectives were as follows:

i. To find out the effects of season and feeding regime on growth performance.
ii. To investigate the effects of season and feeding regime on seminal traits.
iii. To evaluate the effects of season and feeding regime on gonadal and extra-gonadal sperm reserves.
iv. To determine the effects of season and feeding regime on haematological parameters and serum chemistry.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN AND DISTRIBUTION OF GOATS

Most of the world's small ruminants are found in the tropics (Salem, Yousef, El-Sherbiny & Khalil, 1992) where ambient temperatures are high all the years round. Goats belongs to the tribe Caparinea, divided into two genera, *Hemitragus and Capra*. The *Hemitragus*, also called *Tahrs,* are wild goats found in Arabia, the Himalayas and South India. They have 48 chromosomes in their DNA and do not crossbreed with the Capra, which has 60 (Mike, 1996). The genus Capra is the origin of domesticated goats and this include five species: *Capra hircus, C. ibex, C. caucasica, C. pyrenaica,* and *C. falconeri.* These animals, therefore, display a unique adaptability to the harsh environment. Goat are probably the first ruminant animal to be domesticated, some 8,000 years ago (Mike, 1996). This occurred in ancient civilization along the rivers of the Nile in Africa, Tigris and Euphrates in Asia, and Indus in India. When populations migrated from these areas, the domesticated goats spread throughout the continents, most recently to Europe and the Americas (Mike, 1996).

Goats are distributed to extremes of climates: from tropical desert, characterized by ambient temperature extremes (0^{o} to $53^{o}C$) such as in the Thar, Sahel and Negev deserts, with insignificant rainfall and sparse vegetation; high altitude montane areas up to 2,500 m, such s the Hindu-Kush Himalayan region; and the wet tropics with high temperature, humidity, rainfall (3,000 to 5,550 mm); and abundant vegetative cover, such as those in many parts of South-east Asia Babayemi,, Ajayi, Taiwo, Bamikole nand Fajimi (2006). The preferred environments are, however, the arid and semi-arid regions. Domestication of the goat was probably completed in the present-day Iran and Iraq by 7,000 BC, and the domestic dwarf goats had moved into Sub-Saharan

Africa by about 5,500 BC. The spiral or corkscrew horned goats had originally entered Egypt from the east by about 3,500 BC. The centre of evolution of the screw-horned goats is not very clear. Since Egypt and India are peripheral areas of its range, the centre of evolution might have been in the present day Iran and Iraq. It is possible that not all ancient screw-horned goats were derived from the same source. Selection is believed to have affected the forms of ears and horns, and probably led to the dominance of long drooping ears on this type of goats. These ancient screw-horn goats had fairly long legs and short hair and their color was red, black, fawn, white or pied. From Egypt, the screw-horned lop-eared type later spread to the west and south (Babayemi, *et al.,* 2006). At present, their distribution is limited to Sahel, form western Sudan in the east, across Mali and Niger to Mauritania and Senegal in the west (Epstein, 1971). The ancient and recent goats of the African continent were introduced from Asia. The main centres of distribution are northern Nigeria (Sokoto and Kano States) and southern Niger. However, sub-types with color variations are found to the west and east of this region; the climate is semi-arid with a fragile rainfall season of 4 to 6 months; the production system is predominantly agro-pastoral and agro-sylvo-pastoral, where economic trees are also grown (Marai, Shalabi, Bahgat & Abdel-Hafez, 2000). Outside the main centres of its distribution, the colour varies somewhat and various types are recognized, such as Kano Brown and Bornu White. Wilson (1989) reported that Buduma goat of Chad appear to be the same variety as the Bornu White.

2.2 POPULATION AND ADAPTATION OF KANO BROWN GOATS

The world population of goat is 674m, of which 94% are found in the developing countries. Africa and Asia account for about 81% of the total population in the developing countries, including a bewildering variety of breeds (Adeniji, 1975). The largest populations are found in Asia, notably in India, Pakistan and China. In Africa, the largest concentrations are found in

Nigeria, Ethiopia, Sudan and Somalia. Goats, however, appear to be better adapted to the tropical environment than sheep and cattle, going by their higher numbers in the tropics (Valez-Nauer, Carew, & Hayward 1982). Development of successful programs to improve these animals in the humid tropics, thus, requires a clear understanding of their physiological and reproductive responses to environmental thermal stress and the relationship between them and the environment.

However, in Nigeria, most ruminant animal population occurs in the Sudan, Sahel and Guinea Savannah zones. The Kano Brown buck which is a sub-type of Red Sokoto goats is among the most popular goats in Nigeria. The Red Sokoto goats constitute the largest population of about 50% of the total population of goats in Nigeria (Osinowo & Abubakar, 1988; Osinowo, 1992). Goats are predominantly found in the semi-arid zone in Northern Nigeria, between latitudes 120 N and 140 N and longitudes 40 N and 100 E, with a single rainfall season of 4-6 months duration. These areas are cultivated for millet, sorghum and groundnut, residues of which from the major part of the goat are feed in the dry season. In Maradi, most goats are found in the cultivated valleys of seasonal rivers (rainfall 600m), which provide a favorable micro-zone with out-of-season crop residue and browse shrubs (FAO, 2009).

2.3 ECONOMIC IMPORTANCE OF GOATS

Goats have successfully been raised by mankind as a source of meat, milk, hair, mohair, skin (leather) and other products including blood, bones and manure. Even though goats are frequently objects of neglect and prejudice, they provide a flexible financial reserve for the rural population (Sumberg & Cassaday, 1989), and milk production as a secondary function is common with many owners. The importance of goat meat lies in its suitability for domestic consumption. The long generation interval associated with cattle does not apply to other meat producing livestock in Nigeria. Therefore, a substantial increase in population of goats could be quickly

achieved, despite the prejudice in some areas against them (FAO, 1986). Goats assist in income generation to the rural populace and contribute about 30% of the total ruminant population of Nigeria's meat supply (Adu, Buvanendran, & Lakpini, 1979). Analyses have shown that Red Sokoto goats have the highest annual yield of 35,096.60 tons of the total small ruminant population of the country (Osinowo, 1992). The dressing percentage of goat is between 45-41 and carcass yield of 61-65% lean meat, and with about 11-14% fat, 21-28% bone, 30% offals and 3% skin (Nuru, 1985; FAO, 1986). Goat milk is consumed in some areas in the northern part of Sokoto and Borno States. The milk has special attribute of hae rare tubercular bacilli, higher proportion of smaller fat globules that facilitate its easy digestion and it possesses anti-allergic properties. The milk when processed is consumed in different forms, (for example, as "wara" which is soft, wet, unripen cheese, usually white and lumpy in appearance in Nigeria). It is also consumed as yoghurt ("Kindirmo") in some areas of Sokoto and Borno States (FAO, 1986).

The skin of Red Sokoto goat is well known for its superior quality and the higher value it commands in world markets (FAO, 1986). The Red Sokoto goat was the source of "Morocco leather", known in Europe from the medieval period onwards. It was known as "Morocco" because it was transported across the Sahara by Caravans, controlled by Moroccan merchants (FAO, 1986).

2.4 OWNERSHIP AND FLOCK SIZE

Most small ruminants are owned by individuals or families in rural areas. The animals are owned mainly by sedentary cultivators of the Hausa tribe, or of related Hausa-speaking groups. Often confined within house compounds, either loose or tied to stakes, especially during the crop-growing season, when they many be zero-grazed (FAO, 2009). The number per group is small and stock owners form an integral part of the farming system (Asaolu, Odeyinka, Akinbamijo & Sodeinde, 2010). Goat distribution in Africa is not even, and the numbers seem to be higher in the

drier areas. Therefore, larger flock sizes are found in the drier than in the humid areas. In some areas, like West African sub-region, flock sizes decrease from north to south. Flock sizes are generally larger in the hands of pastoral and small holders in the humid agricultural regions (Asaolu *et al.,* 2010).

2.5 BREED OF GOATS IN NIGERIA

The three main breeds of goats that are recognized in Nigeria are the Sahel (desert or West African long-legged goat), the Red Sokoto goats and the West African Dwarf goats (Mason, 1988).

2.5.1 Sahel/Desert Goat

The Sahel or desert goat is found along the northern border of Nigeria, particularly in Borno, where it is often known as 'Balami'; although this name has not been adopted as it would lead to confusion with the better known sheep breeds, Balami. Mason (1988) used 'sahel' which seems appropriate, as this breed is distributed from Senegal to Sudan. In Nigeria, the Sahel goat is generally the breed preferred by pastoralists. Sahel goats are very similar in appearance to sheep with which they are often herded. Asaolu *et al.* (2010) reported that, the coat is which or drappled, the ears are pendulous and legs are notably longer than other breeds.

2.5.2 Red Sokoto Goat

The Red Sokoto, Kano Brown or Maradi goat is probably the most widespread and well-known type in Nigeria (Haumesser, 1975). It is the usual village goats in northern two-thirds of the country. Ngere *et al*. (1984) argued that populations of the Red Sokoto spread south and east from Sokoto through the Savanna belts give rise to the Kano browns. This type of historical speculation is difficult to accept without more detailed evidence. The Red Sokoto is the only Nigerian breed for which there is a record of systematic attempts to stabilize a particular type. Henderson (1929), reviewing the work of the Veterinary Services in Sokoto province, described

hot season withn the period of five years, 219,688 non-red male goats were castrated, resulting in the replacement of non-red skins by the more valuable red in the local markets.

The Red Sokoto goat was the source of 'Morocco leather' known in Europe from the medieval period onwards. It acquired this name because it was transported across the Sahara by caravans controlled by Moroccan merchants. The Red Sokoto is still known for its fine leather (Asaolu *et al.*, 2010).

2.5.3 West African Dwarf Goat

Although the West African dwarf (WAD) goat is found in 'many local types' (Ngere *et al.,* 1984), no published account differentiated them. Although, they are stereotypically said to be native to the forest belts, their present in Borno state and in adjacent republics of Cameroon and Chad suggests that they were far more widespread until recently. They correspond to the West African Grassland Dwarf goat described for Cameroon by Ndamukong, Sewel and Asanji (1989). Indeed, like Muturu cattle, they may once have been the main breed of goats over most of Nigeria. Just as the Zebu has replaced the Muturu, so West African Dwarf goats have been driven to remote areas in the Savannah. Bilaspuri and Singh (1993) reported that there is a strong association between the diffusion of the Red Sokoto goat and Islam, so for example, in southern Sokoto state, the non-Islamized populations still retain West African Dwarf goats while Hausa villages have exclusively Red Sokoto goats.

Goats are not native to West Africa, so the West African Dwarf goats must originally have evolved from a long-legged type, probably ancestral to today's Sahel goat. The West African Dwarf is usually black, although patched, pied, and occasionally all-white animals can be seen, even on the coast. Chang & Landauer (1950) argued that the West African Dwarf was a proportionate dwarf, Epstein (1971) pointed out that the distorted forms and extremely short legs

suggest anchondroplasy. This small size is probably an adaptation to the goats' environment, tough the nature of the selective force is unknown. The West African Dwarf goats in the semi-arid zone resemble Sokoto Red goats in their body proportions. Paradoxically, physiologically experiments have shown that the West African Dwarf goat is not particularly adapted to high ambient temperatures (Montsma *et al*., 1985). High temperature and relative humidity, for example, 30ºC and 60% relative humidity cause a reduction in food intake. The West African Dwarf goat is believed to be trypano-tolerant because it thrives to tsetse areas, but there have been no critical studies of this belief. Burns (1965) observed that the skins have coarse, thinly-spaced outer hairs and small sweat and wax glands and that they lack fat. Alaku and Moruppa (1983) found that Red Sokoto goats slaughtered in the driest months suffered a 55% reduction in skin weight, making it 4.9% of the total body weight.

2.5.4 Sub-types and Races

Outside the main centres of its distribution, the colour varies somewhat and various types are recognized, such a Kano Brown and Borno White. The Buduma goat of Chad appears to be the same variety as the Borno White (FAO, 2009). Haemoglobin variants (3 variants and 5 phenotypes) have been reported to differ from the expected proportions, and it had been postulated that these differences are due to differential susceptibilities to helminth infestation (FAO, 2009).

2.6 PHYSICAL CHARACTERISTICS

The Kano Brown, which is a sub-type of Red Sokoto goats, is a medium-sized type with a light brown coat, horn in both sexes (Ngere *et al.,* 1984) and short-haired. The ears are short and carried horizontally. Adult males and females weigh between 23-30 kg weights at withers of about 65 cm (Akinsoyinu, Tewe, Ngere & Mba, 1982). The head is fine with a prominent forehead profile rather short and straight or slightly dished, with black mucous membranes. The male usually

possesses beard of profuse hair. Short ears are of medium width and are usually carried horizontally. The neck is short, thin and very mobile. The chest is rounded and well proportioned. The withers is not prominent, while the back is of medium length. The legs are short and strong, but well-muscled, both fore-and hind limbs. In the female, the udder is of good conformation, well rounded and with well-spaced teats (FAO, 2009).

2.7 MANAGEMENT SYSTEMS OF GOAT IN NIGERIA

Goats are kept in all agro-ecological zones (Payne & Wilson, 1999), but owing to their ability to survive in harsh arid and semi-arid environments, their presence is comparatively higher than other livestock in such environments (Silanikove, 2000). Generally, the production system can be classified into traditional and modern systems (Kisulaka & Kambarage, 1996). The traditional management system is further subdivided into three groups; the extensive (pastoral), the semi-intensive (agro-pastoral) and intensive systems (Kisulaka & Kambarage, 1996).

2.7.1 Traditional Production System

The extensive system

This is the predominant system of management which was commonly practiced by pastoralist under this system, the animals are allowed to roam about to graze all day without any form of supplementation. The system is common in the arid and semi-arid environments, receiving precipitation below 700mm per annum. Due to unreliability of rainfall, crop agriculture is restricted to irrigated areas, where only drought resistant crops such as sorghum, millet and cassava can be grown (Adeniji, 1975). The two sub-systems found under extensive management system are nomadism and transhumance (Kisulaka & Kambarage, 1996). In nomadism, people and animals are constantly moving in search of water and pasture or to avoid diseases and/or tribal conflicts. A good example of this is the Maasai in Kenya and Tanzania (Das & Sendalo, 1989).

In transhumance system, livestock production is associated with rain-fed agriculture and a good example of transhumant tribe are the Fulani in West Africa and the Wagogo and Wasukuma of Tanzania (Ademosun, 1988). Due to the facts that extensive system of management is associated with low inputs, poor husbandry, nutrition, veterinary care and marketing systems, productivity under this system is extremely low and production losses resulting from mortality and growth rates are high (Kisulaka & Kamabarage, 1996).

The intensive system

Under this system, goats are confined in yard and are provided with feed and water within their confinement (zero grazing) throughout the production year (Das & Sendalo, 1989). The system is common in areas with high population density and intense agricultural activity. Scarcity of land and shortage of labour are the major limiting factors for small ruminant production. Animals are stall-fed, stall-feeding is mainly identified with small-holder fattening programme and research institutes (Ademosun, 1988). The system is increasingly being adopted in urban and peri-urban areas. In this system, flock sizes are determined by owner's capital and availability of land. Animals are fed concentrates and grown fodder crops, some time they are supplemented with household wastes. Poor hygiene in stall feeding units may lead to high incidence of endo/ectoparasites and pneumonia (Kisulaka & Kamabarage, 1996). Intensive management system has a high potential for increased productivity, but it is less commonly practiced in Africa (Kisulaka & Kambarage, 1996).

The semi-intensive system

This is the intermediate between intensive and extensive systems, where goats are allowed to graze natural pasture in the day time and housed at night. Supplementary feed is given in form of concentrate. However, tethering of animals is commonly practiced during rainy season so as to

prevent them from destroying crops in the farm. The semi-intensive management system is common in areas with annual rainfall of more than 1000mm and, therefore, suitable for crop production. In this system, animals are kept as an insurance against crop failure and as a source of income (Adeniji, 1975).

2.7.2 Modern Production System

This system of production is highly capital intensive. The system is not commonly practiced in Africa. It is normally identified with government and research institutes. Animals are stall-fed or grazed on improved pasture. Supplementary feeding (concentrate) is often provided. Generally, productivity of animals is high under this system as a result of modern husbandry practice. Some lose may be encountered, if husbandry practices are poor (Kisulaka & Kambarage, 1996).

2.8 REPRODUCTION

Bucks at a very younger age have been reported to exhibit sexual aggressiveness, penile development and permit intromission with good libido under tropical conditions (Bongso, Jainudeen & Sitizahrah, 1982). Intact bucks of Swiss and northern breeds come into rut in the fall as with the doe's heat cycle. Rut is characterized by decrease in appetite and obsessive interest in the does. In addition to natural mating, artificial insemination had gained popularity among goat breeders, as it allows easy access to a wide variety of bloodlines (Bearden & Fuquay, 2000).

2.8.1 Anatomy of the Male Reproductive System

The testes vary from species to species for shape, size and location. They lie side by side in a vertical place in the scrotum. They have two primary functions: to produce male germ cells (spermatozoa) and to produce male sex hormone (testosterone). Each testis is covered with shiny though connective tissue called the visceral viginal tunic (*tunica vaginalis propria*) which was

derived from the peritoneum during testicular descent. Underneath this layer is tunica albuginea testes which gives support to the testis and it surrounds the tortuous blood vessels near the surface of the testic. Attached to the tunica albuginea is a strand of connective tissue called septula testis that connects inwardly to the mediastinun testis. These networks of connective tissues hold the seminiferous tubules and interstitial cells in place and give shape and support to the testis (Wensing, 1968). The seminiferous tubules produce sperm and the interstitial cells produce testosterone. The spermatozoa produced in the seminiferous tubules are passed into vasa efferentia, usually 15 in numbers to the head of epididymis. The epididymis is very long and convulated which connects the vasa efferentia of the testis and the vas deferens (Gier & Marison, 1969).

The epididymis consists of three parts that have no clear demarcation, but change gradually from one part to another. The head (caput), epididymides wraps over the cranisl border of the testis and it form the bulging head of the epididymides. It then continues into the body (corpus epididymides) of epididymis and move ventrally over the body of the testis. As it reaches the ventral border of the testis, it becomes coiled again to from the bulging tail of the epididymis (cauda epididymedes). The deferent duct is long tubular structure that attaches to the tail of epididiymides (Gier & Marison, 1969). It passes dorsally along the medial side of the testis and cranially to the body of the epididymides and then continues into the spermatic cord into the inguinal ring. It then enters into the body and loops over the urinary bladder and enters into the urethra. The terminal ends of deferent duct have thickened walls with some secretory glands called ampullae (ejaculatory ducts) (Gier & Marison, 1969).

2.9 LIVESTOCK PRODUCTION IN SUB-SAHARAN AFRICA

Livestock production contributes substantially to the agricultural GDP in Sub-Saharan Africa (SSA), up to 35% according to Winrock (1992). The population of sheep and goats were

estimated to be 38.5m sheep and 57.8m goats (FAO, 2012). About 30% of all TLU (Tropical livestock units) in tropical Africa can be found in the arid zone, including 90% of the camels, 30% of the cattle and 40% of the small ruminants De Leuw, McDermott and Lebbiee (1995). Most of the livestock in SSA (about 70%) are handled by rural people, who owned and manage multipurpose enterprises in which livestock is an integral part Winrock (1992). Hence livestock production, contributes to food security through direct production of food (Animal products) and non-food functions (Sanon & Kanwe 2004).

Ruminant animals have the ability to convert plant material that is unsuitable for human consumption into high quality food products. Proteins from animal sources are rich in essential amino acids and the use of animal products has been linked to the level of wealth among people. For instance the per capital consumption of meat was 80.3 kg/year in developed countries in 2003, compared to 28.9 kg/year in developing countries. For SSA the figure is even lower, 11.4 kg/year (FAO, 2006).

The greatest contribution of livestock in rural areas in SSA is in the form of non-food functions (FAO, 2012). Livestock are important for crop production through manure and draught power and is a key factor in mixed farming systems. For most smallholder farmers, animal draught power and nutrient cycling through manure compensate for lack of access to modern inputs, such as tractors and fertilizers, and help to maintain the viability and environmental sustainability of the production. In the Sahelian area almost all farmers keep animals, which remain closely associated with the social habits and welfare of the rural households (Winrock, 1992). The use of livestock as gifts, for dowry or slaughtering for traditional feasts or religious ceremonies reinforces family and social links. However, livestock production in SSA faces many constraints, the most important being feed shortage. Livestock use almost exclusively natural pastures as the main feed resource

(FAO, 2009). The productivity of these pastures is subjected to high variability between and within years, related to rainfall and seasons. The increase in human population has led to an increase in cropland area, decreasing the area used for grazing and encroaching on better pastures. In addition, Sahelian countries since 1969, have experienced the appearance in a random way of dry periods and movement of the isohyets toward the south (Grouzis, 1988), which results in rainfall reduction.

The combined effect of dryness and extensive production have resulted in tree mortality, appearance of bare spaces and simplification of the flora composition toward species which are well adapted to harsh conditions, and also the disappearance of some fodder species. According to Powell, Pearson, Hienaux (2004) a specialized form of agricultural production has been prevailing traditionally in the West African dry lands. Crops and livestock were ethnically and operationally separate but functionally linked enterprises, with exchanges of grain, crop residues and water for manure between sedentary crop farmers and migratory pastoralists. However, this form is shown to be under transition Winrock (1992) stressed, and more sedentary, mixed farming enterprises are developing.

2.10 CONTRIBUTION OF GOATS TO NIGERIAN ECONOMY

Goat production is an important component of the Agricultural production in Nigerian economy. The nation's meat supply is almost exclusively derived from livestock (Rosiji & Iposu, 2002) and other roles includes, enhancing human nutrition, increasing the level of employment and improving the capacity of economy to generate and sustain increase personal income as well as export earnings.

Goat rearing has been recognized in Nigeria as an integral part of the socio-cultural life of the people and hence production system remains largely traditional. Goat is important to small holder’s production system because they require low initial capital and maintenance cost; they are

able to use marginal lands and browse plants; they produce milk and meat in readily useable quantities and they are easily cared for by most family members (Powell *et al.,* 2004). Ranjhan (2001) reported that in many part of the world, goat have adapted to the local environment over years of natural and planned selection which led to the development of many different breeds.

2.11 FEEDING AS COSTRAINTS TO GOAT PRODUCTION IN NIGERIA

Goat being a selective feeder balances its nutritional requirement through grazing on good pastures where grazing lands are available. Gefu (2002) reported that goat production in Nigeria has been characterized by low productivity due to poor management practice, diseases as well as seasonal variation in feed supply. Poor feed resource causes progressive weight loss and decreased fertility a well as milk yield for up to 4-5 months of the year. The severity and duration of low quality feed differ from one place to another within the country. Annual burning of native grasslands, further worsen the ecology and its available feed resources thereby drastically reducing the amount of forage for livestock feeding (Ogundipe, 2002). It has been observed that a combination of these factors, low quality roughage and bush burning significantly reduce the biomass available in quantity and quality that lead to weight losses ranging from 300 to 400g per head per day for cattle (Aregheore, 2001) and up to 15% of body weight in goat.

2.12 NUTRITIONAL REQUIREMENTS OF GOATS

Nutrition plays a major role in the overall productivity, health, and well-being of the goat flock. Costs of feed account for approximately two third of the total cost of production of most farms (Collier, Rhoads & Baumgard, 2008). Nutrient requirements of goat varies depending upon the age, body weight, and stage of production. The five major categories of nutrients required for goat includes, Water, energy, protein, vitamins and minerals. Gimenez (l994) reported that the most common limiting factor in small ruminant nutrition is energy, however, energy shortage

result in decreased production, reproductive failure, increased the level of mortality and increased susceptibility to diseases and parasites. The most plentiful feed available are the best sources of energy, however, sheep and goat are often underfed, Poor-quality pastures and roughages or inadequate amounts of feed are the primary causes of energy deficiency, the major sources of energy for small ruminants are browse plant, pasture hay, and grains (Cupps, 1991). It should be noted that, the quality of protein in the diets is more important than the quantity of feeds offer.

The principal nutrients of all feeding stuffs are water, organic and inorganic mineral matters, crude protein, ether extract, crude fiber and nitrogen free extract (Benerjee, 2007). The nutrients of primary importance in goat are water, energy as measured by total digestible nutrient (TDN); metabolizable energy (ME) or net energy (NE), protein, ether, crude or digestible protein, minerals and vitamins (Aduku, 2004).

2.12.1 Water Requirements

Water is one of the most vital of all nutrients (Aduku, 2004). It is an ingredient or food because it is an indispensable component of a diet as it is tangible, visible, aids swallowing and settles appetite. It is also a nutrient because it is involved in metabolic reactions at cellular level. It is a component of the cell where it gives turgidity and shape to body (Benerjee, 2007). In general, it makes up about two thirds of the fat free animal body weight (water content of the fat free adult body is relatively constant) for many species averaging 93% of total body weight. It is 65-73 % of muscle (Aduku, 2004) and several factors affect water consumption. More water is consumed at high environmental temperature or if dry feed, protein or salt feed is consumed. High water content of feed reduces water requirement.

Goat do not need daily watering in the wet season and watering once a day suffices in the dry season (Aduku, 2004). The production state in the animal such as lactation requires much

water. The consumption of protein feeds by mammals without water hastens death as a result of accumulation of toxic end products such as urea more water is required to dilute it to a harmless concentration and to remove it from tissues and to excrete it (Aduku, 2004).

Goat can lose weight and many other constituents of their body tissues, but a loss of one tenth of the water in the body is lethal. Benerjee (2007) further indicated that dry, non-lactating, non-pregnant female and male West Africa Dwarf sheep and goats need approximately 1.1 kg total water intake per kg-DMI for maintenance.

2.12.2 Energy Requirement

All animals require energy and the amount required depends on the physiological state of the animal (Benerjee, 2007). Adequacy of energy in a ration may be based on digestible energy (DE) total digestible nutrient (TDN), metabolizable energy (ME) and net energy (NE) (Ogundipe, 2002). Energy affects the utilization of other nutrients and overall productivity. The maintenance requirement for energy in goat is similar to the requirements for sheep (Benerjee, 2007) and it is 725.8g starch equivalent per day per 100kg live weight.

For live weight gain the energy requirement would be 3.0g per kg live weight gain. Additional energy is needed in the diet for increased activity, type of terrain, amount of vegetation or range and distance traveled to get feed (Benerjee, 2007). Stall fed goat with minimum activity need a maintenance level of energy in the diet about 25%. Goat on hilly, semi-arid range land need an increase of about 50% above maintenance requirement (Banerjee, 2007). Goat gain weight faster when more energy is provided in the diet. Energy· deficiency cause growth retardation, delayed puberty, decrease in fertility rate and also lower milk production, as the level of energy deficiency increases, goat may lose the strength of resistance to infectious and parasitic diseases (Banerjee, 2007). Energy for growth has been found to be 7.25 kcal ME/g gain which is equivalent

to 4.09 kcal ME (ARC, 1990). Energy requirements of kids at 10, 15,20,25 and 30 kg body weight and growing of 50 g/day was found to be 275, 350,400,450 g and 500 g TDN, respectively (Benerjee, 2007). For maintenance, average energy requirement has been found to be 105.12 kcal ME/kg $W^{0.75}$ per day for pregnancy energy requirement varies between 194.7 and 228.5 kcal ME/kg $W^{0.75}$.

2.12.3 Dry Matter Intake

Dry matter intake is essential to satisfy an animal's appetite and to permit the proper functioning of the digestive tract. According to Ogundupe (2002), animals have certain physical and physiological limitation to dry matter consumption, the dry matter consumption of most farm animals fall between 2.5 and 4.0 kg percent of body weight. The exact amount depends on the roughage to concentrate ration, goat can consume less feed compared to sheep this is probably due to fact that goat balances its nutrients requirement. Dry matter consumption of 2.5-3% was observed for goat and sheep while cattle was up to 11% body weight (Benerjee, 2007). Maigandi and Wasagu (2002) and Abubakar (2004) reported that, apart from diseases and environmental factors other factors significantly affect the dry matter intake which includes, availability of feeds, palatability moisture content and amount of fibrous material present in the feed.

2.12.4 Minerals and Vitamins Requirements

Mineral mixture is added to the concentrate at a 2% level of the macro minerals that have been shown to be supplemented in goat (sodium chloride), calcium, phosphorus and sulphur. This level of mineral supplementation depends on the age, species of animal, quantity and quality of feed, management system adopted and type of production (Aduku, 2004). The recommended level of sodium chloride (salt) is 0.5% of the ration while the recommended ration of calcium to phosphorus ranges from 2:1 to 4:1 (Aduku, 2004). Calcium and phosphorus are virtually the only

two major minerals that are likely to be in short supply and so, more attention should be paid on them in the ration of small ruminants (Ogundipe, 2002). Trace elements like copper, cobalt, Zinc, Iodine, manganese, and Iron deficiency of each of these minerals could precipitate peculiar deficiency, disease like, animal skeletal deform, ataxia, dermatitis and hoof deformation (ARC, 1990).

Ogundupe (2002) reported that, ruminants under different management systems may be exposed sometimes to the danger of mineral deficiency and/or over intake of some minerals (Aduku, 2004). However, it is important to know the effects of minerals deficiency on performance and health of the animals even before clinical signs are evident Aduku (2004). Goat on range or pasture got enough vitamins. Vitamin supplement may be necessary for goat during lactation, they already exist in feedstuff but not in enough amounts for economic animal production. Some cannot be synthesized by the animal and most be obtained exclusively from the diet. In general there is no cause for noticeable deficiency due to shortage of vitamins, under normal feeding practice (Ogundipe, 2002) it is however essential for normal development, growth and maintenance.

2.12.5 Protein Requirements

All animals require protein for growth, reproduction and production, the amount required depends on the physiological state of the animals. Many of the feedstuffs commonly used in ruminant livestock production are deficient in protein (Ogundipe, 2002). According to ARC (1990), the recommended level of crude protein for growing goat and sheep is in the range of 16 to 18 %. Banerjee (2007) reported that a minimum level of 6 % total protein need to be provided in the diet of sheep and goat otherwise feed intake will be reduced, resulting in reduced rumen activity and lowers the efficiency of feed utilization. According to the author, small ruminants on range need high levels of protein in the diet than the stall fed ones because of the increased activity

required to get feed. Urea (non-protein nitrogen) may be used to replace part of the protein needed in the diets of goat. Protein deficiency symptoms in goat includes anorexia, loss of weight, poor hair growth, depressed milk yield and impaired reproduction Warren, Martz, Asay, Hilderbrand, Payne and Vogt (1974). Severe deficiencies can lead to digestive disturbance, anaemia and/or edema (Benerjee, 2007).

2.13 GOAT RESPONSE TO ENVIRONMENTAL STRESS

The heat stress response is a highly conserved cascade of protein activation and altered gene expression in response to a variety of stressors (Collier *et al.,* 2008). Like humans, animals can succumb to disease or fail to reproduce or develop properly when exposed to prolonged periods of high heat (Moberg & Mench, 2000). Animals respond to stress in a variety of ways and individual animals can deal with stress better than others. As environmental temperature changes, homotherms must act to maintain body temperature. In order to maintain a constant body temperature, thermal exchanges between the environment and the animal must be present. These exchanges include both convective and evaporative heat exchanges (Finch, 1986).

2.13.1 Body Temperature

Body temperature follows a diurnal pattern that follows shortly behind that of environmental temperature. Body temperature has been used as a method of assessing the physiological response of an animal to the climatic environment, especially when cattle are exposed to hot conditions (Gaughan, Holt, Hahn, Mader & Eigenberg, 2010). The consistency of an animal's core body temperature is an indication of how well an animal balances heat production and heat losses (Brown-Brandl, Nienaber, Eigenberg, Hahn & Freetly, 2003). Rumen temperature has been shown to exceed rectal temperature by about 2℃ when goat browse on dry feed especialy during a prolond dry season with little or no water (Mader, Davis & Brown-Brandl, 2006).

However, rumen temperature has been shown to follow actual core body temperature relatively well (Beatty, Barnes, Taylor & Maloney 2008). Body temperature has been shown to follow a diurnal pattern tracking in the same pattern as ambient temperature. Rectal temperature has been shown to have a lag time of 4 - 5 hours after peak environmental temperature (Brown-Brandl *et al.,* 2003). Furthermore, a study conducted by Harris, Johnson, George and McDougals (2002) concluded that solar radiation was of considerable importance as a direct cause of increased animal body temperature. There are many factors that affect body temperature in goat. In order to maintain a constant body temperature, the animal must lose the same amount that is gained through metabolism and the external environment. Finch (1986) suggested that heat gain from solar radiation and metabolism usually exceeds heat-loss from radiation, convection and evaporation during the daytime, when temperatures are high, resulting in heat being stored as evidenced by increased body temperature. This stored heat must then be lost during the night when heat can be more easily dissipated from the animal (Marai *et al.,* 2007). However, when environmental conditions during the night are unfavorable to heat transfer from the animal to the environment the animal fails to lose stored heat and is then more vulnerable to heat stress during the following day. The ability of cattle to lose body heat at night is dependent not only on ambient temperature, but also on atmospheric moisture levels or relative humidity (Mader, 2003).

2.13.2 Physiological Response

Sivakumar, Singh and Varshney (2010) measuring an animal's body temperature to assess environmental stress is not always feasible specifically in commercial settings. A viable alternative to using body temperature to assess an animal's heat load is to measure the animals observed behavior responses to environmental conditions, such as panting score and respiration rate (Mader *et al.,* 2006). Respiration rate has been shown to be a good indicator of an animal's heat load.

However, a lag time between maximum ambient temperature and respiration rate of about 2 hours exists (Gaughan *et al.,* 2010). Therefore, in order to get an estimation of the heat load experienced by animals, respiration rates must be taken at least 2 to 3 hours after the hottest part of the day as this is when maximum respiration rates will be observed.

The effect of ambient temperature on respiration rate can be affected by numerous things. Respiration rate is influenced by age, sex, genotype, level of performance, nutrition, time of feeding, as well as previous exposure to hot conditions (Gaughan *et al.,* 2010). As environmental conditions place a greater heat load on an animal, the animal must compensate in order to remain in thermal equilibrium. Cattle compensate for increased environmental heat load by increasing respiration rates and panting. Therefore, respiration rates follow the diurnal patterns of ambient temperature (Brown-Brandl *et al.,* 2003).

2.13.3 Metabolic Response

Heat shock proteins (HSP) are family of proteins found in most living cells. These proteins are present in both prokaryotic and eukaryotic cells, and their high level of conservation, they played an important role in fundamental cell processes (Kregel, 2002; Gutierrez & Guerriero, 1995). Stress-induced accumulation of Heat shock proteins (HSP) have been associated with thermo tolerance, or the ability of a cell or animal to survive, otherwise lethal heat stress (Moseley, 1997).

The mechanism by which these proteins grant stress tolerance is not well understood; however, (Moseley, 1997), relate the important role of HSPs in the processing of stress-denatured proteins. Some HSP have been linked to the production of certain metabolites in the blood. Heme oxygenase (HO) is the rate limiting enzyme of heme catabolism and has been shown to have an

inducible form (HO-1) which is a member of the HSP32 family (Tomaro & Batlle, 2002; Attuwaybi *et al.*, 2004).

Bilirubin is derived from biliverdin which is produced from hemi degradation and has previously been thought of as a cytotoxic metabolite because of its role in jaundice in neonates and its possibility of provoking disabling and irreversible brain damage at high concentrations. Recently, it has been discovered that bilirubin may actually play an important physiological role as a powerful anti-oxidant whose activity may surpass that of α-tocopherol (Yamaguchi *et al.,* 1996; Tomaro *et al.,* 2002; Attuwaybi *et al.,* 2004). Therefore, it can be speculated that the products from this enzyme play an important role in the heat tolerance of the animal's gastrointestinal tract.

Bilirubin is filtered from the blood by the liver where it is then attached to sugars, most commonly, glucuronic acid forming conjugated bilirubin (Kurosaka, Senba, Tsubota, & Kondo, 1998). Under normal physiological conditions, some of these bilirubin conjugates then escape from the hepatocyte and into the serum where they can be measured in the blood serum as direct bilirubin. This direct bilirubin, when measured accurately, then correspond to changes in conjugated bilirubin concentrations within the liver. After conjugation, this conjugated bilirubin is then excreted in bile by the liver via the bile duct and into the small intestine (Harrop & Guzman-Bown, 1930).

It is suggested by Harrop and Guzman-Bown (1930) that neonatal jaundice, or high bilirubin levels in the blood, can occur from diminished bilirubin excretion which is primarily the result of immature conjugative capacity. This would suggest that an increase in conjugated bilirubin concentration in the liver leads to increased excretion of bilirubin though the bile duct further suggesting bilirubin's importance in intestinal integrity. Bhiyan, Ismail, Abdel-Latif, Hassan and Salem (2006) noted a depression in hematocrit and erythrocytes in cattle subjected to

elevated ambient temperatures. Hematocrit concentration seemed to drop in dairy cows exposed to hot environments. This finding was in fact attributed to a decrease in circulating erythrocytes. Bhattacharya and Uwayjan (2005) observed significant effects of temperature on hemoglobin, albumin, and blood urea nitrogen concentration in dairy cattle when exposed to cool, intermediate, and hot environments. The observed reduction in red blood cells and hemoglobin was attributed to the decrease in cellular oxygen that in turn, reduces the animal's metabolic heat load. Therefore, the oxygen binding capacity of the blood is decreased when the animal is under heat stress conditions (Bhattacharya & Uwayjan, 2005).

2.14 SPERMATOGENESIS IN BUCK

Spermatogenesis is defined as the process of formation and liberation of spermatozoa from the undifferentiated germ cells in the seminiferous tubules of the testis (Alexander & Willian, 2000). The spermatozoa undergo maturation in the epididymis where they are stored until ejaculation takes place, sperm production takes 49 days in buck. Testicular size is a good indication of a buck's sperm producing ability. Palpation of the epididymis is a useful guide for determining sperm reserves. During spermiogenesis, the last phase of spermatogenesis, the spermatids undergo a metamorphosis, which is defined as the process by which spermatids undergo changes in morphology to form spermatozoa. During this phase, spermatids are attached to the sertoli cells. After metamorphosis, the newly formed spermatozoa will then be released from sertoli cells through the process called "spermiation" and be forced out through seminiferous tubules into the rete testis. From the rete testis, spermatozoa are forced to epididymis via vas-difference (Bearden & Fuquay, 1997), the process of sperm formation is continuous and the inactive spermatogonia commence division about 7 days after the previous cycle.

2.14.1 Sperm Maturation, Transport and Storage

Spermatozoa are flushed out of the seminiferous tubules to the caput epididymis in the rete testis fluid, secretion by the sertoli cells (White, 1973; Setchell & Brooks, 1988; Alexander & Willian, 2000). Testicular sperm are infertile and must undergo maturation changes in the epididymis to acquire fertilization capacity. Both the capacities for fertility and motility are acquired in the corpus epididymis (Fournier-Delpech, Colas, Courot, Ortawart, & Brice, 1979). The most obvious morphological changes as spermatozoa move from the caput to the cauda epididymis is the movement of the cytoplasmic droplet from the neck of the sperm down the tail, and its eventual loss.

There are subtle changes in the sperm plasma membrance while the nuclear chromatin becomes more stabilized through formation of disulfide linkages. Transport of spermatozoa from the seminiferous tubules through the efferent ducts to the caput epididymis seems to be achieved partly by rete fluid pressure and partly by ciliary and peristaltic movement in the duct (Fournier-Delpech *et al.,* 1979). Most of the rete fluid is reabsorbed in the caput epididymis but additional compounds are added as the spermatozoa pass down the epididymal duct, the cauda epididymis acts as storage organ for spermatozoa.

2.14.2 Sperm Output

Dombo (2002) reported that sperm is carried in a fluid from the epididymis, along tubes to the vesiculae seminales, where they are mixed with other secretions from various glands, before passing into the urethra for ejaculation. During ejaculation, spermatozoa are transported through the ductus deferens, ampullae, pelvic urethra and penis. Sperm from the ampullae are mixed with accessory secretions in the pelvic urethra. The relative contribution of the accessory organs to the seminal fluid differs between species. In the bull, the vesicular gland contributes about half of the

ejaculate while the bulk of the seminal fluid in the dog is contributed by the prostrate. In the boar, the Cowper's or bulbourethral glands produce the gelatinous mass forming the post-sperm fraction (Derek, 1971).

2.14.3 Hormonal Control of Spermatogenesis

Bearden and Fuquay (1997) and Dunn (2002) reported that the initiation of spermatogenesis is under the control of the hypothalamus. The reciprocal action of FSH, LH and testosterone is necessary for the maintenance of spermatogenesis (Salisbury, Van Denmark & Lodge 1978; Bearden and Fuquay, 1997; Kilgour, Pisselet, Dumbols, Courot & Sairam (1984) reported that FSH is necessary for the establishment of the normal population of Sertoli cell and the stimulation of the production of androgen-binding protein from the Sertoli cells. Androgen-binding protein binds with the testosterone making it available for its functions in spermatogenesis (Bearden & Fuquay, 1997).The principal role of LH in the formation of spermatozoa appears to be in the stimulation of the release of testoterone from the Leydig cells that in turn act through the cells in seminiferous tubules to stimulate spermatogenesis.

2.15 FACTORS AFFECTING SPERMATOGENESIS

2.15.1 Temperature

King (1993) reported the testes of the domestic animals to be susceptible to damage if the body temperature rises above normal, which could occur due to raised environmental temperatures. Testicular temperature must be 4-5^{o}C (Coulter, 1988; Coulter & Kastelic, 1994; Dunn, 2002) lower than the body temperature for normal spermatogenesis to occur. McDowell (1972) reported the critical period for the inhibition of spermatogenesis to be 29.4^{0}C under conditions of continuous exposure. Higher temperature alters the scrotal thermo-regulatory mechanism. This will increase the scrotal temperature leading to the damage of primary

spermatocytes, spermatids and spermatozoa (King, 1993; Bearden & Fuquay, 1997). Exposure of the testes to cold seems to be less damaging. Even if the testicular temperature decreases, the animal usually maintains a scrotal temperature through scrotal thermo-regulation by pulling the testes up close to the body. Spermatogenesis is also extremely sensitive to the effect of ionizing radiation and also to the humidity above 50% which destroy the dividing spermatogonia (Hafez, 1974; King, 1993).

2.15.2 Nutrition

The effect of nutrition on buck fertility before and after puberty is manipulated via the effect of the dietary constituents on the hypothalamic-pituitary axis, which may affect testicular development (Brown, 1994). Malnutrition, particularly low energy intake in males, can also impair spermatogenesis. Cupps (1991) reported circulating testosterone to often be decreased by reduced feed intake. Mann and Lutwak-Mann (1981) associated this reduction with the reduced gonadotrophin (LH and FSH) concentration, coupled with reduced sensitivity of the accessory sex gland to testosterone, which in turn may affect efficiency of spermatogenesis.

King (1993) reported that the testicular tissue is susceptible to vitamin A and E deficiencies. This deficiency acts by depressing gonadotrophin secretion by the pituitary gland (Brown, 1994). Dunn (2002) reported that vitamin A and E deficiencies may cause degeneration of the germinal epithelium and testicular degeneration, which may lead to the cessation of spermatogenesis.

Deficiencies in zinc and molybdenum retard testicular growth as a result of the reduced pituitary and gonadotrophin output, which affect spermatogenesis and semen output (Cupps, 1991). Oldham, Adams, Gherraldi, Lindsay & Mackintosh (1978) reported that a reduction in weight of the testes is generally more marked than a reduction in body weight of domestic animals.

Dichlorobromopropane which is used to destroy soil nematodes, has been shown to cause testicular atrophy in rats (Ahmad, Wisner & Warren, 1988) and abnormal testicular biopsies (Biava, Smuckler & Whorton, 1987) which affect spermatogenesis. Other compounds are sulphosalazine and gossypol, which are used in the treatment for ulcerative colitis in humans. In domestic animals, O'Morian, Smethrust, Dore & Levi (1984) reported that compounds of this nature are found to affect sperm maturation rather than affecting spermatogenesis directly. Another element, which has a very dramatic effect on the testis itself, is cadmium. Salts of this metal are reasonably toxic to the kidney and liver and also cause an extreme increase in vascular permeability in the testis of mammalian species, which leads to the stoppage of blood and subsequent necrosis of the testis (Setchell & Brooks, 1988).

2.16 METHODS OF SEMEN COLLECTION

Collection of semen involves the proper scheduling and sexual preparation of the male as well as the proper use of the collection technique. Cole and Cupps (1977) reported that during semen collection, many sources of sperm losses occur including losses before and during collection and during handling. It was also indicated that the efficiency of semen collection depends mostly on the daily sperm output, effect of sexual preparation, increasing sperm output and also decreasing the sources of sperm losses. If semen collection is to be accomplished within a reasonable period of time, it should be well organized (Zemjanis, 1970).

Collecting semen from different species requires different collection techniques. Such methods include the use of artificial vagina (AV), electro-ejaculator and rectal massage (digital manipulation). Semen are mostly collected in rams and bucks by the use of AV and electro-ejaculator (Sakesena & Salmonsen, 1982)). Irrespective of the method used, collection of semen requires appropriate facilities in order to prevent injuries to the animals and their handlers and the

contamination of the ejaculate that may affect the quality of the sample collected (Salisbury *et al.,* 1978).

2.16.1 Artificial vagina

Bearden and Fuquay (1997) reported that artificial vagina is the fastest and the most sanitary method and it provides a good imitation of the natural vagina. A professor of human physiology at the University of Rome, Giuseppe Amantea was the first to invent artificial vagina in 1914. He designed it for collecting dog semen (Taylor and Thomas, 2001). Russian scientists began to imitate his innovative idea to construct various models for specific species such as for stallion, bull and ram (Taylor & Thomas, 2001).

Artificial vagina consists of an outer thick, canvas-reinforced rubber cylinder about 30cm and 6.5 cm in diameter through which is passed an inner liner of latex or artificial rubber which is reflected back at each end and bound firmly to the casing to form a water jacket. Water of the required temperature is introduced through a stopper molded into the outer casing. A rubber cone is attached to one end and a graduated glass collecting tube of about 15 ml capacity is inserted into its narrow end. The cone must be securely bound unto the casing and the cone must fit tightly over the mouth of the collecting tube using ring or a rubber castrator ring. The artificial vagina is filled with water at 44-46ºC. Enough water is included to produce a satisfactory pressure on the penis where it is inserted. A little lubrication in the form of soft paraffin is applied to the mouth of the artificial vagina with a glass rod. A protective cover of sponge materials is fitted over the collection tube and a jacket to cover the tube and cone in order to protect the semen from cold shock, damage and breakage. Semen is collected into a collecting receptacle attached at the end of the artificial vagina (Mason, 1988)). The size of artificial vagina used is very essential and if more than one ejaculation is required, more than one vagina should be used (Rao & Haranath, 1984).

2.16.2 Electro-ejaculator

The electro-ejaculator was first developed by Gunn in the late 1940s for collecting semen from bulls and rams (Taylor & Thomas, 2001). The method is also used for collecting semen from uncooperative or crippled males which lack the libido or ability to mount or from bulls in which health problems limits their physical abilities (Cupps, 1991; Bearden & Fuquay, 1997). Zemjanis (1970) reported that the success of using of electro-ejaculator is highly dependent on efficient experience of the operator that handles it. It is an electrical device that is inserted rectally into the bull, ram or buck. An electrical current, ranging from 0 to 3 in voltage with low amperage of 0.5 to 1.0 is used to stimulate the nerves which cause ejaculation. The device itself is made up of a bipolar electrode and a source that allows the collector to alternate the current to be passed through. It has been adapted for use not only in the common piece of domestic animals but also on various laboratory animal including lower primates (Zemjanis, 1970). The volume and the sperm cell concentration of a sample are influenced by the intensity and duration of stimulation (Robert, 1971).

It has the advantage of using unrestrained rams and it is particularly valuable as a screening test of the semen quality of large numbers of rams. Semen samples collected by electro-ejaculation are adequate for semen evaluation (Zemjanis, 1970). It was further reported that this technique causes side effects such as over-extension, kyphosis, slipping and a marked pain response by the animal.

2.16.3 Rectal massage

Rectal massage is the manual manipulation or stimulation of vesicular gland, ampullae and pelvic urethra that resulted in the protrusion of the glans penis and subsequent release of seminal fluid (Sekoni, 1981; Barth & Okon, 1989). The most important advantage of this method is that it

allows rapid semen collection, however accompanied by contamination of semen with urine (Sekoni, 1981; Page, 2002).

2.16.4 Recovery

It is done after normal copulation. An insemination catheter with an attached suction bulb may be inserted into vagina following ejaculation and, semen is then siphoned into it. The semen recovered using this method may be used for e valuation as it is contaminated with the fluids of the female tract. However, it may also be used for AI in the same animal where the cervix is obstructed (Sorense, 1979).

2.16.5 Sponge

This is one of the most important method for semen collection in tropical Africa. The sponge may be used to recover the semen by placing it in the vagina prior to copulation and the removed afterward to obtain a semen sample (Sorense, 1979).

2.16.6 Spooning

A long-handle sterile spoon is used to recover the semen from the floor of the anterior vagina after copulation (Sorense, 1979).

2.16.7 Blotting

This is another method of semen collection, blotting the vagina after copulation is used in sow. this method involves placing the flat microscope slide against the lips of the vulva, immediately following dismounting of the boar and sampling the semen from the vagina. The volume of semen may be small, but may be used for semen evaluation (Sorense, 1979).

2.17 SEMEN EVALUATION

Semen analysis comprises a set of descriptive measurement of spermatozoa and seminal fluid parameters that help to estimate semen quality (Cameroon, Murphy & Oldman, 1998). The

ideal method of evaluating the fertility of a breeding male other than his ability to produce pregnancy is by the examination of its semen (Sekoni, 1993). Several techniques which are based on physical, morphological and biochemical examinations are utilized for the assessment of semen quality and there are lots of reviews on the subject. Conventional semen analysis includes measurements of particular aspects of spermatozoa such as concentration, motility and morphology of seminal plasma. Quantification and identification of non-spermatozoidal cells and detection of antisperm antibodies are also parts of basic semen analysis (Comhaire and Vermeulen, 1995).

Spermatozoa were first described by Leeuwenhoek in the 17th century but it was not until 1928 that the sperm count was found to be associated with fertility potential (Seibel & Zilberstain, 1995). Since that time a variety of sperm tests and semen parameters have been developed with the hope of clarifying whether or not a man or animal could impregnate their partners.

Normal semen is an admixture of spermatozoa suspended in secretions from the testis and epididymis which are mixed at the time of ejaculation with secretions from the prostate, seminal vesicles, ampullae and bulbourethral glands. The final composition is a viscous fluid that comprises the ejaculate (WHO, 1992).

2.17.1 Appearance and volume

To avoid cold shock during collection, semen sample should reach laboratory below body temperature and should have opaque appearance indicative of high sperm cell concentration. Average volume of semen ejaculate varies greatly with species; bull (4 ml), and ram (1 ml). However, volume and density are inversely related (Dunn, 2000). In general, smaller size and

young animals within a species produce smaller volumes of semen. Frequent ejaculation results in lower average volume and production of immature spermatozoa.

2.17.2 Sperm concentration

The determination of approximate number of spermatozoa per milliliter of semen is extremely essential because it is a highly variable semen characteristic.When combined with the volume of the ejaculate, this quantity of spermatozoa determines how many females can be inseminated (Zaneveld & Polakoski, 1977).

2.17.3 Sperm morphology

Most semen contains some abnormally formed spermatozoa. However, this is not associated with lower fertility rates until the proportion of abnormal sperm exceeds about 20%; though, some types of abnormalities are not associated with infertility. Observations of normal and abnormal forms are made and the percent of each type is noted. The normal and abnormal spermatozoa can be distinguished using slides prepared with eosin–nigrosin for studying live/dead sperm proportions (Melrose, 1970). Several stain mixtures have been used to estimate the percentage.

The morphology of sperm cells is a major criterion in semen evaluation, because deformed sperm cells (i.e. deformed head and tail) tend to be incapable of fertilization of ova (Evans & Maxweil, 1977). It may be a basic indicator for predicting the fertilizing ability of spermatozoa, based upon correlation between particular categories of spermatozoa and fertility results (Lukaszewicz, 1998). Sperm morphology can serve as an indicator of some disorders in spermatogenesis. Morphological examination of spermatozoa for abnormalities or damage due to processing is carried out on stained smears under the microscope. The normal sperm cell consists of a head, neck and tail. The head is morphologically simple with a cone-shape acrosome. The

neck region, which joins the head with the tail segment, is formed by a centriolar complex. Surrounding the centriolar complex is the midpiece. All semen samples contain a proportion of abnormal cells (Sekoni, 1981).

Primary abnormalities originated in the testis during spermatogenesis (during the development of the testicular tubules) while secondary abnormalities originated in the epididymis, due to changes taking place during storage in the epididymis (Rao, 1980). The designation of primary and secondary abnormalities refers to the origin of the defect and not to the severity of the defect. Tertiary morphological abnormalities are those arising from poor handling techniques. Elliott (1978) recommended not tolerating more than 20% abnormalities of sperm head and/or mid-piece in routine artificial insemination practice. Causes of abnormalities include nutrition, heat stress or high temperature, genetic factors, high humidity and diseases.

Supravital staining is used for the estimation of percentage of live and dead spermatozoa (Dott & Foster, 1972). Unstained samples may be observed by phase-contrast or differential-interference-contrast microscope (Jones, 1973) or may involve freeze-etching techniques utilizing the scanning electron microscope (Fruend & Rudolf, 1974).

2.17.4 Sperm motility

Sperm motility describes the ability of sperm to move properly towards an egg. It is commonly believed to be one of the most important characteristics for evaluating fertility potential of sperm ejaculate. The speed of sperm is known as the rate of motility, or forward progression, and is often judged on a scale of one to five (Prien, 1991). Insufficient sperm motility is a common cause of sub-fertility or infertility. Motility is also expressed as a percentage of cells that are moving under their own power through locomotion of the tail. Various methods of semen analysis

have been developed to provide objective assessment of sperm motility; however, the simplest of these involve a visual appraisal of the percentage of motile sperm and the quality of the motility of individual cell. The sperm cells in the ejaculate or dilute suspension is estimated under several fields using light microscope. A pre-warmed stage of 37^{o}C to 40^{o}C and a high power 40 x microscope should be used in estimating the percentage of progressive motile cells. Fresh semen diluted with enough physiologic solution such as normal saline should be dropped on microscope slide so that each cell is visible (Hafez, 1987).

The activity of the spermatozoa may be electrically measured as changes in electric impedance between a pair of platinum electrodes placed in the semen. Although very subjective, the estimation of motility of spermatozoa under cover slip is perhaps the most common of the physical tests (Osinowo, 1992).

2.17.5 Live and dead spermatozoa

The proportion of live to dead can be estimated by supravital staining with a stain mixture such as nigrosin-eosin. The cells that were alive when the stain was applied exclude the stain, and the dead cells stain red with eosin against the dark nigrosin background. The results are highly correlated with progressive motility of sperm cells (Cole & Cupps, 1997). Investigators obtained significant correlation between conception rates and live/dead count, motility rating and impedance change frequency. Munro (1961) observed reduced fertility in samples with live spermatozoa counts of less than 70%.

2.17.6 Semen pH

The pH of semen is determined by acidic secretions of the prostate and alkaline secretion of the seminal vesicles. Haugen & Grotmol (1998) reported that the mean pH values are well above

8.0 regardless of the method of analysis. The time of examination has suggested that the range of normal values needs to be reexamined. To obtain semen pH, pH paper range 6.1 to 10.0 is used.

2.18 SEMEN QUALITY

Semen quality is a measure of the ability of sperm to successfully fertilize an ovum. Semen quality data are required for successful artificial insemination and semen handling techniques. Sperm production and quality can be affected by both animal size and physiological status. Farm animals which are selected for the production of meat and milk are held for commercial and not for emotional purposes. In such animals (cattle, swine, poultry, rabbits, sheep and goats), a rigorous selection for fertility has been performed in males leading to sires with outstanding semen quality (Rodriguez-Martinez, 2000).

2.19 FACTORS AFFECTING SEMEN QUALITY

2.19.1 Nutrition

Semen quality and quantity are the major factors of concern in reproduction and can be adversely affected by malnutrition. There is evidence that the effect of nutrition on semen quality is mediated via the effect of dietary constituents on the hypothalamic-pituitary axis, although there are also some indications that dietary changes affect the testis growth indirectly (Brown, 1994). A restricted diet is associated with a decrease in the release of LH and FSH, which affects semen production and quality through the effect on testicular size (King, 1993). Similar results have been also reported by Oldham *et al.* (1978) where the level of nutrition is associated with a reduction in testicular size which in turn affects the production and quality of spermatozoa. A low plane of nutrition suppresses the production of gonadotrophin by the pituitary gland and the secondary sex hormones, so that atrophy of the prostate and seminal vesicles occurs thereby affecting semen quality interms of fluid volume and concentration. During the period of nutritional stress, the

animal body secrets adrenocorticotropic hormone (ACTH) which in turn stimulates the secretion of glucocorticoids which lower the circulation of secretion of FSH and LH and hence inefficient spermatogenesis and poor semen quality (Bearden & Fuquay, 1997).

Rams receiving high energy diets were better in terms of body condition, semen production, and scrotal circumference and gonadotrophin output than those on low energy diets (Alkass & Bryant, 1982). Nutrition influences testicular growth, sperm production capacity and fertility, particularly in the tropic where there is seasonality in the quantity and quality of feed.

Age at first ejaculate, number of ejaculates and number of spermatozoa were significantly correlated with nutrient composition in a study of young bulls fed ad-libitum and those given approximately 29% nutrients, though other semen characteristics were reported to be unaffected by nutritional differences (Mudra, 1974). In many species, a selenium deficiency affects the morphology and motility of the spermatozoa and may be linked to the sub-fertility in many domestic animals. The spermatozoa membranes are attacked by the increasing formation of oxygen reactive species which lower the viability and fertility of the spermatozoa (Irvine, 1996). Selenium increases the formation of anti-oxidant glutathione peroxide activity, which decreases the reactive oxygen species and hence increase in spermatozoa viability and fertility (Bar & Radde, 2009).

Underwood (1981) reported that zinc is responsible for larger semen production as it is involved in the nucleic acid and protein metabolism for production of the sex hormones, including testosterone and GNRH. Underwood and Sommers (1969) indicated that zinc requirements for spermatogenesis are greater than the requirements for body growth, so a deficiency may alter spermatogenesis and lead to a high proportion of abnormal spermatozoa. Zinc deficiency affects the morphology and abnormalities in semen since it is associated with the attachment of the head

to the tail. Bar and Radde (2009) reported that zinc deficiency may also lead to an increase in reactive oxygen species, which affect sperm viability. Prolonged dietary vitamin A deficiency impaired semen quality and semen production. Vitamin A deficiency lowered the spermatozoa concentration, semen storage capacity and also delayed sexual maturity and suppressed spermatogenesis in young bulls (Cupps, 1991).

2.19.2 Age

Salisbury *et al.* (1978) found semen production and quality to increase beyond the first year after puberty. Coe (1999) associated age with one of major causes in the variation of semen quality among the bulls, due to physiological changes that occur as bulls grow to sexual maturity.

Testis size increases for at least 5 years after puberty (Amann & Almquist, 1962). However, as maturity and age advances, the detrimental effect of stress and disease are likely to cause the direct relationship between the semen production and age disappear.

Spermatozoa morphology is often used as one of the important criteria in the evaluation of semen quality in domestic animals (Howlader & Huq, 1997). An increase in the frequency of abnormal sperm cells has been observed with advancing age in bulls (Rao, 1980). Even in the human (Kidd *et al.,* 2001) reported an increase in semen volume of 3 - 22%, sperm motility of 3 - 37% and number of normal sperm of 4 - 18% to be associated with an increase in age. Van Denmark and Free (1970) also reported semen volume to increase with age and body weight.

2.19.3 Testicular Size

Testicular size and circumference have a direct correlation with spermatozoa output as observed by several researchers (Osinowo, 1992). Component of semen quality other than spermatozoa number has also been correlated with testis size and consistency (Heersche, 1976). Factors other than testicular size, such as genetic and environmental factors which affect total

testicular spermatozoa production may also limit the value of scrotal measurement for predicting subsequent spermatozoa output (Osinowo, 1992). Hoogenboezem (1995) indicated that scrotal circumference is positively correlated with the overall potential breeding efficiency and seminal characteristics. Scrotal circumference has a heritability estimate of 50% (Lasley, 1978), which means that it is influenced to a large extent by genetic rather than environmental factors.

Coulter (1988); Culter and Kastelic (1994) indicated that a pendulous scrotum may improve the testicular thermo-regulation by moving the testis away from the body and thus facilitating heat loss. Brito, Silva, Rodriquez, Vieira, Deragon, and Kastelic (2002b) also reported that the scrotal surface temperature had a negative correlation with sperm motility and that scrotal surface gradient had a positive correlation with sperm concentration. Also, Brito *et al.* (2002) found scrotal circumference to have a positive relationship with ejaculate volume and negative correlation with sperm motility and major sperm defects (Watson, Sapsford & McCance 1956).

Hoogenboezem (1995) suggested that semen quality and scrotal circumference are affected by factors related to underdevelopment of the testes and testicular degeneration. These factors may be related to certain management practices such as feeding excessive energy which leads to fat deposition in the scrotum and reduced body condition of the bull (Coulter and Kozub, 1984; Cupps, 1991).

2.19.4 Season

Season can include many factors such as temperature, photoperiod, and relative humidity and feed quality. Differences in the quantity of feed (Siratskii, 1990) or in feed composition (Castillo, Tizol, Alverez, Perez & Baez, 1987).), and environmental temperature, humidity and seasonal variation (McDowell, 1979) could affect semen output.

In the area where there is marked seasonal variation in environmental temperature, bull semen quality tend to be lower during summer (Curtis, 1983) as this results in thermal stress which causes testicular degeneration and abnormal scrotal thermo-gramm and hence lower the semen output (McDowell, 1979; Curtis, 1983).

Experiments carried out in temperate climate indicated that fertility of semen frozen in winter was slightly higher than semen frozen in summer (Foote, 1972). Similarly, Well, Awa and Fancy (1972) reported seasonal, monthly and weekly variations in per cent normal acrosome at infrequent collection region. Ejaculate volume, normal spermatozoa and per cent live spermatozoa in short zebu were significantly higher in wet than in dry season (Igboeli & Rakha, 1971). Kumi-Diaka Nagaratnam and Ruwan (1981) reported seasonal changes in semen quality in exotic (*Bos taurus*) but not indigenous (*Bos indicus*) bulls studied over a period of 12 months in a tropical environment. These findings showed that fertility of animals may be greater in the rainy than in the dry season. The implication of these is that semen should be collected and preserved in the rainy season for AI and that mating should be encouraged in the rainy season.

The effect of temperature on semen quality is very essential for the following season: Firstly, temperature often modifies feed intake and changes ascribed to temperature may really be due to altered nutrition. Secondly, temperature and photoperiod are positively correlated in many parts of the country and under natural conditions; it might be difficult to differentiate which portion of the effect is due to temperature or due to photo period (McDowell, 1979).

The motility of the spermatozoa varies with temperature and sperm metabolic activity (Salisbury *et al.,* 1978). The metabolic activity increases with an increase in temperature up to 37^0C, where protein denaturing occurs and there after sperm cells lose their motility and die (Van Denmark & Free, 1970). Phillips (1976) found the most obvious sign of cold shock to be loss of

motility and indicated that during cold shock, there is a decrease in the rate of fructose breakdown, decrease in the uptake of oxygen and fall in ATP production resulting in poor semen motility.

2.19.5 Breed

It has been found that larger breeds of cattle tend to have a later onset of puberty than the smallest breeds within the same environment (Robert, 1971). Reports indicate that short horn zebu bulls indigenous to the tropics grow slowly and attain puberty later than the Taurine breeds (Igboeli & Rakha, 1971). A low fertility rate of *Bos indicus* as against *Bos taurus* is manifested most clearly by reduced pregnancy rates in commercial bull herds (Fields, Heneteges & Cornelisse, 1982). Growth rate and reproductive traits at puberty were found to be significantly better for Brahman bulls than Angus bulls, with the former attaining puberty at earlier age (Fields, Heneteges & Cornelisse 1982).

2.20 HAEMATOLOGY AND SERUM BIOCHEMISTRY

Blood provides favorable internal environment to all the cells of the body either directly or indirectly and provides protection against the external environment. Blood contains cellular elements; red blood cells (erythrocytes), white blood cells (leukocytes) and platelets (thrombocytes) (Anonymous, 2014). Haematology refers to the study of the numbers and morphology of the blood cellular components and the use of these results in the diagnosis and monitoring of disease (Merck Manual, 2012). These results are used in conjunction with the history, physical exam and other laboratory findings. While serum biochemistry is the scientific study of (serum) the liquid portion of the blood. One of the benefits of hematological studies to the veterinarian is the application of the knowledge of the blood characteristics to detect various blood diseases of an animal. Haematology is an essential component of clinical pathology that is devoted to the study of blood, blood producing tissues and diseases of blood (Anonymous, 2014).

Haematological and biochemical blood components are influenced by the quantity and quality of feed (Gramb, Uchechi, Kehinde Bala & Onimisi, 2011). Thus, blood components screening in the nutritional research can act as an essential supportive hint for more accurate and reliable diagnosis of various physiological disorders and these pictures should be comprehensively interpreted by correlating with other nutritional parameters (Singh, Pal, Mandal, Singh & Pathak, 2002).2.21 HAEMATOLOGICAL INDICES

2.21.1 Haemoglobin

Haemoglobin is a complex molecule, formed of four heme units attached to four globins (two α and two β globins). Iron is added in the last step by the ferrochelatase enzyme. Haemoglobin has the physiological functions of transporting oxygen to tissues of the animal for oxidation of food ingested so as to release energy for oxidation of food or other body functions and also transportation of carbondioxide out of the body cells. Interference with the normal production of heme or globin leads to anaemia (Sir, 1988). Haemoglobin also known as enthrocyte functions majorly in three (3) ways; transportation and releases of oxygen and carbondioxide (gas exchange), contribute to blood volume and thereby participates in the dynamics of blood circulation and also participate in the blood clotting mechanisms (Coles, 1986).

2.21.2 Packed cell volume (PCV)

Packed cell volume (PCV) (or hematocrit or erythrocyte volume fraction) refers to the percentage of blood volume that is occupied by red blood cells (erythrocytes) in an animal, it provides an accurate practical evaluation of RBC status (David, 1988) therefore an increase in its percentage shows a better transportation of oxygen and absorbed nutrients. A low PCV indicates anaemia while an increased PCV is most often caused by dehydration (David, 1988). It is considered an integral part of an animal's complete blood count results, along with haemoglobin concentration, white blood cell count and platelet count. It has been established that a reduction in

the levels of nutrients in feeds results in a decrease in packed cell volume (PVC) and heamoglobin (Hb) of animals (Hawkey & Dennett, 1989). In cattle a low plane of nutrition was found to be responsible for reduced values of PCV, Hb and TP (Ehoche, Alhassan & Umoh, 1990).

2.21.3 Red blood cells

Red blood cells also known as RBCs, erythrocytes red blood corpuscles, haematids or erythroid cells are the most common type of blood cells and the vertebrates organism's principal means of delivering oxygen to the body tissues via the blood flow through the circulatory system. The function of RBC is to carry oxygen to the tissue at pressures sufficient to permit rapid diffusion of oxygen (Jeffcott, 1988). This is done by a carrier molecule heamoglobin; a vehicle (RBC) capable of bringing the intact haemoglobin to the cellular level; and a metabolism geared to protect both the RBC and the haemoglobin from damage. Interference with synthesis or release of haemoglobin, production or survival of RBC, or metabolism causes disease (Harold & Amstutz., 1988). Swenson (1990) reported that nutritional status of animals can affect its RBC count. RBCs are responsible for the transportation of oxygen and carbondioxide in the blood as well as manufacture of Hb hence higher values indicate a greater potential for this function and a better state of health (David, 1988).

2.21.4 Mean corpuscular volume (MCV)

Mean corpuscular volume (MCV), Mean corpuscular haemoglobin concentration (MCHC) and Mean corpuscular haemoglobin (MCH) are red blood cell indices used to further characterize and classify anaemia. MCV is an indication of RBC size. MCV measured in femtolitres (fl) = (PCV × 10 ÷ RBC). Anaemia with a high MCV is classified as a macrocytic anaemia while anaemia with a low MCV is classified as a microcytic anaemia (Jeffcott, 1988). A low MCV in an anaemic adult animal indicates iron deficiency from slow loss of blood (usually gastro intestinal

or renal) (Jeffcott, 1988). MCHC indicates the concentration of haemoglobin per unit volume of RBC. The MCHC (g/dL) = (haemoglobin × 100) ÷ PCV. It provides similar information as the MCH but is considered to be more accurate (Sir, 1998). The MCH calculated in pictograms (pg) = (haemoglobin × 10) ÷ RBC. A low MCHC accompanying macrocytosis is indicative of a regenerative anaemia. A low MCHC accompanying microcytosis is seen in iron deficiency while an increased an increased MCHC indicates hemolysis (Sir, 1988).

2.21.5 White blood cells (WBC)

White blood cells (WBC) also known as leukocytes consist of the phagocytes and the lymphocytes. The principal function of phagocytes is to defend against the invading microorganisms by ingesting and destroying them, thus contributing to cellular inflammatory responses. Phagocytes are of two types – mononuclear phagocytes and granulocytes. Mononuclear phagocytes arise primarily from the marrow and are released into the blood as monocytes (David, 1988; Sir, 1988). Granulocytes on the other have a segmented nucleus and are classified according to their staining characteristics as neutrophils, eosinophils, or basophils. Monocytes form a link to the specific immune system by processing antigen for presentation to lymphocytes and by producing substances like interleukin-1, which initiates fever and lymphocyte activation and stimulates early hematopoietic progenitors (Jeffcott, 1988). Eosinophils, while having a role as phagocytes, also have more specific functions that include providing a defense against parasites and modulating the inflammatory process. They respond chemotactically to histamine, immune complexes and eosinophil chemotactic factor of anaphylaxis, a substance released by degranulating mast cells (Jeffcott, 1998; Tambuwal, 2002). Basophils are not true phagocytes but contain large amounts of histamine as well as other mediators of inflammation (Sir, 1988). Depressed leukocyte (WBC), lymphocytes and monocytes counts resulted in leukopenia,

lymphopenia and monocytopenia. Leucopenic, lymphopenic and monocytopenic humans and animals are more susceptible to disease causing agents, less resistant disease process and hence less productive (Coles, 1986).

Haemoglobin and PCV mean values of 8.55g/dl and 27.32% respectively were reported for five healthy goats on wheat straw mixed with starch and urea (Sandhu, Saini & Randhawa 2001). The low levels of haemoglobin and PCV was ascribed to the fact that wheat straw, starch and urea are deficient in iron and cupper. Non supplementation of iron in the diet might have led to the decline in the haemoglobin and PCV with time. Aruwayo, Maigandi, Malami and Deneji (2009) reported initial values for PCV, Hb, RBC and WBC as 30.50 – 33.50%, 6.53 – 10.20g/dl, 4.85 – 6.20 $\times 10^{12}$/L and 5.45 – 6.85 $\times 10^{9}$/L, respectively when growing lambs were fed diets containing fore – stomach digesta and poultry litter waste. The authors reported improvement in some final values. Fajemisin, Fadiyama and Alokan (2010) reported PCV, RBC, WBC, MCV, MCH and MCHC values to be 24.50 – 28.00%, 10.51 – 14.19, 2.25 – 3.31, 19.65 – 23.31fl, 6.60 – 7.90pg and 33.06 – 33.90g/dl, respectively.

In an experiment with Yankasa rams fed graded levels of *Tamarindus indica* (tamarind), Garba and Abubakar (2012) reported the following values; PCV (6.65 – 8.30%), Hb (8.65 – 10.75g/dl) and RBC (1.80 – 2.24 $\times 10^{6}$/µL). In a study Aliyu, Maigandi, Muhammad and Garba (2012) reported haematological indices of Yankasa ram lambs fed urea, poultry droppings and or urea treated *Pennisetum pedicellatum* (Kyasuwa). The authors obtained similar values for the control and the treated groups signifying non-deleterious effect of the treatments on the animals. Similarly, Lukden and Finangwai (2013) reported some haematological values of Hb (8.90 - 10.50g/dl), PCV (26.00 – 30.50%) and RBC (3.25 – 3.80%) for Yankasa rams fed urea treated Acha (*Digiteria exilis*) straw. Girgiri, Abubakar, Medugu, Saleh and Gure (2013) obtained the

following values 9.30 – 11.30g/dl, 28.00 – 34.00%, 3.10 – 4.00, 3.50 – 7.50, 25.00 – 30.00, 0.75 – 0.90ft and 3321.40 – 3333.30g/dl for Hb, PCV, RBC, WBC, MCH, MCV and MCHC, respectively for Yankasa rams fed varying levls of Doum palm (*Hyphaenethebaica* L) meal.

Samanta, Sarkar, Bose, Duttagupta & Senapati, (1995) reported on the influence of macro and micro elements on anemia related to production and reproduction of grazing cattle. Spontaneous cases of anaemia were recorded in grazing cattle. The anemic cattle with loss of milk production (group II) and anoestrus (group III) showed a decrease in the levels of haemoglobin (8.18 and 9.18%), PCV (24.12 and 27.60%), blood glucose (35.14 and 33.58mg%) and total protein (7.94 and 7.16g%) respectively, compared to the control (group I) (haemoglobin 11.68%; PCV 33.46%; blood glucose 42.78mg% and total protein 8.24g%). However, supplementation of minerals to animals of both the groups showed satisfactory response to improved body condition, milk yield and reproductive performances. This further proves that livestock rearing by grazing alone or without supplementation of certain minerals can rarely satisfy the mineral requirements of cattle, and such cattle may likely suffer from various problems. Ehoche *et al.* (1990) reported a decline in PCV, haemoglobin and TP values of Zebu bulls during mid (PCV 26.7 and 26.1%; haemoglobin 8.9 and 8.6gm/dl and TP 7.1 and 6.9gm/dl) and final (PCV 26.5 and 25.9%; haemoglobin 9.0 and 8.8gm/dl and TP 6.9 and 6.8gm/dl) feeding periods on low and medium planes of nutrition respectively, compared to bulls on high plane of nutrition whose PCV, haemoglobin and TP for mid and final feeding periods were 28.0 and 28.1%; 9.1 and 9.8gm/dl ; 7.4 and 7.5gm/dl respectively (Bello & Tsado). Also plasma urea nitrogen levels were significantly lower during feed restriction and the first half of the full feeding period in animals on low and medium planes of nutrition than in animals on high plane of nutrition.

Knowledge on blood parameters is of value in the diagnosis of some diseases. Howlader and Huq (1997) reported a significantly lower haemoglobin and PCV values in infected goats than non-infected goats. Haemoglobin and PCV values of 9.17gm% and 26.60% respectively for infected goats and 10.51gm% and 32.2% respectively for non-infected goats were reported. The lower haemoglobin and PCV values were attributed to a considerable amount of iron loss through the processes of absorption and excretion of iron by the *Fasciola gigantica* flukes. It was thus, concluded that chronic *F gigiantica* infections significantly lower the haemoglobin and PCV values in goats. Romney *et al.* (1993) reported a decline in PCV values of infected N'dama heifers. Similarly, haemoglobin and PCV values of does infected with *Haemonchus contortus* were significantly lower than that of non-infected does (Howlader and Huq 1997).

2.21.6 Neutrophils

They are called polymorphonuclear leucocytes. They are a special type of white blood cell that destroyed bacteria and virus. The neutrophil has an average half-life of 6 hours in circulation. To maintain the normal circulating blood level, it is therefore necessary to produce over 100 billion neutrophils per day. Most neutropils enter the tissue and are attracted to the endothelial surface by selectins. When bacteria invade the body the inflammatory response is stimulated in the bone marrow is to produce and release large number of neutrophils. Bacterial products interact with plasma factors and cells to produce agents that attract neutrophils to the infected area (chemotaxis). The cell membrane bound enzyme, NADPH oxidase is activated with the production of toxic oxygen metabolites. This combination makes the neutrophils a very killing machine and effective in killing foreign organisms (Ganong, 2005).

2.21.7 Eosinophils

They are special type of WBC cells, also called 'Eos' that regulate the immune system. Similar to neutrophils, eosinophils have a short half- life in circulation, are attracted to the surface

of endothelial cells by selectins, bind to integrins which attach them to the vessel wall and enter the tissues by diapedesis. Like neutrophils, they release proteins cytokines and chemokines that produce inflammation but are capable of killing invading organisms. However, the selectins and integrins have some selectivity in the way in which they respond and in the killing molecules they secrete (Merck Manual, 1988). They are especially abundant in the mucosa of the respiratory and urinary tracts. Circulating eosinophils are increased in allergic diseases such as asthma and in various other respiratory and gastrointestinal diseases (Ganong, 2005).

2.21.8 Basophils

Basophils are a type of white blood cell that regulates the immune system. Low values are not clinically significant but can be seen in some forms of anemia or leukemia and high values in cases of chronic infections, and allergies. Basophils also enter tissues and release proteins and cytokines. They contain histamine and other inflammatory mediators when activated by histamine and are essential for immediate- type hyper sensitivity reactions (Ganong, 2005).

2.21.9 Monocytes

Monocytes are also called “Monos” and enter the blood from the bone marrow and circulate for about 72 hours. They then enter the tissues and become tissues macrophages. Their lifespan in the tissue is unknown, but bone marrow transplantation data in humans suggests that they persist for about 3 months. It appears that they do not re- enter the circulation. Some of them end up as the multinucleated giant cells seen in chronic inflammatory diseases such as tuberculosis. The tissues macrophages include the Kupffer cells of the liver, pulmonary alveolar macrophage and microglia in the brain, all of which come from circulation. Duncan, Prasse and Mahaffey, (1994) reported that in the past, they have been called the reticulo-endothelial system but the

general term tissue macrophage system seems more appropriate. Their function is to destroy bacteria and virus particles. All monocytes began life as lymphocytes (Ganong, 2005).

The macrophage becomes activated by lymphokines from T – lymphocytes. The activated macrophage migrates in response to chemo tactic stimuli engulfs and kills bacteria by processes generally similar to those occurring in neutrophils. They also secrete up to 100 different substances, including factors that affect lymphocytes and other cells, prostaglandins of the E. series, and clot- promoting factors (Ganong, 2005).

2.21.10 Lymphocytes

Lymphocytes are the key elements in the production of immunity. They are also called mononuclear leukocytes or simply "lymphs". One of their functions is to transform into monocytes and destroy bacteria and virus particles. After birth, some lymphocytes are formed in the bone marrow. However, most are formed in the lymph nodes, thymus, and spleen from precursor cells that originally came from the bone marrow and were processed in the thymus or bursa equivalent. Lymphocytes enter the blood stream from the most parts via the lymphatics. At any given time, only about 2% of the body lymphocytes are in the peripheral blood. Most of the rest are in the lymphoid organs (Ganong, 2005).

Table 1 Haematological Reference Values for Sheep and Goats

Parameters	Normal ranges
PCV (Hematocrit) %	27-45
Hemoglobin (g/dl)	9-15
Red Blood Cells ($\times 10^6/\mu l$)	9-15
Mean Corpuscular Volume (fl)	28-40
Mean Corpuscular Hemoglobin (pg)	8-12
Mean Corpuscular Hemoglobin Concentration (g/dl)	31-34
White blood cells	4-12
Neutrophils- segmented/ band (%)	10-50/0
Lymphocytes (%)	40-75
Monocytes (%)	0-6
Eosinophils (%)	0-15
Basophils (%)	0-3

Source: Duncan *et al.* (1994)

2.22 BLOOD SERUM CHEMISTRY

Serum biochemical analyses are used to determine the level of heart attack, liver damage and evaluate protein quality and amino acids utilization in animals (Harper, Rodwell & Mayes 1999). The blood urea nitrogen (BUN) test is a measure of the amount of nitrogen in the blood in the form of urea and a measurement of renal function. Urea is a by-product from metabolism of proteins synthesized by the liver from ammonia; it is freely filtered by the glomerulus of the kidneys, but about half the filtered urea is passively reabsorbed during passage through the renal tubules. The liver produces urea in the urea cycle as a waste product of the digestion of protein. Blood urea nitrogen and creatinine are the substances in blood most often used to assess renal function (Duncan *e al.,* 1994; Jeffcott, 1988). Normal range for BUN in sheep is 3.7 – 9.3mmol/L (Sir, 1988). An increase in BUN level is known as azotemia. An elevated BUN may be caused by impaired renal function, congestive heart failure as a result of poor renal perfusion, dehydration,

shock, and hemorrhage into the intestinal tract, acute myocardial infarction stress and excessive protein intake or protein catabolism (Duncan *et al*., 1994). Similarly, decreased BUN may be seen in liver failure, malnutrition, anabolic steroid use, over hydration, pregnancy (due to increased plasma volume), impaired nutrient absorption and syndrome of inappropriate anti-diuretic secretion (Duncan *et al*., 1994). High protein diets and increased protein catabolism from fever or tissue necrosis can cause mild increases in BUN. In ruminants BUN concentration tends to be lower due to a diet relatively low in protein and to metabolism of urea by rumen flora, decreased BUN levels can occur in severe liver disease (Harold & Amstutz, 1988).

2.22.1 Total protein (TP)

Total protein (Tp), globulin and albumin are average responsive to total protein intake (Whitaker, 1998). Increased plasma protein concentration is most often due to dehydration or to hyperglobulinemia seen in an immune response (David, 1988). Albumin (Latin: album, white) refers generally to any protein that is water soluble, which is moderately soluble in concentrated salt solutions and experiences heat denaturation. They are commonly found in blood plasma and are unique to other plasma proteins in that they are not glycosylated (the ability to add a saccharide unit to a protein). Albumin is a protein made by the liver. A serum albumin test measures the amount of this protein in the clear liquid portion of the blood (Bello & Tsado, 2013).

2.22.2 Aspartate aminotransferase (AST)

Aspartate aminotransferase (AST) is associated with mitochondria and cytoplasm, alteration in activity could imply alteration in the cytosolic content. The mitochondrion is regarded as the engine house of the cell and exposure of this organelle to assault of any form could imply cell death. AST is often used to detect liver disease in large animals, but this enzyme is not liver – specific because it is also increased in myocardial and skeletal muscle diseases ((Haold & Amstutz,

1988). Alanine aminotransferase (ALT) is a liver – specific hepatocellular enzyme in some animals (Jeffcott, 1988). ALT is present in the liver and other cells and is useful in measuring hepatic necrosis (Cornelius, 1989). AST and ALT are present in many tissue cells, especially liver and heart cells therefore increased values indicate necrosis of the cells (Kaneko, 1980). Transaminases are the most commonly used indicators of cellular necrosis and as mentioned high levels in serum may indicate liver malfunctioning. They occupy a central position in amino acids metabolism therefore increased in their activities in the serum could have a consequential effect on the amino acids metabolism in these tissues. Furthermore, it may indicate some sort of injury to the organs. Such damage may cause the enzymes to leak from the injured organs to the blood stream.

An increase in serum AST and ALT above the normal range has been reported to signify necrosis and myocardial infection or response to the presence of a number of toxic factors (Sir, 1988). Increase in serum values of AST is associated with cell necrosis of many tissues (Kaneko, 1980). Normal ALT levels indicate that the activities of osteoblast (a cell from which bone develop) were not affected because the blood levels of ALT is usually a good indicator of the rate of bone formation (Guyton, 1991). Alkaline phosphatase (ALP) is a sensitive indicator of cholestasis, it is also non-liver-specific. Although, increased serum ALP is a sensitive indicator of cholestasis (bile stoppage), there are many sources of ALP including chondroblast, osteoblast, the hepatobiliary system, renal tubules, gastrointestinal mucosa and placenta (Duncan *et al*., 1994; Merck Manual, 1988). Active growth causes ALP levels to be 2 – 4 times higher in young animals than in adults due to increased production of the bone isozyme. But the intestinal, renal and placental isozymes are not usually important sources of increased ALP activity ((Haold & Amstutz, 1988). Therefore, increases in liver enzymes should be interpreted in conjunction with

other clinical signs and therapeutic history because production of enzymes such as ALT, AST and ALP can be induced by drugs, including glucocorticoids.

2.22.2 Bilirubin

Bilirubin (formerly referred to as hematoidin) is the yellow breakdown product of normal heme catabolism. Heme is found in haemoglobin, a principal component of red blood cells. Bilirubin is excreted in bile and urine and elevated levels may indicate certain diseases (Gaull, 1984) Normal bilirubin values buttressed the absence of haemolysis (destruction of red blood cells and the release of the haemoglobin they contain) since bilirubin is an insoluble molecule derived from the breakdown of haemoglobin in the spleen (Sirois, 1995). Total biliribun is made up of conjugated (direct) and unconjugated (indirect) bilirubin. A predominance of unconjugated bilirubin is suggestive of haemolytic jaundice while that of conjugated bilirubin is generally associated with hepatic diseases and extrahepatic biliary obstruction. Increase in levels of conjugated bilirubin usually indicates obstructive diseases of the bile duct system. Sirois (1995) further reported that increases in the levels of both proportions of bilirubin indicate hepatocellular diseases (diseases relating to liver cells). In addition, damaged cells often impair circulation within the liver so that conjugated bilirubin is not released into the bile duct. Biliribun is responsible for the yellow colour of bruises, the yellow colour of urine (via its reduced breakdown product, urobilin), the brown colour of faeces (via its conversion to stercobilin) and the yellow discolouration in jaundice (Sirois, 1995).

Several authors have reported on serum biochemical indices of ruminants. Aliyu, Maigandi, Muhammad and Garba (2012) studied the blood profile of Yankasa sheep fed on treated *Pennisetum pedicellatum* (Kyasuwa). The authors did not encounter any ill-health as the result of feeding treated Kyasuwa. Garba and Abubakar (2012) found that, the concentration of the total

protein or its fractions as albumin and globulin were not affected in Yankasa sheep fed graded levels of *Tamarindus indica* (tamarind) leaves. Aruwayo *et al.* (2009) reported that urea concentration, total protein, albumin and globulin values in blood plasma were 4.67 – 6.34mmol/L, 4.74 – 5.27g/dl, 3.44 – 3.82g/dl and 1.05 – 1.82g/dl, respectively at the beginning of a trial in growing lambs fed fore-stomach digesta and poultry litter waste. Slight increases and decreases were observed in their final values. Girgiri *et al*. (2013) reported on the haemato-biochemical indices of Yankasa rams fed varying levels of Doum palm (*Hyphae nethebaica* L) meal. There results showed that blood serum levels of total protein were 56.00–82.00g/L; for albumin were 28.00 – 34.00g/L and for urea 5.20–7.20mmol/L. Blood serum asparatate amino–transferase (AST), alanine amino-transferase (ALT) and alkaline phosphate (ALP) levels were 1.70-4.10IU/L, 1.12-4.15 and 37.00-40.20, respectively. Total biliribin was 11.00-18.00, which were all within the normal range (Girgiri *et al*., 2013).

2.22.3 Total protein

Total protein, glucose and urea nitrogen mean values of 7.0g/dl, 54.29mg/dl and 17.99mg/dl respectively were reported for five healthy goats on wheat straw mixed with starch and urea (Sandhu *et al.,* 2001). The authors reported a decline in total plasma protein, glucose and urea nitrogen levels as compared to the base value. The decrease in plasma protein and urea nitrogen levels was attributed by the authors to the fact that the animals were being fed on wheat straw which is a poor source of crude protein (Boyd, 1984). Higher levels of urea in blood could be attributed to the presence of some anti-nutritional factors which might have lowered the quality of the protein, indicating imbalance of amino acids in the diet and caused elevated blood urea concentration (Sandhu *et al.,* 2001).

2.22.4 Serum albumin

Serum albumin is the most abundant blood plasma protein which measures protein in the blood. Low albumin (hypoalbuminemia) may be caused by liver disease, nephritic syndrome, burns, protein-losing enteropathy, mal absortion, malnutrition, late pregnancy, artifact, genetic variations and magnancy. Alex and LaVerne (1983) reported that high albumin (hyper albuminemia) is almost always caused by dehydration. In most cases of retinol (vitamin A) deficiency, the albumin level can become raised to high- normal values. This is because retinol causes cell to swell with water (Gaull, 1984).

2.22.5 Creatinine

It is a breakdown of creatinine phosphate in muscle, and is usually produced at a fairly constant rate by the body. Chemically, creatinine is a spontaneously formed cyclic derivation of creatine. Creatinine is filtered out of the blood by the kidneys, though; a small amount is actively secreted by the kidneys into the urine. Gaull, 1984 reported that filtering of the kidney is deficient, blood level rises. Therefore, creatinine levels in the body and urine may be used to calculate the creatinine clearance, which reflects the glomerular filtration rate which is a measurement of renal function. The amount of creatinine secreted daily is a function of the muscle mass and is not affected by diet, age, sex or exercise (Alex & LaVerne, 1983).

2.22.6 Serum aspartate aminotransferase

Serum Aspartate Aminotransferase is found in practically every tissue of the body, including red blood cells (Azab & Abdel-Maksound, 1999). It is in particularly high concentration in cardiac muscle and liver, intermediate in skeletal muscle and kidney in much lower concentration in other tissues (Singh, Pal, Mandal, Singh & Pathak, 2002). The measurement of the SAST level is helpful for the diagnosis and following cases of myocardial infarction,

hepatocellular disease and skeletal muscle disorders. In trauma or in diseases affecting skeletal muscle, after a renal infarct and in various haemolytic condition (Alex and LaVerne, 1983).

2.22.7 Serum alanine aminotransferase

The concentration of Serum Alanine Aminotransferase in tissues is not nearly as great as for Serum Aspartate Aminotransferase. It is present in moderately high concentration in liver, but is low in cardiac and skeletal muscles and in other tissues Maxwell, Robertson, Spence and Mecorquodade (1990). Their uses for clinical purpose are primarily for diagnosis of liver diseases and ambiguous increase in serum ALT is associated with myorcardial infarction. When both enzymes (Alanine Aminotransferase and Aspartate Aminotransferase) are elevated in serum, the liver is the primary source of the enzymes (Alex and LaVerne, 1983).

2.22.8 Serum total cholesterol

Tambuwal, Agale and Bangana (2002) cholesterol is the principal body sterol that is most in famous of the essential lipid component. It is a complex alcohol formed of four fused rings and a side chain, it is solid at room temperature (Simaraks, Chinrasri & Aengwanich, 2004). It is present in all tissues and can be converted by adrenals and the gonads into steroid hormones. Duncan *et al.* (1994) reported that cholesterol present in all membranes including those of lipoprotein is always non- esterified (free), it is stored in cells and in the lipid core of lipoprotein as cholesterol esters. Most cholesterol in the body are synthesized from acetyl CoA but this varies inversely to some extent with the cholesterol content of the diet. Excess dietary cholesterol over a period of time slowly increases esters in the liver. 70-75% of the cholesterol in plasma is esterified with a long chain unsaturated fatty acid. An elevated serum cholesterol concentration has been implicated as one of several risk factors in coronary artery disease (Alex and LaVerne, 1983).

Table 2 Blood Serum chemistry Reference Values for Small Ruminants

Parameters	Normal Ranges
Sodium (mmol/l)	142-160
Potassium(mmol/l)	4.3-6.3
Chloride (mmol/l)	101-113
HCO_3^-(mmol/l)	20-27
Urea (mmol/l)	3.7-9.3
Creatinine(µmol/l)	76-174
Cholesterol(mmol/l)	1.1-2.3
Glucose (mmol/l)	2.4-4.5
Protein (g/l)	59-78
Albumin (g/l)	27-37
Globulin (g/l)	32-50
Alkaline Phosphatase (µ/L)	27-156
Alanine Aminotransferase (µ /L)	15-44
Aspartate Aminotransferase. (µ/L)	49-123

Source: Boyd (1984)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The study was carried out at the University Teaching and Research Farm and at Laboratory of the Department of Animal Science, Bayero University, Kano. Kano is located within the longitude 9°30 and 12°30" E and the latitude 9°30" and 8°42 N at an altitude of 403' m above the sea level (Olofin, 2008). The annual temperature and relative humidity ranged between 38°C to 43°C and 40.0 to 51.3%, respectively (Olofin, 2007). The region is characterized by tropical wet and dry climate. The rainy season (May to September) and dry season (October to April) with annual rainfall ranges between 787-960 mm (KNARDA, 2001).

3.2 EXPERIMENTAL BUCKS AND THEIR MANAGEMENT

A total of forty eight (48) Kano Brown bucks with average initial body weight of 10 ± 2 kg and 12 month old were purchased at Wudil Market of Kano State and used for this study. The scrotum and testes of each buck was visualized, palpated and carefully inspected before selection of experimental bucks so as to rule out any form of abnormalities. The general health status of experimental bucks were examined and quarantined before the commencement of the study. Bucks were given antibiotic prophylaxis using 20% Oxytetracycline (long acting) at the dose rate of 10 mg per kg body weight, bucks were also dewormed using Albendazole suspension at the dose rate of 7.5 mg per kg weight, they were vaccinated against *peste des pestits ruminants* (PPR) using PPR Vaccine at dose rate of 0.5 ml per buck subcutaneously. Bucks were housed in a group (Four bucks per treatment) allowing two weeks for adaptation period before the commencement of the experiment. The experimental pen was thoroughly cleaned, fumigated and disinfected before the arrival of experimental animals, pen sanitation was carried out regularly throughout the experimental period.

3.3 EXPERIMENTAL DESIGN AND TREATMENTS

The studies were conducted for a period of 12 weeks (84 days) in each of the three experiments. A total of forty eight (48) bucks were used for this study in which sixteen (16) Kano Brown bucks were allotted to four dietary treatments with four bucks per treatment. The feeding trials were conducted in three different seasons; Dry (March to June), Rainy (July to October) and Harmattan (November to February). The experimental design was 4 x 3 factorial arrangement in a randomized complete block design with four dietary regimes and three seasons. Treatments were evaluated as follows:

Table 3 Feeding Regimes and Treatments

Treatments	Feeding Regime
Treatment I:	Browsing only (zero supplementation)
Treatment II:	Supplementation in the morning with browsing
Treatment III:	Supplementation in the morning and in the evening with browsing
Treatment IV:	Zero browsing

3.4 EXPERIMENTAL DIETS

Experimental diet was formulated using cotton seed cake, cowpea husk, maize offal, wheat offal and salt, clean water and mineral salt lick were given *ad-libitum*. The supplementation was offered at the rate of 1.5% body weight of each buck, therefore quantity feed to be offered is subject to increase on weekly basis depending upon the changes on body after weight. Hay was offered ad-libitum to only treatment four throughout the experimental period. Feed ingredients were purchased at Sulhu Agro-vet and Logistic Services and Yan Awaki Ruminant Market in Kano Metropolis. The composition of the concentrate includes 19% maize offal, 30% cotton seed cake, 30% wheat offal, 20% cowpea husk and 1% salt, this gives 16% CP and 2381 kcal/kg energy

3.5 MEASUREMENT OF BODY DIMENSION

Body weight was measured bi-weekly using scale designed for body weight (Brawis), graduated from 1 to 50 kg. The scale was hung in the experimental pen. Body dimensions such as body length, chest circumference, wither height, neck length and scrotal circumference were measured using measuring tape as described by Olayemi, Faroimi and Fagbohun (2006).

3.6 HAEMATOLOGY AND SERUM CHEMISTRY

3.6.1 Blood Sample Collection

Ten (10) ml of blood sample was collected from three bucks in each treatment using sterile syringe and needle, placed in a sample bottle and then taken to Haematology Laboratory (for haematological analysis) and Chemical Pathology Laboratory (for biochemical analysis) at the Aminu Kano Teaching Hospital, Kano. The blood sample was drawn from the jugular vein after restraining the animals. Three (3) ml of the blood was placed in a sterile sample bottle containing Ethylene Diamine Tetracetic acid (EDTA) for haemotological studies and the remaining 7 ml (without anticoagulant) was used for blood chemistry (serum metabolites) as described by Coles (1986).

3.6.2 Haematological Indices Determination

The haematological parameters measured were Haemoglobin (Hb) content using cyanmethaemoglobin method (Coles, 1986). Packed cell volume (PCV), red blood cell, white blood cell and its white cell count (leucocytes), lymphocytes and neutrophils were determined as described by Coles (1986). Mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were calculated using the formula described by Haold and Amstutz, (1998).

$$\text{MCV (fl)} = \frac{\text{Haematocrit (\%) x 10}}{\text{RBC in millions/mm}^3}$$

Mean corpuscular Hemoglobin (MCH) was calculated using the formula as follows

$$\text{MCH (pg)} = \frac{\text{Hb in g/100ml blood x 10}}{\text{RBC in millions/mm}^3}$$

The mean corpuscular hemoglobin concentration (MCHC) was calculated as follows.

$$\text{MCHC (g/dl)} = \frac{\text{Hb in g/100ml blood x 10}}{\text{Haematocrit}}$$

3.6.3 Serum Chemistry Analysis

Blood urea concentration was estimated by Nessler reaction (Tanis & Naylor, 1968). Serum total protein was estimated by the Biuret method as described by Kohen & Allen (1995). Albumin was estimated by Bromocresol Green (BCG) method (Peter, Biamonte & Doumas, 1982) whereas globulin concentration was determined by finding the difference between total protein and albumin. Albumin: globulin ratio was calculated by dividing albumin value by the calculated globulin value. Aspartate aminotranferase (AST), alanine aminotransferense (ALT) and alkaline phosphatase (ALP) activities were estimated using spectrophotometric method as described by Hoder and Rej (1983). Blood glucose was determined by glucose oxidase method as described by Esonu *et al.* (2001) whereas total bilirubin was determined using orbital technique as described by Stone (1954).

3.7 EVALUATION OF SEMINAL TRAITS

Semen sample was collected bi-weekly using artificial vagina (designed for sheep and goats) and labeled accordingly. The color of the ejaculate was determined by visual observation

immediately after semen collection. Semen volume was determined using a graduated transparent test-tube. The volume of the ejaculate was read and recorded in milliliters immediately. Semen pH was determined using calibrated Chemocraft ®pH paper graduated from 1 to 14 with different means of identification. An inch of the pH paper was inserted in the semen sample for at least five seconds and air dried immediately. pH paper was then monitored to observed changes in the semen color against the color chart, only corresponding pH number for the color present on the chart was recorded as pH of a particular sample (Rekwot, Oyedipe, Dawuda & Sekoni, 1997).

Sperm motility was determined using microscopic observation, a drop of semen sample was placed on a pre-warmed (34^0C to 37^0C) glass slide and covered with 22 x 22 mm cover slip and examined at x 10 eye pieces object magnification immediately after semen collection. The total progressive motility was recorded in percentages.

The sperm concentrations were determined using hemocytometer (Rekwot *et al*., 1997; Zeneveld & Polakoski, 1997) followed by semen dilution of 1:201. Sperm concentration was expressed in millions per milliliter (x 10^6 /ml) and calculated using the following formula C = 50, 000 x N x D.

Where,

C = sperm concentration

N = sperm count

D = dilution ratio using distil water.

Live/dead count was determined by examining semen stained with eosin-nigrosin solution. Dead spermatozoa picked the color of the stain (pinkish) while live spermatozoa remained colorless. This was done by counting 100 sperm cells, as described by Rekwot, Oyedipe, Akerejola, Kumi-Diaka and Umoh (1984).

Sperm morphologies/abnormalities were determined by placing of small quantity of semen sample in buffered formul saline under microscope at x 40 eyepiece magnifications.

3.8 DETERMINATION OF GONADAL AND EXTRA GONADAL SPERM/SPERMATIDS RESERVES

At the end of the experiment, twelve (12) bucks (three per treatment) were orchidectomised and the testes were used to determine the gonadal and extra-gonadal sperm reserves, as described by Igboeli and Rakha (1987) and Rekwot, Oyedipe, Akerejola, Kumi-Diaka and Umoh (1984); Rekwot, Oyedipe, Dauda and Sekoni (1997). Twelve (12) testes were harvested and used for gonadal sperm reserves. Right and left testes were labelled and appropriately used to determine the gonadal and epididymal sperm reserves. Right and left testes weight (g), length (cm) and volume (ml) were recorded accordingly. The epididymis, visceral vaginal tunic and tunica albuginea were carefully separated from the testes using scapel blade.

Left and right testes were homogenized separately using high speed blender operated for 2 minutes in 50 ml normal saline that contained100 IU/ml of sodium penicillin G and 1g/mL streptomycin. The Homogenate volume was measured after rinsing the blender with 20 ml of effluent. It was further diluted with 80 mL of normal saline after transferring 5 mL of the homogenate to a conical flask. The homogenate was stored overnight at 5^{o}C. The sperm concentration was determined using hemocytometer, as described by Rekwot *et al.* (1997).

The epididymis from each testis was carefully separated with scapel blade and the length and weight of whole epididymis were measured. It was then carefully separated into three (3) parts (*caput, corpus and cauda epididymides*), length and weight of each part were measured and minced in 20 ml of normal saline using sharp scissors and stored overnight at 5^{o}C. The minced epididymal parts were filtered using gauze and filtrate volume was measured. One millimeter (mL) of the filtrate was placed in a test tube and further diluted with 2 mL of normal saline. The

epididymal sperm reserves was determined using hemocytometer as described by Rekwot *et al.* (1987) and Gyang (1990). Sperm reserves were expressed in billions using the procedures of Osinowo, Bale and Eduvie (1982); Bustwat and Zaharaddeen (1998). Testicular and epididymal weight were obtained using electronic weighing scale while length (cm) was measured using a meter rule (cm).

3.5 WEATHER DATA AT THE EXPERIMENTAL SITE

Temperature and relative humidity of experimental pens and the surrounding environment were monitored across the three season's minimum temperature in the morning at (8:00 am) and maximum in the afternoon at (2:00 pm) using digital thermo-hydrometer (Brannan England). As far as possible, one of these instruments was hung on the wall (120 cm above the ground) inside the experimental pen and the other one was hung outside the experimental house at 120 cm above the ground to provide the record of the temperature and relative humidity experienced by the buck during the experiment.

Based on the record of ambient temperature and relative humidity, the study was conducted during dry season (March to June), rainy (July to October) and harmattan (November to February) seasons. Data obtained for temperature and relative humidity were used to develop an index for measuring thermal comfort zone for the bucks. It was measured according to the following equation THI = db^{o}C – {(0.31 - 0.31 RH) (db^{o}C – 14.4) (Marai *et al.,* 2000). Where db^{o}C is the dry bulb temperature (^{o}C) and RH is relative humidity (%) /100. Information on average macro-climate was also obtained from Aminu Kano International Airport, meteorological station on the minimum and maximum temperature (26 to 42^{o}C), relative humidity (20 and 65%) and rainfall (698 to 985 mm) from November, 2015 to December, 2016.

Where;

THI= Temperature Humidity Index

Db^0C= Dry bulb Temperature

RH= Relative humidity

Table 4 Mean Temperature and Relative Humidity of the Experimental Site

Variables	Seasons		
	Dry	Rainy	Harmatttan
Temperature (°C)	39.37±2.0	28.32±2.0	20.21±2.0
Relative humidity (%)	20.05±2.0	68.79±2.0	32.89±2.0

3.10 STATISTICAL ANALYSIS

Data collected were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedure of SAS (2009, version 9.2). Means were separated using Duncan multiple Range Test ($P < 0.05$).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Body dimensions of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

Table 5 shows the results of body dimensions of Kano Brown bucks as influenced by main and interactive effects of season and feeding regime. There were significant ($P < 0.05$) differences in final body weight (kg) among the different feeding regimes. Highest mean for final body weight (19.10 kg) was recorded in bucks offered morning and evening supplementation whereas bucks on zero browsing had the lowest mean value (16.45 kg). There was no significant ($P > 0.05$) difference in body length and neck length among the treatments, even though highest mean values for body length (67.25 cm) was recorded in bucks under zero supplementation.

Table 5 presents the result of seasonal effect on body dimensions of Kano Brown bucks which differed significantly ($P < 0.05$) among the three seasons. Bucks in the rainy season feed supplementation had the highest mean value of final body weight (17.50 kg), (Dry, Rainy and Harmattan) whereas bucks in the dry season had the lowest value (16.65 kg). The mean values for heart girth, withers height, body length, neck length and scrotal circumference were significantly ($P < 0.05$) higher in bucks in the rainy season than those kept during the dry season.

Table 5 Body Dimensions of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season and Feeding Regimes

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Initial weight (kg)	10.00	10.00	10.00	10.00	-
Final weight (kg)	17.20^{b}	17.20^{b}	18.10^{a}	16.45^{c}	0.22
Average daily weight gain (kg)	0.86	0.86	0.96	0.80	-
Heart girth (cm)	64.42^{b}	65.75^{b}	70.17^{a}	67.67^{ab}	0.54
Withers height (cm)	68.00^{a}	66.58^{ab}	65.50^{ab}	64.50^{b}	0.54
Body length (cm)	67.25	65.50	66.58	65.33	0.51
Neck length (cm)	20.45	22.55	20.61	20.85	0.55
Scrotal circumference (cm)	20.65^{ab}	19.85^{b}	20.74^{ab}	21.05^{a}	0.32

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Body weight (kg)	16.65^{b}	17.50^{a}	17.35^{a}	0.21
Heart girth (cm)	64.25^{b}	69.81^{a}	68.43^{b}	0.48
Withers height (cm)	64.19^{b}	68.06^{a}	57.18^{a}	0.53
Body length (cm)	63.44^{c}	68.38^{a}	66.19^{b}	0.52
Neck length (cm)	19.99^{b}	21.84^{a}	19.89^{b}	0.36
Scrotal circumference (cm)	19.93^{b}	21.87^{a}	19.44^{b}	0.32

	Interactive effect feeding regime/season
Parameters	LOS
Body weight (kg)	***
Heart girth (cm)	*
Withers height (cm)	*
Body length (cm)	*
Neck length (cm)	*
Scrotal circumference (cm)	**

^{abc} Means within the same rows with different superscript are significantly different ($P < 0.05$), SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementations, ZB = Zero Browsing, LOS = Level of Significance.

Figure 4.1 shows the result of interactive effect of season and feeding regime on body weight. Bucks under morning and evening supplementations had the highest mean value (18.50 kg) whereas bucks under zero supplementation recorded the lowest mean value during dry season. However, bucks under morning and evening supplementations performed best in terms of body weight than those under rainy and harmattan seasons respectively. The bucks under zero browsing had the lowest mean values (17.00 kg and 16.50 kg) during rainy and harmattan seasons respectively.

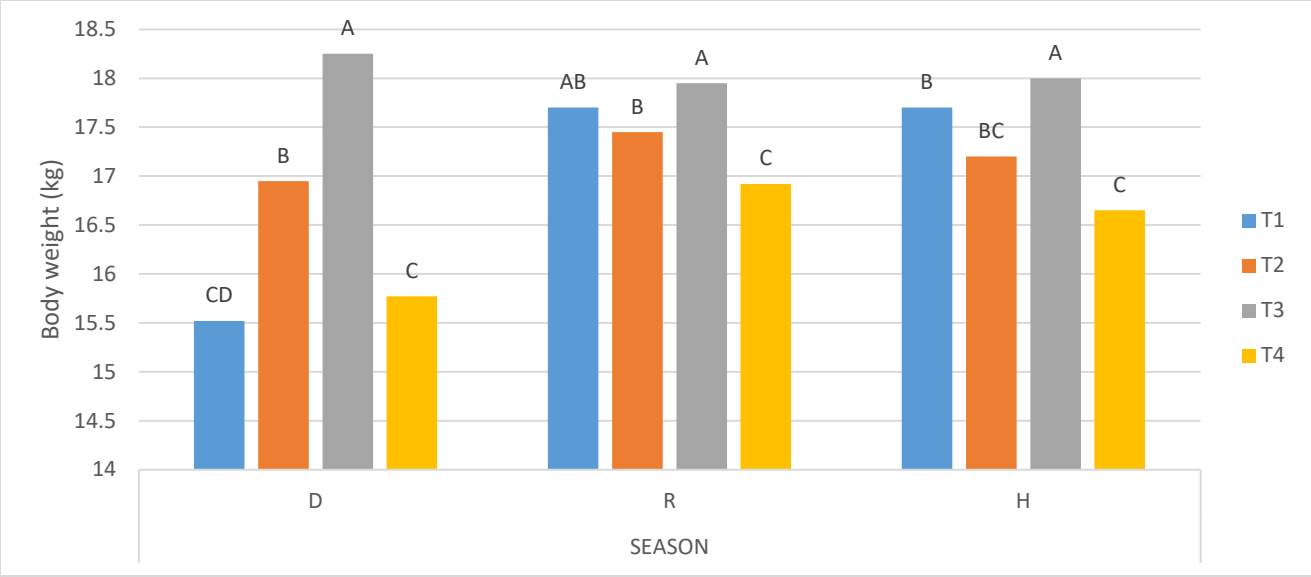

Figure 4.1 Interactive Effects of Season and Feeding Regime on Body Weight

The results of interactive effects of season and feeding regime on body length are presented in Figure 4.2. Bucks under zero supplementation recorded the highest mean value of (67 cm) during dry season whereas those under morning supplementation had the highest mean (69 cm) during rainy season. However, bucks under zero supplementation recorded the highest value (68 cm) during harmattan season whereas bucks under zero browsing had the lowest mean value (63 cm) for body length.

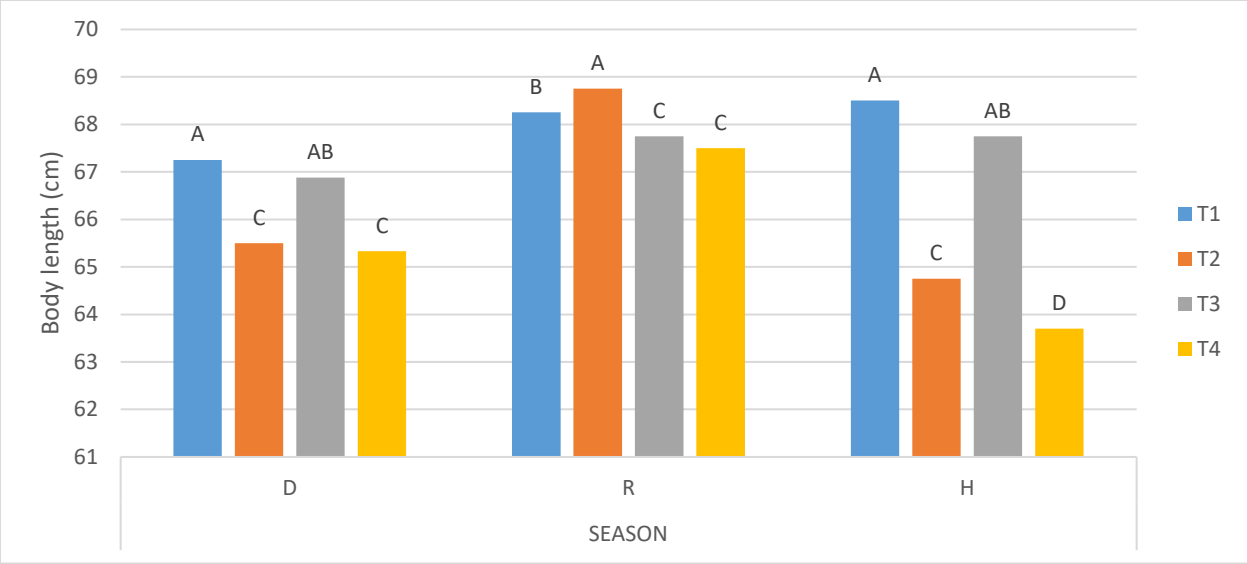

Figure 4.2 Interactive Effects of Season and Feeding Regime on Body Length

The result of interactive effects of season and feeding regime on chest circumference is presented in Figure 4.3. Bucks under morning supplementations recorded the highest mean value (70 cm) for chest circumference in the dry season while bucks under morning supplementation had the lowest mean value (65 cm). Similarly, bucks under morning supplementations had the highest mean value (70 cm) during harmattan season. However, bucks under zero browsing had the highest mean value (65 cm) for chest circumference in the rainy season whereas bucks under morning supplementation recorded the lowest mean value (63 cm).

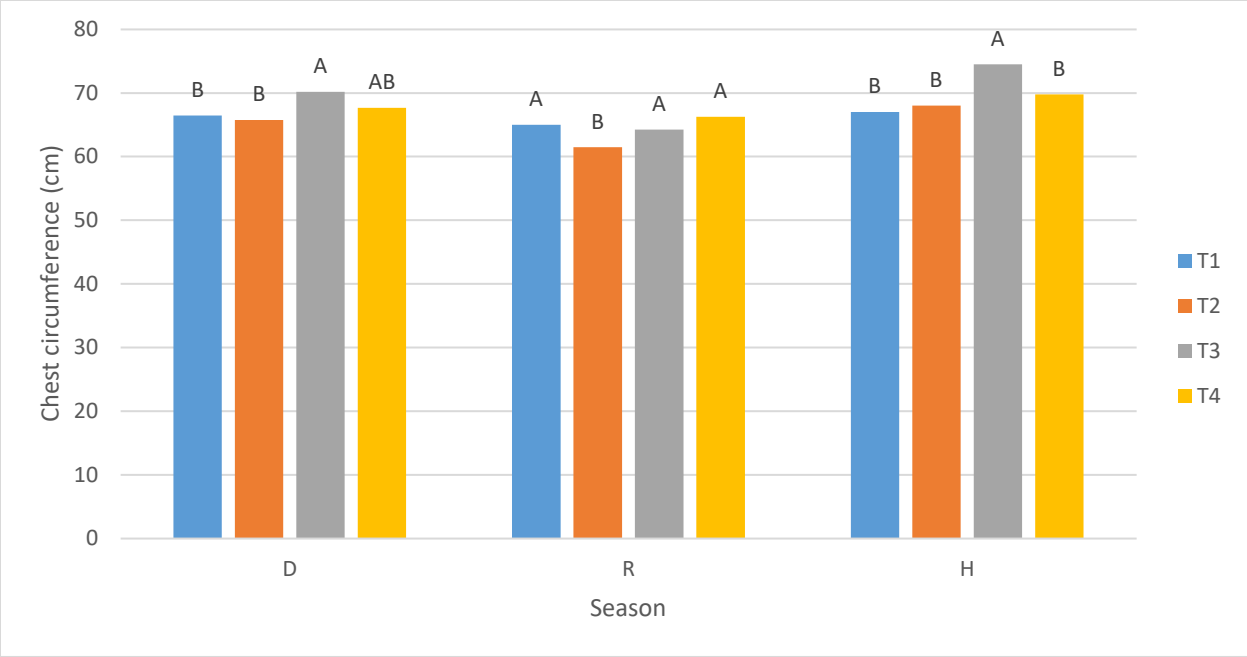

Figure 4.3 Interactive Effects of Season and Feeding Regime on Chest Circumference of Kano Brown Bucks

Significant ($P < 0.05$) difference was observed among the three seasons for scrotal circumference among the feeding regimes as shown in Figure 4.4. Highest mean value (22 cm) for scrotal circumference was recorded in bucks under zero browsing during dry season. Similarly, bucks under morning and evening supplementations had the highest mean value (21 cm) for scrotal circumference during the harmattan season.

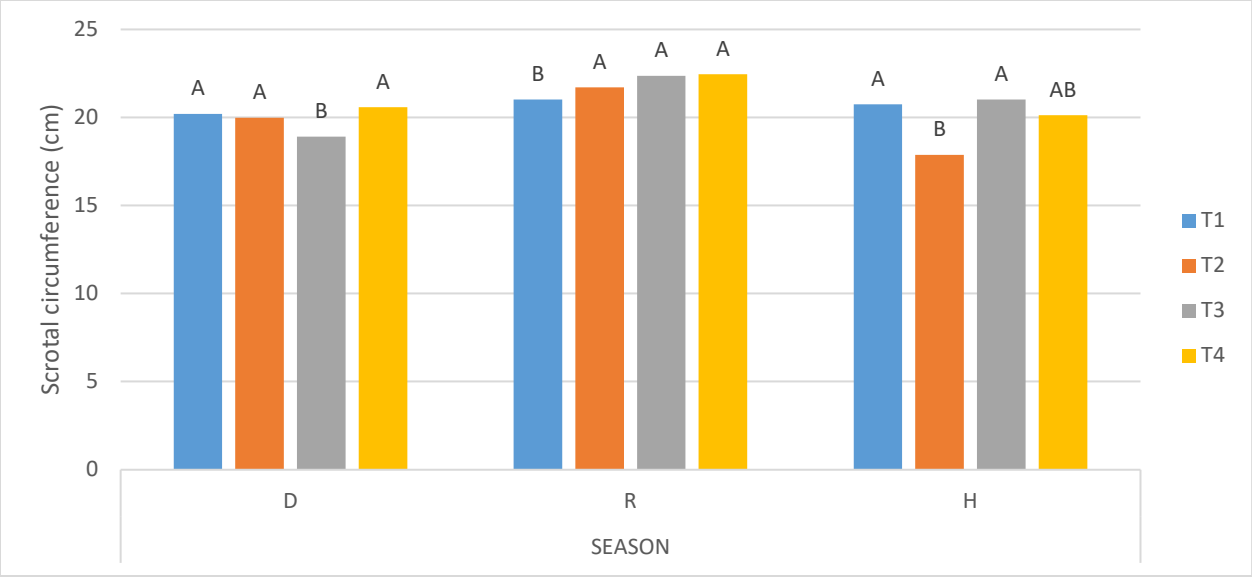

Figure 4.4 Interactive Effects of Season and Feeding Regime on Scrotal Circumference

4.1.2 Main and Interactive Effects of Season and Feeding Regime on Seminal Traits of Kano Brown Bucks

Data on seminal traits of Kano Brown bucks as influenced by main effect of feeding regime are presented in Table 6. The results revealed that there were no significant ($P > 0.05$) differences with respect to semen color, live spermatozoa and sperm motility among the treatments. The highest value (3.41) for semen color was observed in bucks under zero browsing while bucks under zero supplementation had the lowest mean value (2.92). The mean value (7.50) of semen pH was significantly ($P < 0.05$) higher under zero supplementation than those under morning supplementation (5.67). The mean sperm concentration ($3024.20x10^6$/ml) was highest in bucks under morning and evening supplementations compared to those on morning supplementation ($2009.30x10^6$/ml).

However, the effect of season on seminal traits showed non-significant ($P > 0.05$) differences among the bucks in respect of semen color and sperm motility, even though the highest value for semen color (3.37) and for sperm motility (78.43%) were for bucks during rainy season than during the dry season with the lowest mean values for semen color (2.94) and for sperm motility (71.81%) respectively, as shown in Figure 5. The result also showed significant ($P < 0.05$) differences among the bucks for semen pH, semen volume and live spermatozoa. The mean sperm concentration ($3139.70x10^6$/ml) was significantly ($P < 0.05$) higher in bucks during rainy season than bucks during dry season ($1871.90x10^6$/ml).

Table 6 Main and Interactive Effects of Season and Feeding Regime on Seminal Traits of Kano Brown Bucks

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Semen color	2.92	3.25	3.25	3.41	0.38
Semen pH	7.50[a]	5.67[b]	6.92[a]	7.00[a]	0.30
Semen volume (ml)	1.20[b]	3.37[a]	1.56[b]	1.44[b]	0.27
Sperm concentration (x10^6/ml)	2550.40[b]	2009.30[c]	3024.80[ab]	3114.90[a]	7.76
Live spermatozoa (%)	70.33	79.50	77.83	78.33	1.07
Sperm motility (%)	74.08	71.08	77.58	75.75	1.14

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Semen color	2.92	3.37	3.31	0.31
Semen pH	6.00[b]	7.31[a]	7.00[a]	0.30
Semen volume (ml)	2.98[a]	1.42[b]	1.35[b]	0.28
Sperm concentration (x10^6/ml)	1871.90[b]	3139.70[a]	3014.10[a]	7.80
Live spermatozoa (%)	72.13[b]	80.31[a]	77.06[ab]	1.07
Sperm motility (%)	71.81	78.43	73.63	1.14

Interactive effect of feeding regime/season	
Parameters	LOS
Semen color	*
Semen pH	***
Semen volume (ml)	***
Sperm concentration (x10^6/ml	***
Live spermatozoa (%)	*
Sperm motility (%)	*

[abc] Means within the same rows with different superscript are significantly ($P < 0.05$) different SEM= Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

The interactive effects of season and feeding regime on semen color of Kano brown bucks are presented in Figure 4.5. The result showed a significant ($P < 0.05$) difference among the seasons and feeding regimes. Highest mean value (3.0) and (3.50) was recorded in bucks under zero browsing in the dry and rainy seasons respectively. Similarly, bucks under morning supplementation recorded the highest mean value (3.40) for semen color during harmattan season. However, the lowest mean value (2.50) was recorded in bucks under morning supplementation during dry season.

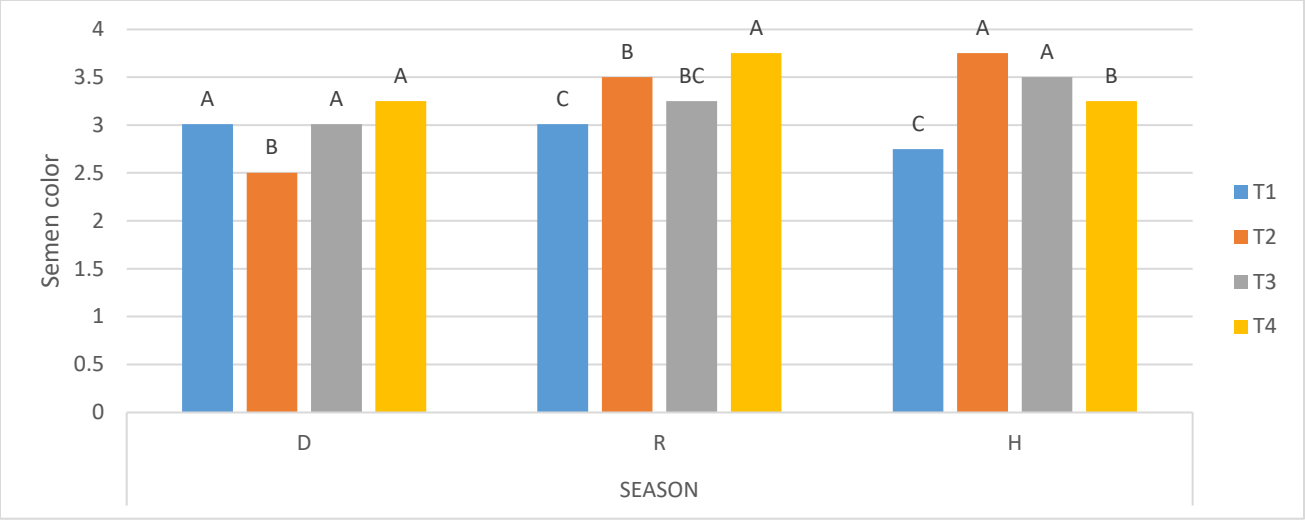

Figure 4.5 Interactive Effects of Seasons and Feeding Regime on Semen Color of Kano Brown Bucks

Figure 4.6 shows the result of interactive effects of season and feeding regime on sperm concentrations. Significant ($P < 0.05$) difference was observed on bucks under different seasons and feeding regimes. Lowest mean values ($2500x10^6$/ml) and ($2600x10^6$/m) for sperm concentration were recorded during rainy and harmattan seasons under the same feeding regime (zero supplementation). Highest mean ($2600x10^6$/ml) for sperm concentrations was recorded in bucks under zero browsing whereas bucks under morning supplementation had the lowest mean ($1200x10^6$/ml) during dry season.

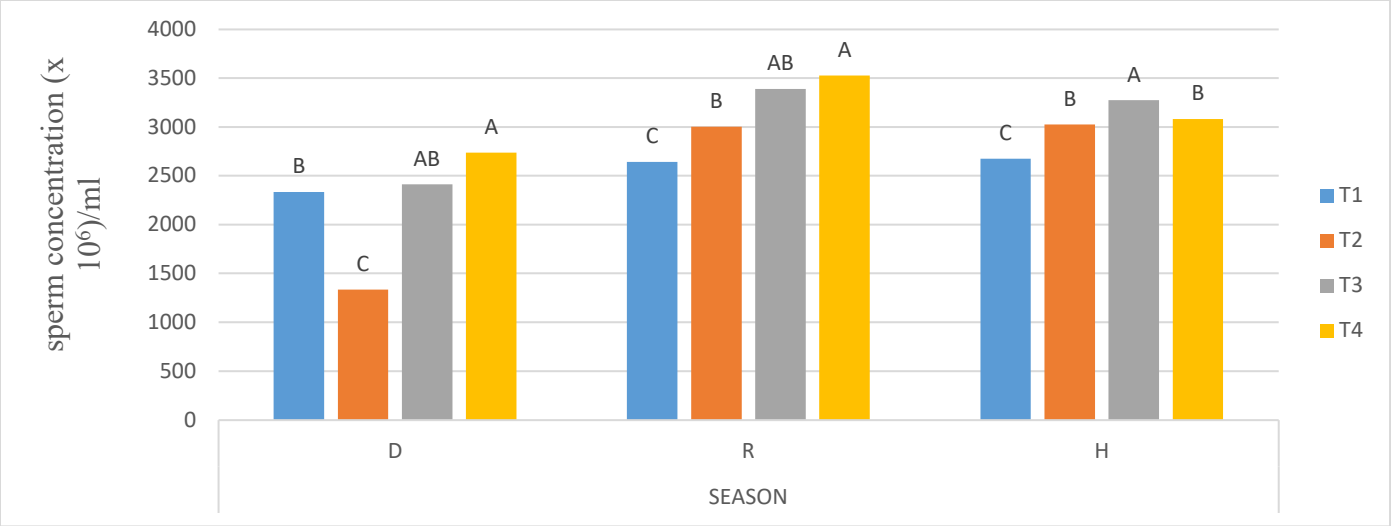

Figure 4.6 Interactive Effects of Season and Feeding Regime on Sperm Concentration

The highest mean values (7.5, 7.7 and 7.2) for semen pH were recorded during dry, rainy and harmattan seasons respectively in bucks under zero browsing while bucks under morning and evening supplementations recorded the lowest mean value (6.7 and 6.8) semen pH for dry and harmattan seasons respectively as shown in Figure 4.7.

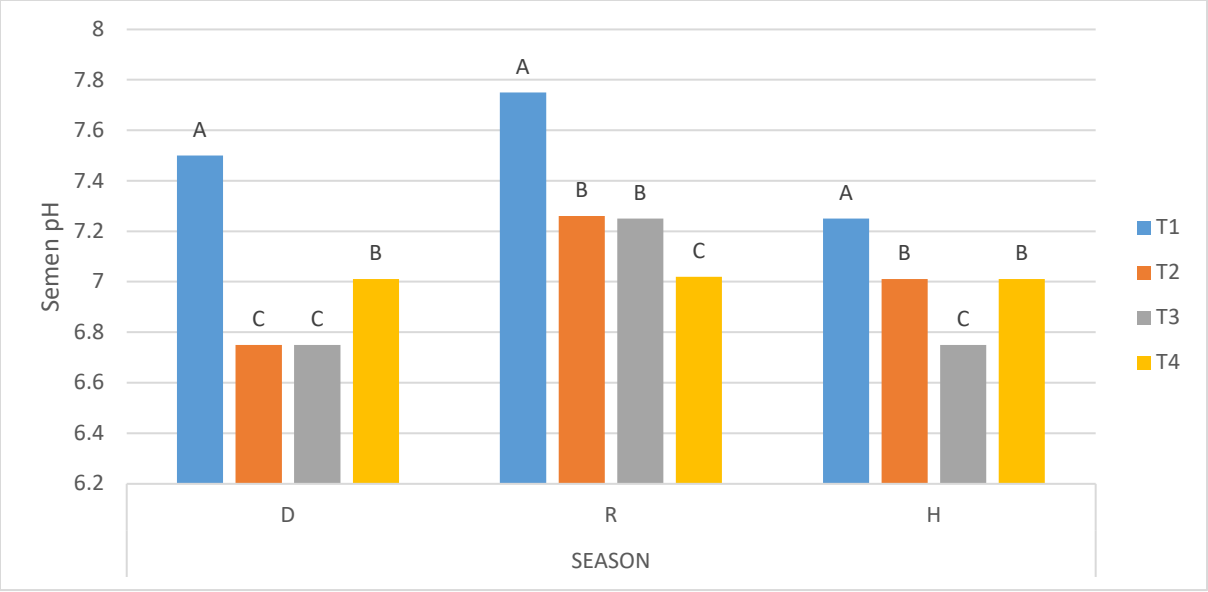

Figure 4.7 Interactive Effects of Season and Feeding Regime on Semen pH

The mean values for sperm motility as influenced by interactive effects of season and feeding regime are presented in Figure 4.8. Bucks on morning supplementation recorded the lowest mean values during the dry, rainy and harmattan seasons. However, bucks under morning and evening supplementations had the highest mean values (75%) rainy season and (77%) for harmattan season respectively.

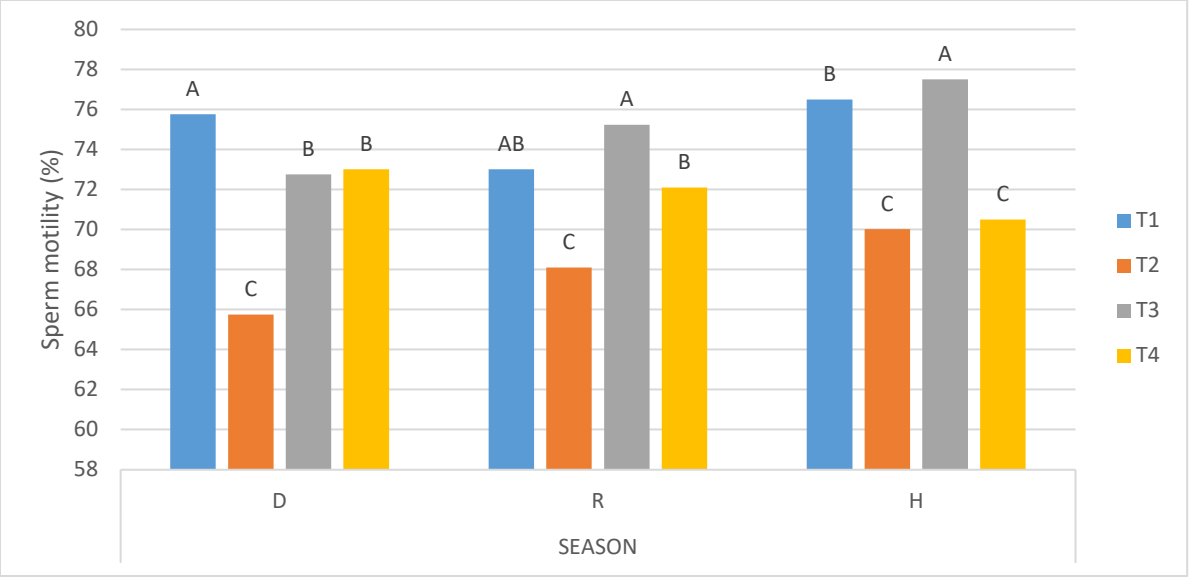

Figure 4.8 Interactive Effects of Season and Feeding Regime on Sperm Motility

The results of interactive effects of season and feeding regime on live spermatozoa of Kano brown bucks differed significantly ($P < 0.05$) among the feeding regimes under different seasons as presented in Figure 4.9. Highest mean value (82%) was recorded in bucks under zero browsing during rainy season whereas bucks under morning supplementation had the highest mean value (79%) during harmattan season.

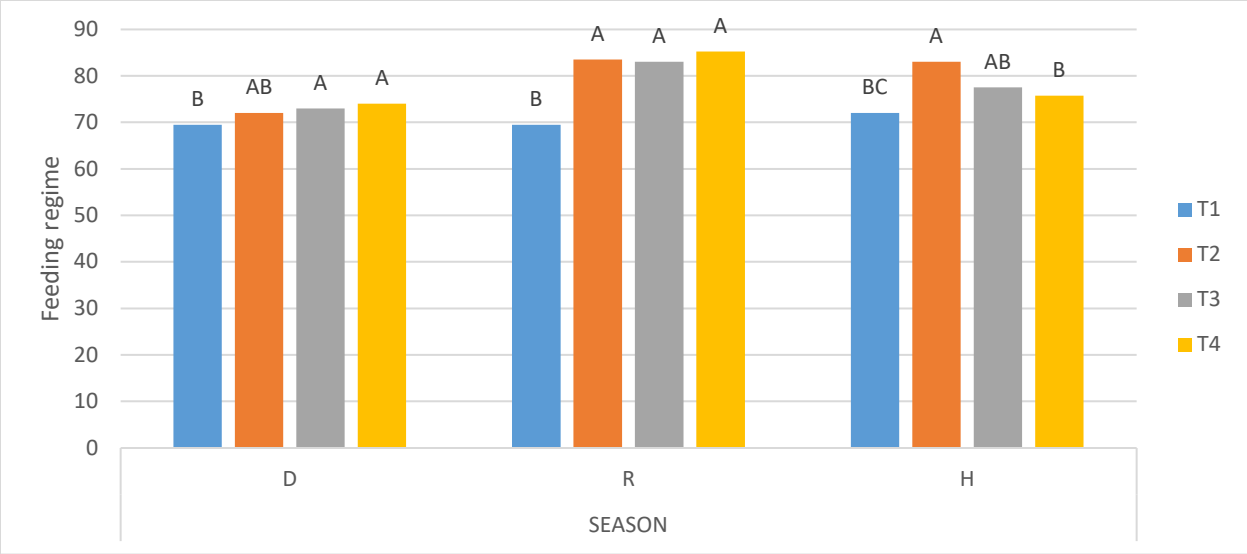

Figure 4.9 Interactive Effects of Season and Feeding Regime on Live Spermatozoa

4.1.3 Main and Interactive Effects of Season and Feeding Regime on Gonadal Sperm Reserves (X10^6 /g/testis) of Kano Brown Bucks

There were significant (P > 0.05) differences in bucks with respect to left testis sperm concentrations as present in Table 7. Highest mean value (2230.10x10^6/g/testis) for left testis sperm concentrations was recorded in bucks under morning and evening supplementations compared to those under zero browsing (1715.20x10^6/g/testis). There were also significant (P < 0.05) differences for right testis sperm concentration among the treatments. Bucks under morning and evening supplementation had the highest value (2049.70 x10^6/g/testis), right testis sperm concentration while those on zero browsing recorded the lowest mean value (1490.20 x10^6 /g/testis).

Seasonal effect on gonadal sperm reserves (x10^6 /g/testis) in the harmattan of Kano brown bucks shows significant (P < 0.05) differences. The result for the dry season recorded the highest mean value (1994.42 x10^6 and 2604 x10^6 /g/testis) for right and left testis whereas rainy season recorded the lowest mean values (1631.08x10^6 /g/testis) for left testis sperm concentration.

Table 7 Main and Interactive Effects of Season and Feeding Regime on Gonadal Sperm Reserves ($X10^6$ g/testis) of Kano Brown Bucks

	Feeding Regime				
Parameters ($x10^6$)/g/testis	ZS	MS	MES	ZB	SEM
Right testis	1885.90[ab]	1716.80[bc]	2049.70[a]	1490.20[c]	6.35
Left Test	2113.20[b]	1764.00[c]	2230.10[a]	1715.20[d]	1.70
Average	1999.55	1740.40	2139.90	1602.70	-

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Right testis	1994.42[a]	1674.00[b]	1688.50[b]	4.32
Left Testis	2604.75[a]	1631.08[b]	1631.08[b]	2.41
Average	2299.58	1652.90	1660.15	-

Interactive effects of seasons and feeding regimes

Parameters	LOS
Right testis	***
Left Testis	***

[abc] Means within the same rows with different superscripts are significantly ($P < 0.05$) different SEM= Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

Bucks under morning and evening supplementations recorded the highest mean value for right testis sperm concentrations as shown in Figure 4.10. However, the lowest mean values were obtained in bucks under zero browsing during rainy ($1600x10^6$/ml) and ($1200x10^6$/ml) harmattan seasons respectively.

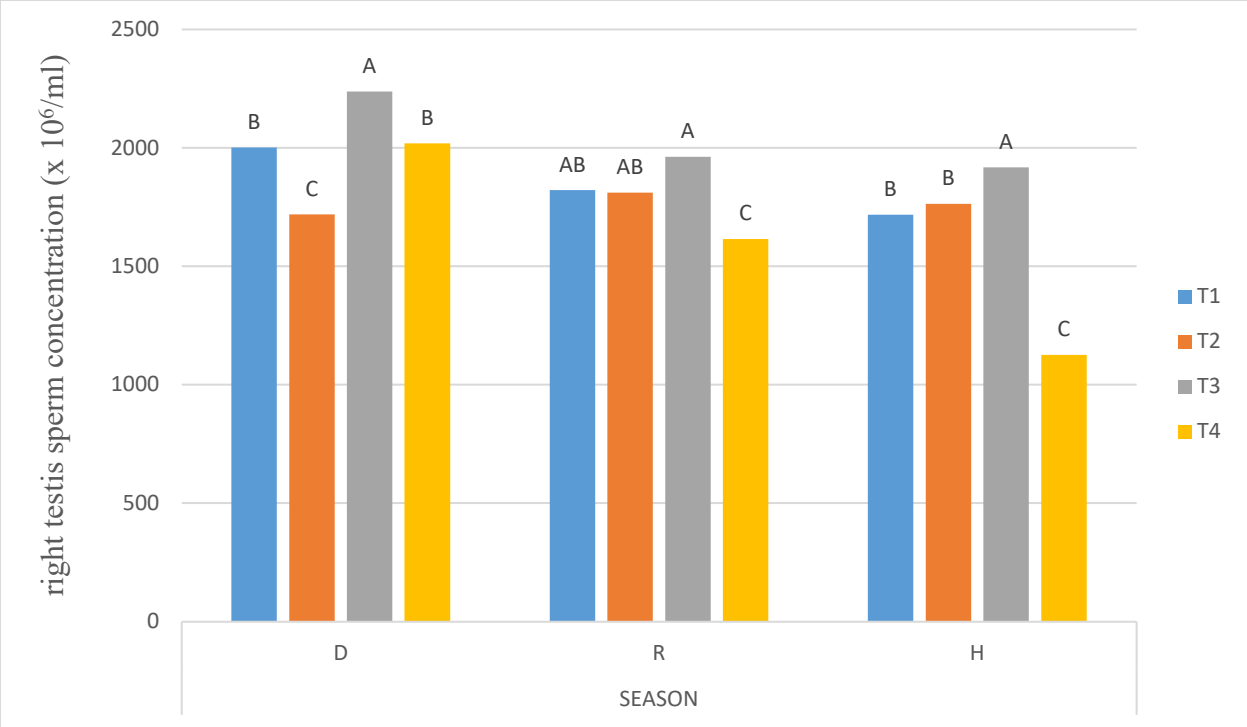

Figure 4.10 Interactive Effects of Season and Feeding Regime Right Testis Sperm Concentrations

The result of interactive effects of seasons and feeding regimes on left testis sperm concentration is presented in Figure 4.11. Significant ($P < 0.05$) difference was observed among the feeding regimes during the different season. Highest mean values ($2900x10^6$/ml and $2950x10^6$/ml) for left testis sperm concentrations were recorded in bucks under zero supplementation during the dry and rainy season respectively. While the lowest mean values ($1300x10^6$/ml and $1250x10^6$/ml) were recorded in bucks under zero browsing during rainy and harmattan seasons respectively.

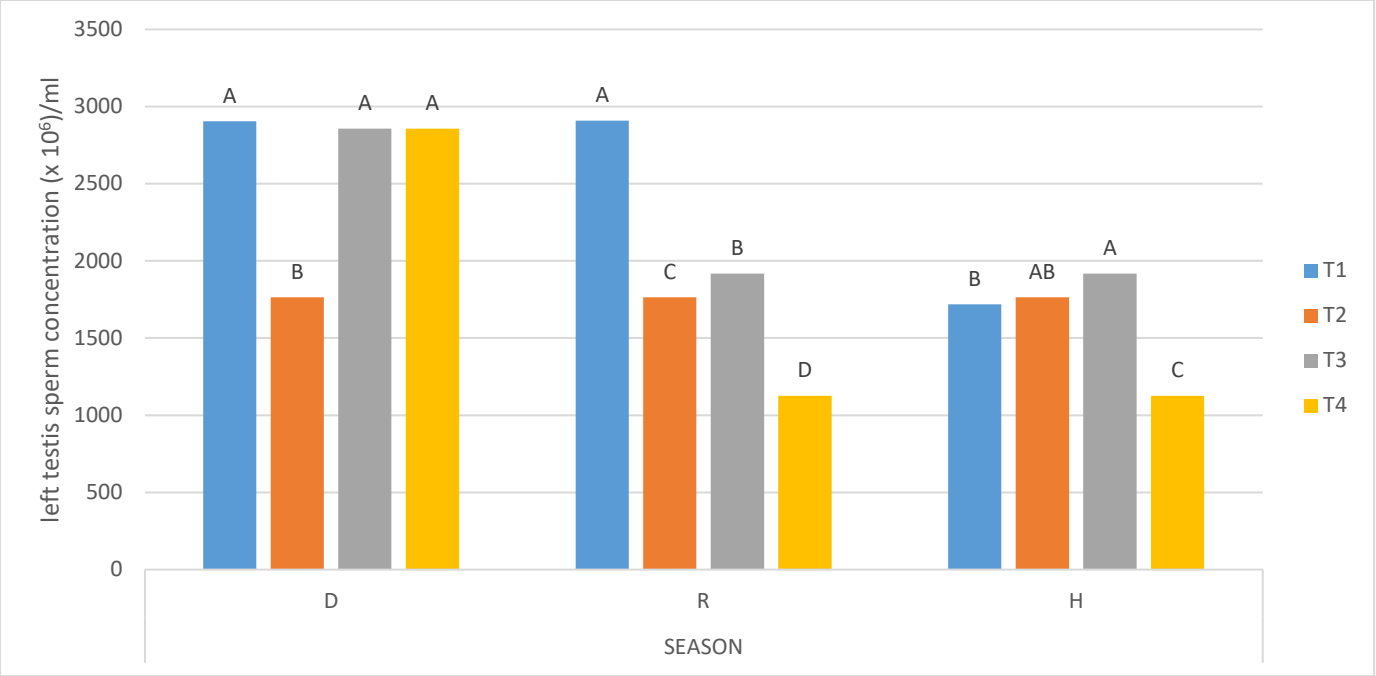

Figure 4.11 Interactive Effects of Season and Feeding Regime on Left Testis Sperm Concentrations

4.1.4 Extra-gonadal Sperm Reserves (X10^6 /G/testis) of Kano Brown Bucks Influenced by Feeding Regime

The mean values of extra-gonadal sperm reserves of Kano Brown bucks as influenced by feeding regimes are presented in Table 8. There were significant ($P < 0.05$) differences among the treatments with respect to right and left caput, corpus and cauda epididydimides sperm concentration. Highest value (1523.11x10^6 /g/testis) for right caput epididymides were recorded in bucks under zero browsing than those bucks under morning supplementation (929.11 x10^6 /g/testis). Highest value (1452.78 x10^6 /g/testis) for right corpus epididymides was in bucks under zero supplementation whereas bucks under morning supplementation had the lowest mean values (1030.00 x10^6 /g/testis). The mean value of cauda epididymides was higher (2049.67 x10^6/g/testis) in buckss under morning and evening supplementation whereas animals under zero browsing had the lowest mean values (1490.22 x10^6 /g/testis).

Similarly, the result showed that season had a significant ($P < 0.05$) effect on extra-gonadal sperm reserves (x10^6 /g/testis) of Kano brown bucks. Highest mean value (1582.00 x10^6/g/testis) for right caput epididymides were in bucks during dry season whereas bucks fed during the rainy season recorded the lowest mean values (1017.67 x10^6 /g/testis). Moreover, cauda epididymis sperm concentration was lower (1631.08 x10^6 /g/testis) for left cauda in animals kept during the rainy season as shown in Table 8.

Table 8 Extra-gonadal Sperm Reserves of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season and Feeding Regime.

	Feeding Regime				
Parameters (x10^6/g/testis)	ZS	MS	MES	ZB	SEM
Right caput	90.22^{c}	929.11^{c}	1417.11^{b}	1523.11^{a}	2.96
Left caput	964.56^{c}	893.11^{c}	1314.22^{a}	1156.56^{b}	3.49
Right corpus	1452.78^{a}	1030.00^{d}	1260.67^{b}	1140.00^{c}	3.49
Left corpus	1436.44^{a}	1039.00^{d}	1312.89^{b}	1132.67^{c}	33.72
Right cauda	1885.89^{b}	1716.78^{c}	2049.67^{a}	1490.22^{d}	2.64
Left cauda	2113.22^{b}	1764.00^{c}	2230.11^{a}	1715.22^{d}	2.59

	Season			
Parameters (x10^6/g/testis)	Dry	Rainy	Harmattan	SEM
Right caput	1582.00^{a}	1017.67^{b}	1037.50^{b}	2.96
Left caput	1557.33^{a}	835.50^{b}	853.50^{b}	3.49
Right corpus	1422.58^{a}	1120.00^{b}	1120.00^{b}	3.92
Left corpus	1465.08^{a}	1112.83^{b}	1112.82^{b}	3.37
Right cauda	1697.50^{a}	1674.00^{b}	1688.50^{b}	4.65
Left cauda	1994.42^{a}	1631.08^{b}	1632.80^{b}	2.59

Interactive effects of season and feeding regime	
Parameters (x10^6 /g/testis)	LOS
Right caput	***
Left caput	***
Right corpus	***
Left corpus	**
Right cauda	***
Left cauda	***

^{abcd} Means within the same rows with different superscript are significantly ($P < 0.05$) different SEM= Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

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Significant ($P < 0.05$) differences were recorded in bucks under different feeding regimes as presented in Figure 4.12. Highest mean values (2000 $x10^6$/ml) for left caput epididymis was recorded in bucks under zero supplentation whereas those in morning supplementation had the lowest mean (800 $x10^6$/ml) during the dry season. Bucks under zero supplementation had the lowest value of (400 $x10^6$/ml and 500 $x10^6$/ml) during rainy and harmattan seasons respectively.

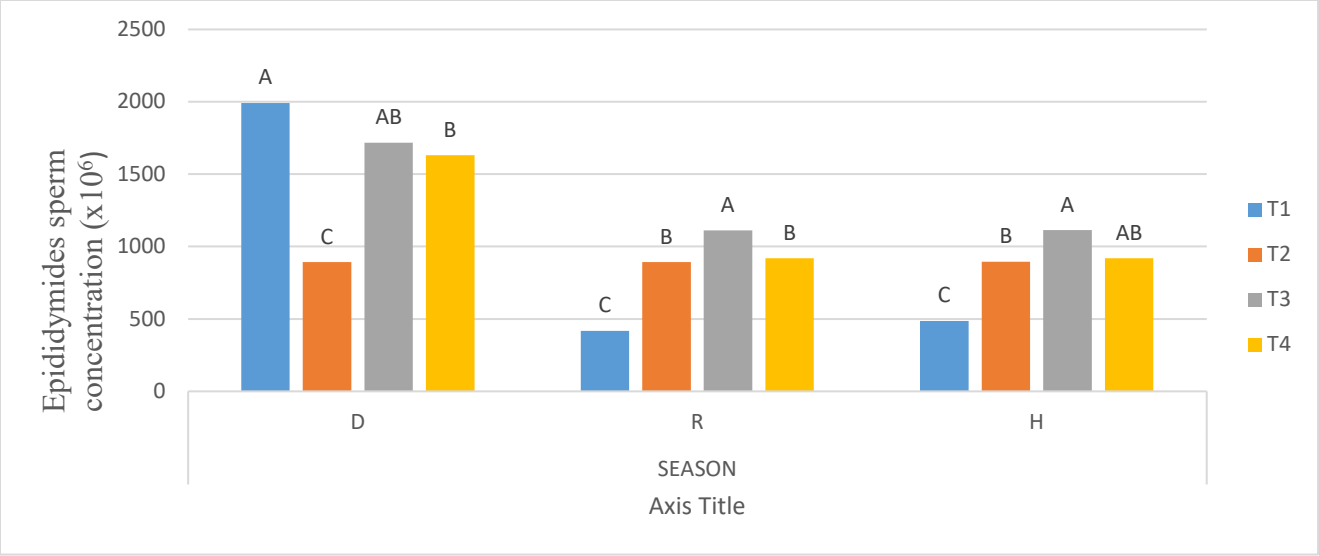

Figure 4.12 Interactive Effects of Season and Feeding Regime on Left Caput Epididymides Sperm Concentrations

The mean values of the interactive effects of season and feeding regime on Kano Brown bucks are presented in Figure 4.13. Bucks under zero supplementation had the highest mean values during dry, rainy and harmattan seasons. No significant ($P > 0.05$) differences were observed for bucks under morning and evening supplementation and those under zero browsing with respect to left corpus epididymides sperm concentrations.

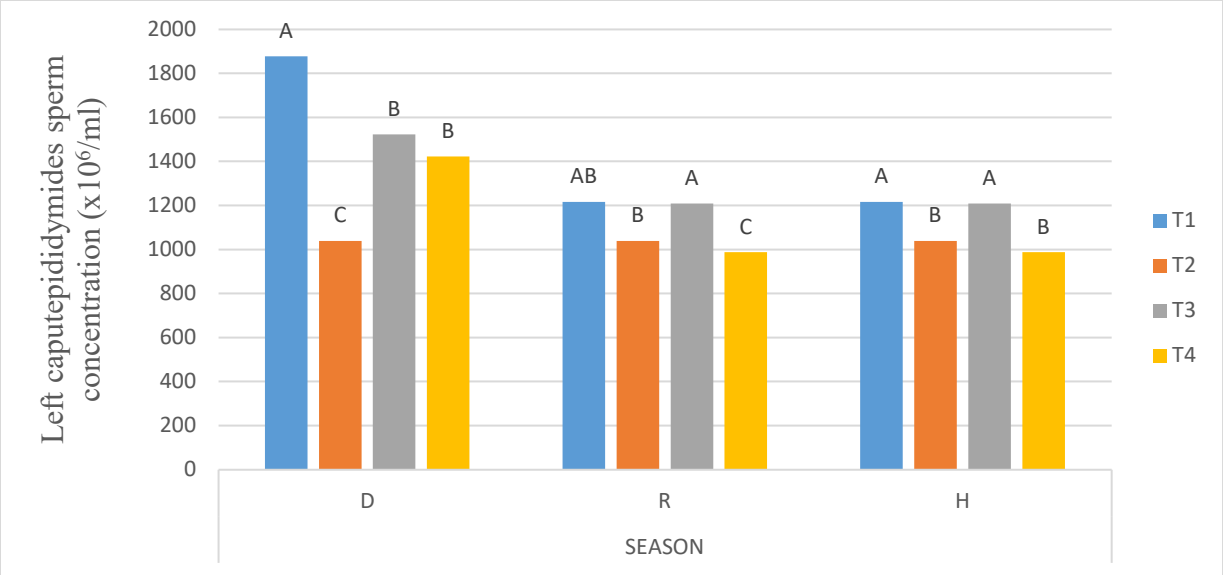

Figure 4.13 Interactive effects of season and feeding regime on left corpus epididymides sperm concentrations

4.1.5 Testicular Morphometry of Kano Brown Bucks as Influenced by Main Effect of Season and Feeding Regime

The mean values of testicular morphometry of Kano Brown bucks as influenced by main effect of season and feeding regime are shown in Table 9. The highest mean value (69.66g) for right testis weight was in bucks under morning and evening supplementation and bucks on zero browsing had the lowest mean value (52.66g). Similarly, left testis weight was higher under zero supplementation than in bucks under morning supplementation (48.16g). The mean value (90.94 cm) for right testis length was significantly ($P < 0.05$) higher in bucks on zero supplementation while bucks on zero browsing had the lowest value (75.98 cm). Highest value (198.45cm) for paired testis length was recorded in bucks under morning and evening supplementations than those under zero browsing (149.39 cm).

However, seasonal effect on testicular morphometry of Kano Brown bucks as presented in Table 9 showed significant ($P < 0.05$) difference among the three seasons investigated. Bucks fed during the dry season had the highest mean value (58.96g) for left testis weight compared to during rainy season (51.84g). The mean value (90.00 cm) for right testis length in bucks during the harmattan season was higher than those during rainy season (88.31 cm).

Table 9 Testicular Morphometry of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Right testis weight (g)	60.74[b]	50.50[c]	69.66[a]	52.66[c]	0.86
Left testis weight (g)	60.94[a]	48.16[c]	56.17[ab]	51.67[bc]	0.85
Paired testis weight (g)	120.21[a]	98.21[c]	125.20[ab]	103.31[bc]	1.21
Right testis length (cm)	90.94[b]	88.30[b]	90.o0[a]	75.98[d]	0.23
Left testis length (cm)	91.58[b]	87.20[c]	102.07[a]	73.38[d]	0.18
Paired testis length (cm)	181.72[a]	175.63[c]	198.45[a]	149.38[d]	0.30

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Right testis weight (g)	59.63[a]	57.76[b]	57.60[b]	0.86
Left testis weight (g)	58.96[a]	51.84[b]	51.92[b]	0..85
Paired testis weight (g)	110.27[a]	108.95[b]	108.99[b]	0.86
Right testis length (cm)	89.93[b]	88.31[b]	90.00[a]	0.33
Left testis length (cm)	92.26[a]	87.93[b]	81.11[b]	0.80
Paired testis length (cm)	179.73[b]	168.13[c]	187.13[a]	0.64

Interactive effects of season and feeding regime	
Parameters	LOS
Right testis weight (g)	-
Left testis weight (g)	*
Paired testis weight (g)	*
Right testis length (cm)	**
Left testis length (cm)	*
Paired testis length (cm)	**

[abcd] Means within the same rows with different superscript are significantly ($P < 0.05$), different SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

4.1.6 Epididymal Morphometry of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

The results of epididymal morphemetry of Kano Brown bucks are presented in Table 10. There were significant ($P < 0.05$) differences among the treatments as bucks on morning and evening supplementation had the highest value (8.49g) for right epididymal weight (g) while those under morning supplementation had the lowest (5.19g). The mean values of epididymidal length were higher for right epididymides length (11.10 cm) in bucks on morning and evening supplementation while those under zero supplementation had the lowest value (5.34 cm) for right epididymal length.

However, the effects of season on epididymal morphometry of Kano Brown bucks was significantly ($P < 0.05$) higher in bucks during harmattan (6.66g) for right epididymal weight as shown in Table 10. Bucks during the dry season had the lowest mean value (5.48g). Similarly, the mean value of epididymal length was higher (8.74 cm) for right epididymides in bucks reared during the dry season compared to those raised during harmattan (8.95 cm).

Table 10 Epididymal Morphometry of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Right epididimis weight (g)	5.82[b]	5.19[b]	8.49[a]	5.21[b]	0.42
Left epididymis weight (g)	9.03[b]	5.50[bc]	8.84[a]	5.03[c]	0.48
Right epididymis length (cm)	5.34[c]	8.02[bc]	11.10[a]	8.56[ab]	2.02
Left epididymis length (cm)	10.92[b]	10.40[b]	12.79[a]	8.37[c]	0.88

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Right epididimis weight	5.48[b]	6.39[ab]	6.66[a]	0.42
Left epididymis weight (g)	5.56[b]	6.96[a]	7.28[a]	0.15
Right epididymis length (cm)	8.74	8.95	8.92	2.02
Left epididymis length (cm)	10.98	10.90	10.98	0.88

Interactive effects of season and feeding regime	
Parameters	LOS
Right epididimis weight (g)	*
Left epididymis weight (g)	*
Right epididymis length (cm)	**
Left epididymis length (cm)	*

[ab] Means within the same rows with different superscript are significantly ($P < 0.05$) different SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

The mean values of right epididymides weight of Kano brown bucks as influenced by interactive effects of seasons and feeding regimes are presented in Figure 4.14. The result shows significant ($P < 0.05$) difference for right epididymis weight among the season under different feeding regimes. Highest mean value (10g) was recorded in bucks under morning and evening supplementations during harmattan season whereas bucks under morning supplementation had the lowest mean (6g) for the same season.

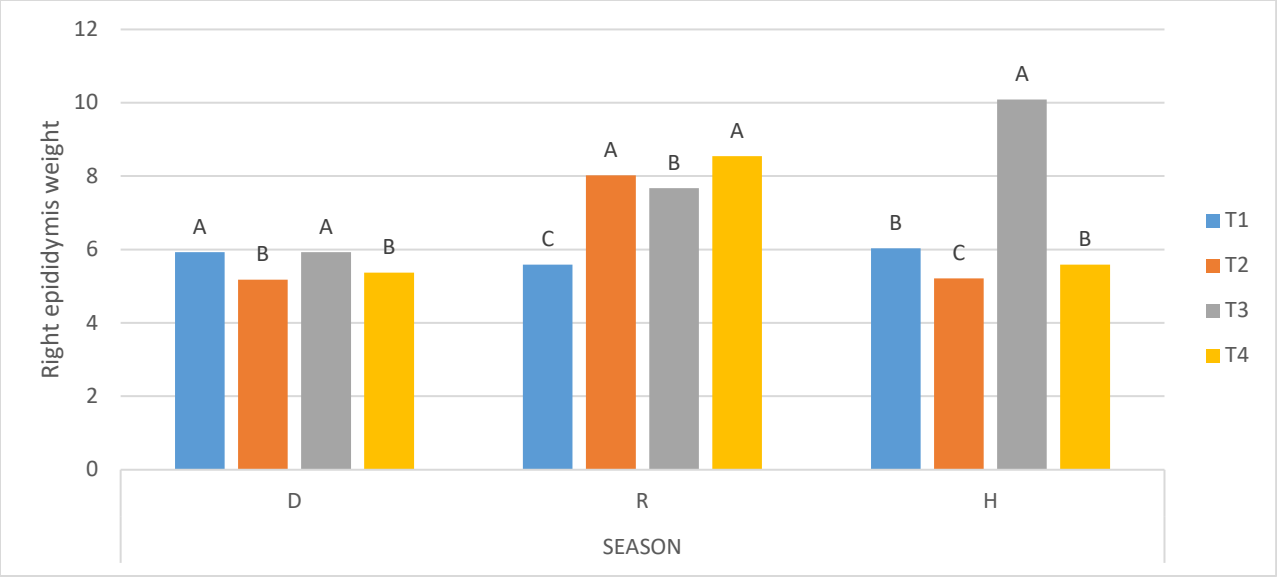

Figure 4.14 Interactive Effects of Season on Right Epididymis Weight

Figure 4.15 shows the result of interactive effects of season and feeding regimes on left epididymides weight of Kano brown bucks. Highest mean value (10.10g) was obtained in bucks under morning and evening supplementations during rainy season and (10.05g) under the same feeding regime during harmatan season.

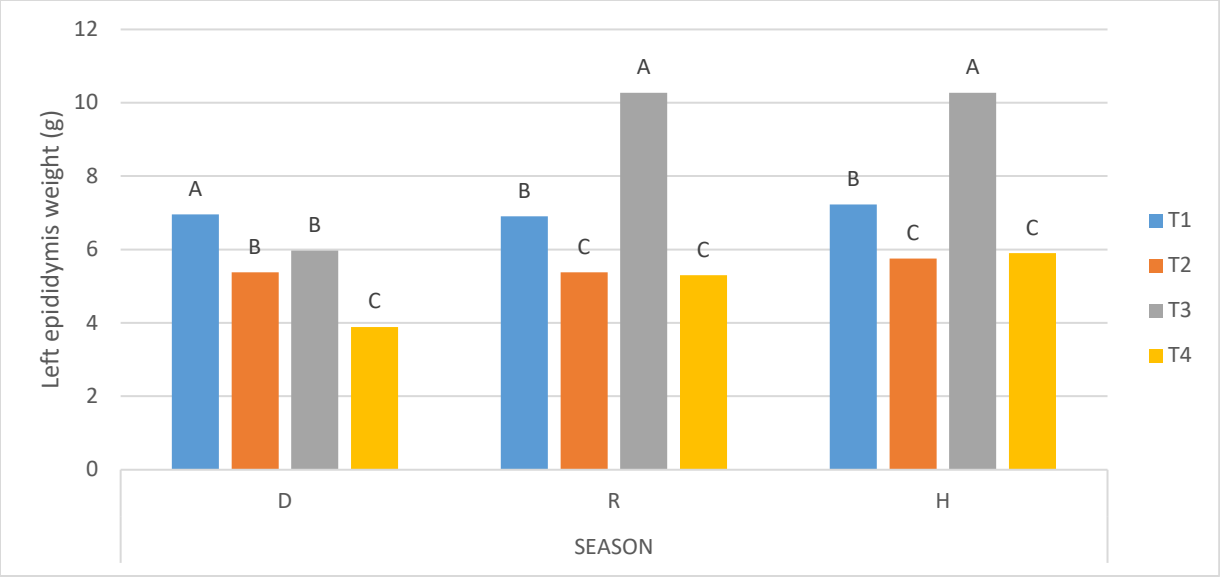

Figure 4.15 Interactive Effects Season and Feeding Regime on Left Epididymis Weight

4.1.7 Testicular Homogenate and Filtrate Volume of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

There were significant ($P < 0.05$) differences in testicular homogenate and filtrate volume of Kano Brown bucks as shown in Table 11. Highest value (31.79 ml) for right testis homogenate volume in bucks under morning and evening supplementation and bucks under morning supplementation had the lowest value (15.14 ml). Right testis filtrate volume was higher (38.03 ml) in bucks under zero supplementation while animals under morning supplementation had the lowest mean (20.76 ml). The mean value of left testis filtrate volume (ml) was significantly ($P < 0.05$) higher (45.44 ml) in bucks on zero supplementation whereas bucks under zero browsing had the lowest mean (36.36 ml).

Moreover, the results of seasonal effects on testicular homegeante and filtrate volume of Kano Brown bucks are depicted in Table 11. Harmattan season had the highest value (21.89 ml) for right testis homogenate volume whereas animals during rainy season had the lowest mean value (12.12 ml). There were also significant ($P < 0.05$) differences in right and left testis filtrate volume (ml) among the three seasons. Highest mean (42.30 ml) was recorded in bucks during harmattan season while those in the dry season had the lowest value (33.84 ml).

Table 11 Testicular Homogenate and Filtrate Volume (ml) of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Right testis homogenate	18.09[b]	15.14[c]	31.29[a]	19.22[b]	0.23
Left testis homogenate	20.19[c]	19.33[d]	25.52[a]	21.30[b]	0.33
Right testis filtrate	38.03[b]	20.76[c]	63.81[a]	35.18[b]	0.86
Left testis filtrate	43.46[b]	59.28[a]	40.93[c]	36.36[d]	0.59

	Season			
Parameters	Dry	Rainy	Harmattan	SEM
Right testis homogenate	20.89	21.12	21.18	0.48
Left testis homogenate	19.69[b]	22.49[a]	22.57[a]	0.33
Right testis filtrate	33.84[b]	42.18[a]	42.30[a]	0.86
Left testis filtrate	43.30[b]	45.78[a]	45.94[a]	0.59

Interactive effects of season and feeding regime	
Parameters	LOS
Right epididimis weight	***
Left epididymis weight	***
Right epididymis length	***
Left epididymis length	**

[abcd] Means within the same rows with different superscript are significantly ($P < 0.05$) different SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, Z B = Zero Browsing, LOS = Level of Significance.

The interactive effects of season and feeding regime on left testis homogenate volume are presented in Figure 4.16. There were no significant ($P > 0.05$) differences with respect to left testis homogenate volume of Kano Brown bucks. However, bucks under morning and evening supplementations had the highest mean values during rainy and harmattan sesaons whereas bucks under morning supplementation had the lowest value.

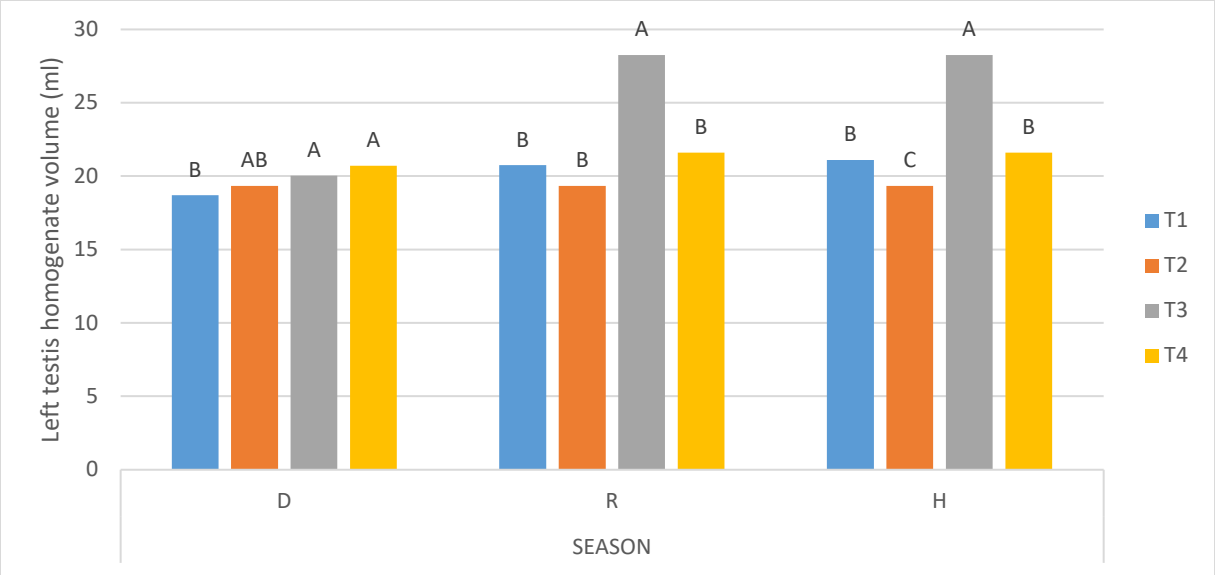

Figure 4.16 Interactive Effects of Season and Feeding Regime on Left Testis Homogenate Volume

The result of interactive effect of season and feeding regime of Kano Brown bucks is presented in Figure 4.17. No significant ($P < 0.05$) differences were observed for bucks under zero supplementation and those on morning supplementation with respect to right testis homogenate volume during rainy and harmattan seasons. Similarly, bucks under morning and evening supplementations recorded the highest mean values (36 ml).

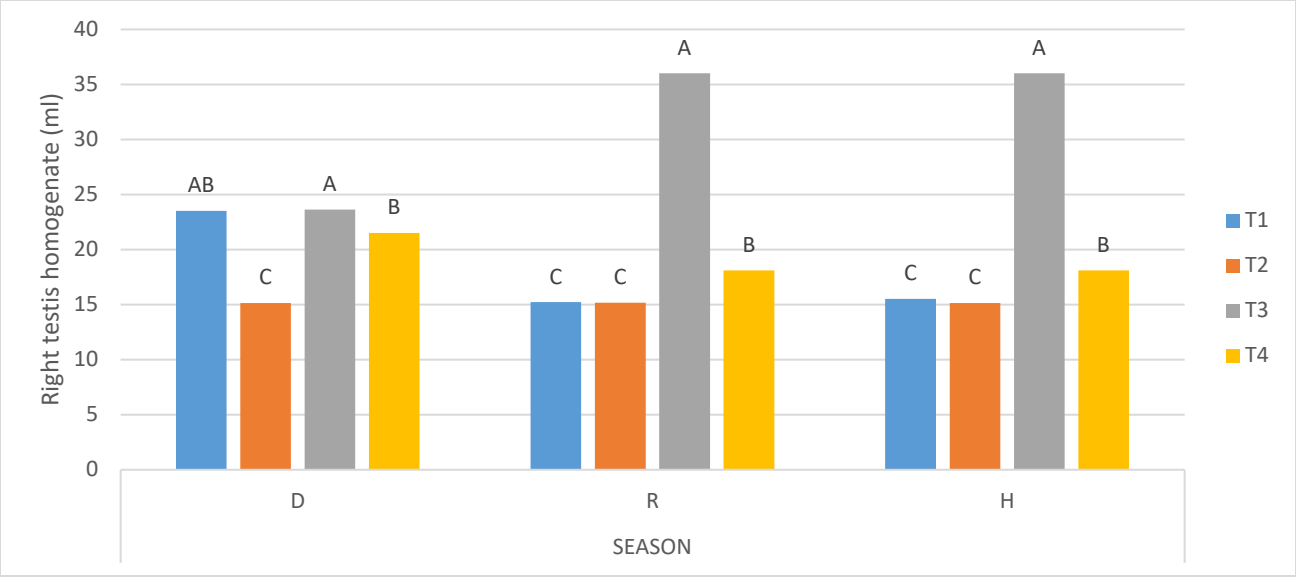

Figure 4.17 Interactive Effects of Season and Feeding Regime on Right Testis Homogenate Volume

Significant ($P < 0.05$) differences were observed for left testis filtrate volume of Knao Brown bucks as affected by interactive effects of season and feeding regime (Figure 4.18). Highest mean value (59.00 ml, 68.00 ml and 69.50 ml) was recorded in bucks under morning supplementation during dry, rainy and harmattan seasons respectively. However, the lowest mean value of (30 ml) was recorded in bucks under zero supplementation during dry season.

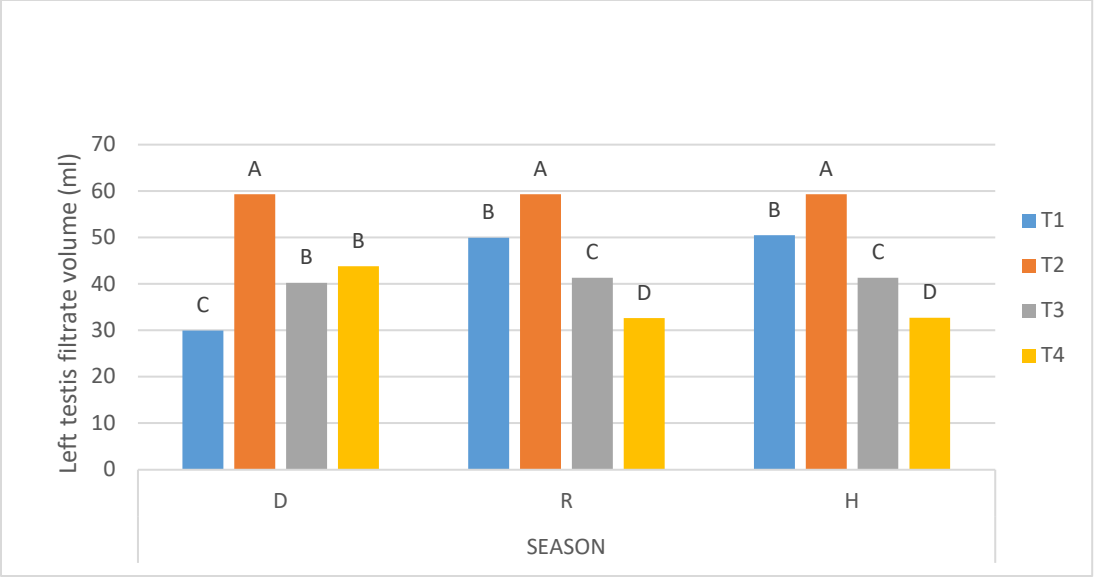

Figure 4.18 Interactive Effects of Season and Feeding Regime on Left Testis Filtrate Volume

The mean values of right testis filtrate volume of Kano brown bucks as influenced by interactive effects of season and feeding regime are presented in Figure 4.19. The results showed significant ($P < 0.05$) differences among the season and feeding regimes. Bucks under morning and evening supplementations had the highest mean values.

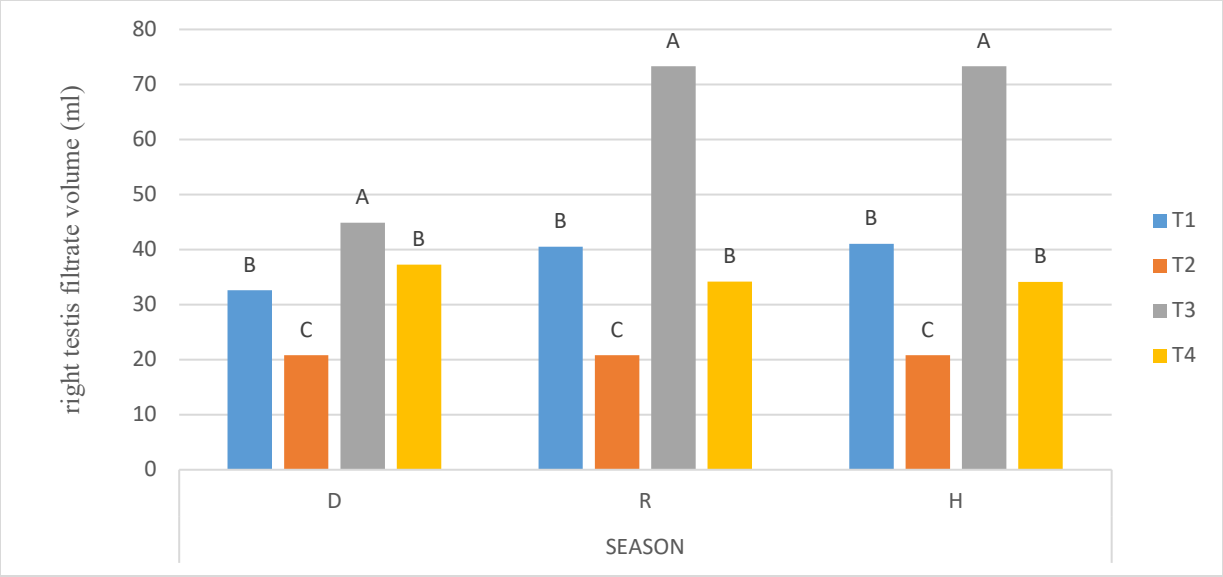

Figure 4.19 Interactive Effects of Season and Feeding Regime on Right Testis Filtrate Volume

4.1.8 Epididymal Homogenate Volume (ml) of Kano Brown Bucks as Affected by Feeding Regime and Season

Table 12 shows the results of epididymal homogenate volume of Kano brown bucks. There were significant ($P < 0.05$) differences among the treatment means. The highest mean for right caput epididymal homogenate volume was recorded in animals under morning supplementation and bucks on zero supplementation had the lowest mean (9.22 ml). Similarly, left caput epididymal value was higher (12.86 ml) in bucks on morning and evening supplementation compared to those on zero browsing which had the lowest value (10.74 ml). There were significant ($P < 0.05$) differences in bucks for left and right corpus and cauda epididymal homogenate volume. Highest value (27.72 ml) for left cauda epididymides homogenate volume was in bucks under zero browsing while animals under zero supplementation had the lowest mean (8.33 ml).

Furthermore, Table 12 also present the result of seasonal effect on epididymal homogenate volume of Kano Brown bucks. Dry season had the highest mean (11.52 ml) for right caput epididymal homogenate volume while bucks during harmattan season had the lowest value (10.67 ml). There were no significant ($P > 0.05$) differences among the bucks with respect to their left caput epididymides, left and right cauda epididymides homogenate volumes, even though highest value (11.25 ml) was recorded in bucks during the dry and rainy seasons with harmattan having lowest mean (11.85 ml).

Table 12 Epididymal Homogenate Volume (ml) of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season and Feeding Regime

	Feeding regime				
Parameters	ZS	MS	MES	ZB	SEM
Right caput epididymides	9.22^{c}	11.52^{a}	10.58^{b}	11.01^{a}	0.35
Left caput epididymides	11.93^{bc}	11.99^{ab}	12.86^{a}	10.74^{b}	0.53
Right carpus epididymides	9.33^{b}	11.19^{a}	9.30^{a}	10.71^{a}	0.44
Left carpus epididymides	9.56^{a}	12.18^{a}	9.20^{c}	11.20^{b}	1.19
Right cauda epididymides	12.56^{a}	9.89^{c}	10.60^{bc}	11.72^{bc}	0.51
Left cauda epididymides	8.33	8.19	11.21	21.72	8.87

	Seasons			
Parameters	Dry	Rainy	Harmattan	SEM
Right caput epididymides	11.52^{a}	10.21^{b}	10.07^{b}	0.35
Left caput epididymides	11.27^{b}	12.20^{a}	11.96^{ab}	0.53
Right carpus epididymides	9.65^{b}	10.25^{ab}	10.47^{a}	0.41
Left carpus epididymides	10.23	10.54	10.75	0.39
Right cauda epididymides	11.25	11.25	11.08	0.51
Left cauda epididymides	17.28	10.25	10.08	8.78

	Interactive effect of feedng regime regime/season
Parameters	LOS
Right caput epididymides	NS
Left caput epididymides	NS
Right carpus epididymides	**
Left carpus epididymides	*
Right cauda epididymides	***
Left cauda epididymides	*

^{abcd} Means withint thesame rows with different superscript are significantly (P<0.05) different SEM=Standard error of mean, ZS=Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, ZB = Zero Browsing, LOS = Level of Significance, NS = No Significant Difference.

4.1.9 Epididymal Filtrate Volume of Kano Brown Bucks as Influenced by Season and Feeding Regime

The mean values of epididymal filtrate volume of Kano Brown bucks are resented in Table 13. The result revealed significant ($P < 0.05$) difference among the feeding regimes. Animals on zero browsing recorded the highest (9.89 ml) mean value of right caput epididymal homogenate volume and bucks under zero supplementation had the lowest mean (7.25 ml). Similarly, the mean for corpus and cauda epididymal homogenate volume was higher (10.44 ml) in bucks under morning supplementation for right corpus epididymal homogenate volume and bucks on morning and evening supplementation had the lowest mean values (7.63 ml) as shown in Table 13.

Epididymal filtrate volume of Kano Brown bucks was influenced by season as shown in Table 13. Highest value (8.91 ml) for right caput epididymal filtrate volume was in bucks in the dry season whereas as shown in Table 13. Rainy season had the highest value (7.84 ml). Significant ($P < 0.905$) differences were observed for both corpus and cauda epididymides.

Table 13 Epididymal Filtrate Volume (ml) of Kano Brown Bucks as Influenced By Main and Interactive Effect of Season and Feeding Regime

	Feeding Regime				
Parameters	ZS	MS	MES	ZB	SEM
Right caput	7.23^{c}	8.33^{b}	7.89^{bc}	9.89^{a}	0.42
Left caput	9.59^{b}	10.69^{a}	10.22^{a}	8.83^{c}	0.27
Right corpus	9.20^{b}	10.44^{a}	7.63^{c}	10.00^{ba}	0.29
Left corpus	9.41^{b}	10.97^{a}	7.70^{c}	9.64^{b}	0.36
Right cauda	10.11^{a}	8.33^{b}	6.68^{c}	10.56^{a}	0.39
Left cauda	7.02^{c}	8.33^{b}	8.54^{b}	10.12^{a}	0.31

	Seasons			
Parameters	Dry	Rainy	Harmattan	SEM
Right caput	8.91^{a}	7.84^{b}	8.25^{ab}	0.42
Left caput	8.79^{b}	10.25^{a}	10.46^{a}	0.26
Right carpus	9.45	9.02	9.49	0.39
Left carpus	9.41	9.29	9.59	0.35
Right cauda	9.08	8.72	8.97	0.39
Left cauda	8.98^{a}	8.10^{b}	8.43^{ab}	0.31

	Interactive effect feeding regime/season
Parameters (ml)	LOS
Right caput	***
Left caput	***
Right corpus	*
Left corpus	*
Right cauda	***
Left cauda	**

^{abcd} Means within the same rows with different superscript are significantly ($P < 0.05$) different, SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, ZB = Zero Browsing, LOS = Level of Significance LOS = Level of Significance.

4.1.10 Haematological Parameters of Kano Brown Bucks as Influenced By Main and Interactive Effects of Season and Feeding Regime

Data on haematological parameters of Kano Brown bucks are presented in Table 14. The result showed non- significant differences among the treatments means. Haemogloblins, packed cell volume and mean corpuscular volume. Highest mean value (12.23g/dl) for haemoglobins was recorded in bucks under zero supplementation whereas bucks under morning and evening supplementation had the lowest mean (10.76g/dl). There was significant ($P < 0.05$) differences in red blood cell in which bucks under morning and evening supplementation had the highest mean ($9.98x10^6$/ul) whereas bucks under morning supplementation had the lowest mean ($6.70x10^6$/ul). No significant ($P > 0.05$) difference was observed for monocyte among the animals under different feeding regimes even though highest mean (4.37%) was recorded in bucks under morning and evening supplementation whereas bucks under morning supplementation had the lowest value (1.60%) as presented in Table 14.

The value for haematological parameters of Kano brown bucks as influenced by season are presented in Table 15. Significant ($P < 0.05$) difference was observed among the three seasons investigated with respect to red blood cell and white blood cell. Highest mean ($9.68x10^6$/ul) was recorded in bucks during rainy season than bucks in dry season having the lowest mean ($7.84x10^6$/ul). No significant ($P > 0.05$) differences was observed in bucks for eosinophils, basophil and mean corpuscular volume. Highest mean values (2.46%) for basophils was recorded in animals during harmattan season followed by bucks during dry season with mean values of 1.88% as showed in Table 15.

Table 14 Heamatological Parameters of Kano Brown Bucks as Influenced by Main and Interactive Effects of Feeding Regime

Parameters	Feeding Regime				SEM	Reference Values
	ZS	MS	MES	ZB		
Hb (g/dl)	12.23	11.98	10.76	12.13	0.72	9-l5
PCV (%)	41.33	42.33	37.89	40.33	2.86	27-45
RBC ($x10^6$/ml)	7.00^{b}	8.33^{b}	7.06^{b}	13.56^{a}	0.79	11-15
MCV (fl)	84.33^{ab}	6.70^{b}	9.89^{a}	7.56^{ab}	7.54	28-40
MCHC (g/dl)	16.00	14.33	15.30	15.67	12.48	31-54
MCH (pg)	88.33^{a}	72.70^{b}	76.90^{ab}	84.69^{ab}	6.79	31-34
White blood cell (%)	17.49	18.00	18.91	19.47	1.32	8-12
Neutrophils (%)	20.13^{b}	20.56^{b}	24.54^{a}	23.54^{a}	1.02	10.-50
Lymphocytes (%)	40.82	53.55	42.10	42.69	6.21	40-75
Eesinophils (%)	7.00^{a}	6.00^{ab}	5.11^{b}	6.00^{ab}	0.67	1-15
Basophils (%)	2.50^{ab}	1.66^{b}	2.88^{a}	2.00^{ab}	0.39	0-3
Monocytes (%)	2.67	1.60	4.37	3.99	0.96	0-6

^{abcd} Means within the same rows with different superscript are significantly different ($P < 0.05$), SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, ZB = Zero Browsing, LOS = Level of Significance LOS = Level of Significance. Hb = Haemoglobin, PCV = Packed cell volume, RBC = Red blood cell, MCV = Mean corpuscular volume, MCHC = Mean corpuscular haemoglobin concentration, MCH = Mean corpuscular haemoglobin

Table 15 Heamatological Parameters of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season

	Seasons			
Parameters	Dry	Rainy	Harmattan	SEM
Hb (g/dl)	12.02	11.59	11.75	0.72
PCV (%)	40.74	40.75	39.92	2.85
RBC ($x10^6$/ml)	7.84^b	9.68^a	9.43^a	0.79
MCV (fl)	80.76	78.66	78.66	7.25
MCHC (g/dl)	21.57	21.58	21.58	12/47
MCH (pg)	76.92	82.50	82.52	6.79
White blood cell (%)	19.35	20.05	16.00	11.32
Neutrophils (%)	20.83^b	22.79^a	$22,79^a$	1.02
Lymphocytes (%)	54.60^a	55.82^a	23.91^b	6.31
Eesinophils (%)	5.4167	6.33	6.33	0.67
Basophils (%)	1.88	2.45	2.46	0.39
Monocytes (%)	2.40^a	3.85^a	4.67^b	0.96

	Interactive effect feeding regime and seasons
Parameters	LOS
Heamoglobin (g/dl)	NS
Packed cell volume (%)	NS
Red blood cell ($x10^6$/ml)	***
Mean corpuscular volume (fl)	NS
Meancorpuscularhemoglobin	***
concentration (g/dl)	*
Mean corpuscular rhemoglobin (pg)	NS
White blood cell (%)	*
Neutrophils (%)	NS
Lymphocytes (%)	*
Eesinophils (%)	*
Basophils (%)	*
Monocytes (%)	

[abcd] Means within the same rows with different superscript are significantly ($P < 0.05$) different, SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, ZB = Zero Browsing, LOS = Level of Significance LOS = Level of Significance. Hb = Haemoglobin, PCV = Packed cell volume, RBC = Red blood cell, MCV = Mean corpuscular volume, MCHC = Mean corpuscular haemoglobin concentration, MCH = Mean corpuscular haemoglobin

No significant difference ($P > 0.05$) was recorded in bucks under zero supplementation, morning supplementation and zero browsing for MCHC, whereas bucks under morning and evening supplementations differed significantly ($P < 0.05$) among the feeding regimes during rainy season as shown in Figure 4.20. This is similar to harmattan season. Highest mean value (30g/dl) was obtained in bucks under morning and evening supplementations whereas bucks under morning supplementation had the lowest mean value (25g/dl) during dry season.

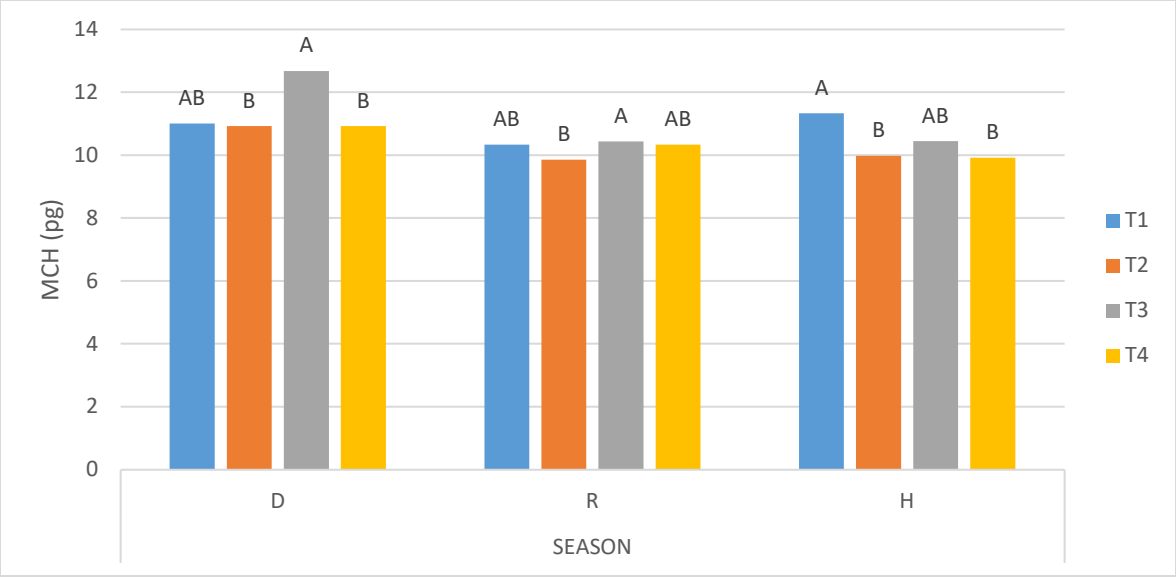

Figure 4.20 Interactive Effects of Season and Feeding Regime on MCHC

Figure 4.21 presents the result of interactive effects of season and feeding regimes on the neutrophils of Kano Brown bucks. Significant differences were observed among the treatments observed.

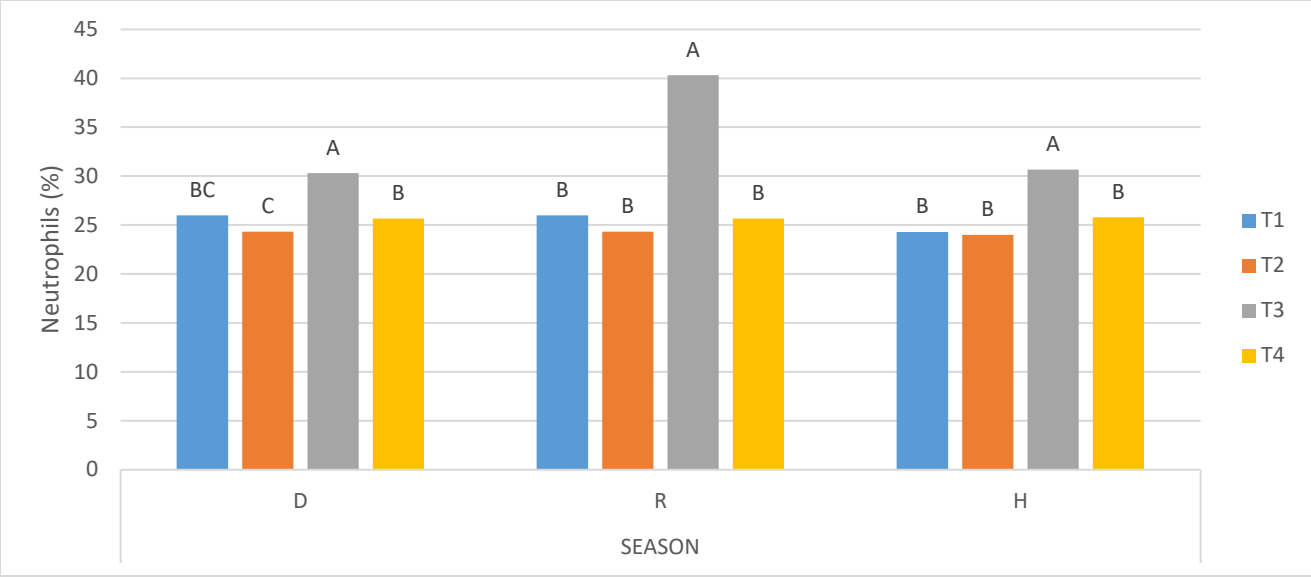

Figure 4.21 Interactive Effects of Season and Feeding Regimes Neutrophils

Figure 4.22 shows the result of interactive effects of season and feeding regime on neutrophils of Kano brown bucks. No significant difference ($P > 0.05$) was observed for bucks under zero supplementation, morning supplementation and bucks in zero browsing during dry season. Furthermore, bucks under zero supplementation and those under morning supplementation did not differ significantly ($P < 0.05$) whereas those under morning and evening supplementations and zero browsing recorded significant ($P < 0.05$) differences.

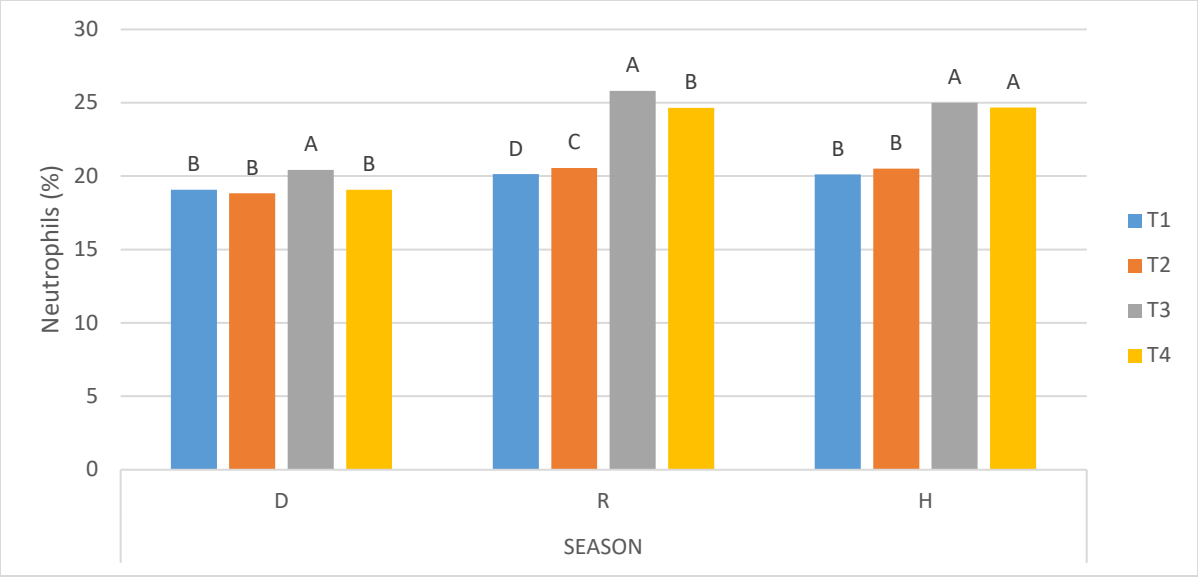

Figure 4.22 Interactive Effects of Season and Feeding Regime on Neutrophils

The result of interactive effects of season and feeding regime on RBC is presented in Figure 4.23. Significant ($P < 0.05$) difference was observed among the feeding regimes during the difference seasons. Bucks under morning and evening supplementations recorded the highest mean values among the three seasons.

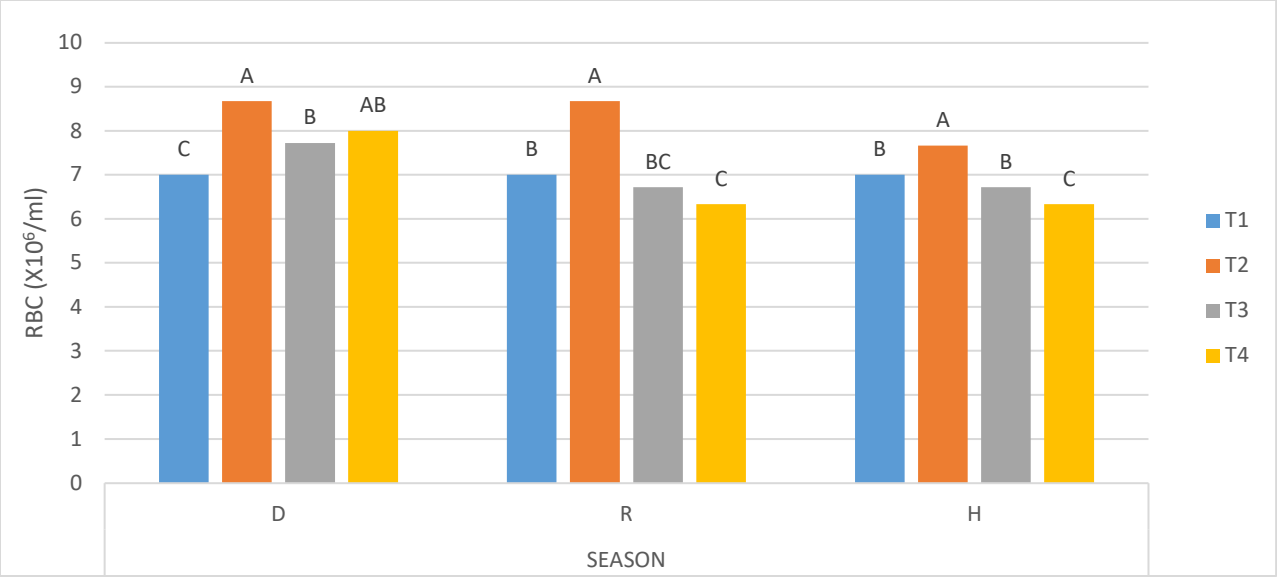

Figure 4.23 Interactive Effects of Seasons and Feeding Regimes on RB

4.1.11 Blood Serum Chemistry of Kano Brown Bucks as Affected by Main and Interactive Effects of Season and Feeding Regime

Table 16 shows the results of blood serum chemistry of Kano Brown bucks as affected by main and interactive effects of season and feeding regimes. There were non-significant ($P > 0.05$) differences among bucks under different feeding regime with respect to urea, calcium and alamine aminotransferase. Highest value (6.04 mmol/L) for urea was recorded among the bucks under zero browsing while bucks under morning and evening supplementation had the lowest mean (4.82 mmol/L). There were significant ($P < 0.05$) differences among the treatment means in total protein and cortisol. Highest value (71.00 mmol/L) was found in bucks under morning supplementation and bucks under zero browsing had the lowest mean (62.33 mmol/L). Similarly, animals under morning and evening supplementation had the highest value (337.78 mmol/L) for cortisol and bucks under zero supplementation had the lowest mean (229.90 mmol/L) as shown in Table 17.

The effect of season on blood serum chemistry of Kano Brown bucks differed ($P < 0.05$) significantly among the three seasons for urea, sodium and potassium, even though highest value (5.57mmol/L) for urea was recorded in bucks during harmattan obtained the lowest mean values (5.24mmol/L). There were no significant ($P > 0.05$) differences in for alkaline phosphate and cortisol among the seasons studied, highest value (337.25 mmol/L) was in bucks during the dry season whereas bucks during harmattan season had the lowest mean (301.20 mmol/L) as depicted in Table 17.

Table 16 Blood Serum Chemistry of Kano Brown Bucks as Influenced by Main Effects of Feeding Regime

Parameters	Feeding regimes					
	ZS	MS	MES	ZB	SEM	Ref. Values
Urea (mmol/L)	5.10	5.63	4.87	6.04	0.62	3.7-9.3
Sodium (mmol/L)	129.67^{a}	125.33^{ab}	128.78^{a}	120.22^{b}	3.89	142-166
Potassium (mmol/L)	3.74^{b}	4.03^{ab}	4.27^{a}	4.10^{ab}	8.21	4.3-6.3
Hydrogen carbonate (mmol/L)	21.78^{c}	31.33^{a}	27.00^{b}	26.44^{b}	1.39	20-27
Chloride (mmol/L)	102.00	100.60	100.00	100.10	2.2.52	101.113
Creatinine (mmol/L)	76.66^{b}	54.33^{c}	83.22^{a}	69.66^{b}	3.62	76-174
Glucose (mmol/L)	4.62^{a}	3.22^{b}	4.16^{a}	4.05^{a}	0.29	2.4-4.5
Total cholesterol (mmol/L)	2.63	3.66	4.19	3.99	0.29	1.1-2.3
High density lipoprotein (mmol/L)	0.63^{c}	0.89^{bc}	1.20^{ab}	1.35^{a}	0.19	0.8-2.6
Triglyceride lactatedehydrogenase	0.72^{b}	1.55^{a}	1.54^{a}	1.61^{a}	0.22	0.5-2.8
Low density lipoprotein (mmol/L)	2.61	2.45	2.91	1.99	1.02	0.8-4.3
Alkaline phosphatase (u/L)	26.00^{ab}	30.33^{a}	24.56^{ab}	23.78^{b}	2.81	27-156
Alanineamintransferase (u/L)	26.55	27.00	24.67	24.22	1.75	42-110
Aspartaaminotransferase (u/L)	72.78^{b}	111.67^{a}	74.89^{b}	70743^{b}	3.79	49-123
Bilirubin: total (g/l)	5.94^{a}	1.37^{b}	6.09^{a}	6.44^{a}	0.62	4-18
Bilirubin: direct (g/l)	2.11^{b}	5.00^{a}	2.37^{b}	2.69^{b}	0.64	0-7
Total Protein (g/l)	67.11	70.00	68.22	62.33	5.06	59-78
Globulin (g/l)	40.89^{a}	35.00^{b}	28.55^{b}	30.33^{b}	1.97	2.1-2.28
Calcium (mmol/L)	2.11	2.09	2.14	2.11	0.11	0.9
Inorganic Phosphate (mmol/L)	1.29^{b}	1.27^{b}	1.72^{a}	1.40^{b}	0.07	1.70
Cortisol (mmol/L)	229.89^{b}	329.67^{a}	337.78^{a}	361.00^{a}	42.27	171-536

^{abcd} Means within the same rows with different superscript are significantly($P < 0.05$), different, SEM = Standard error of mean, ZS = Zero supplementation, MS = Morning supplementation, MES = Morning and evening supplementation, ZB = Zero Browsing, LOS = Level of Significance LOS = Level of Significance.

Table 17 Blood Serum Chemistry of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season

	Seasons			
	Dry	Rainy	Harmattan	SEM
Urea (mmol/L)	5.39	5.57	5.24	0.62
Sodium (mmol/L)	128.41	125.08	124.50	3.58
Potassium (mmol/L)	4.07	4.03	4.09	0.21
Hydrogen carbonate (mmol/L)	26.67	26.66	26.58	1.39
Chloride (mmol/L)	102.75	98.75	98.67	2.51
Creatinine (mmol/L)	75.67[a]	68.67[b]	68.58[b]	3.61
Glucose (mmol/L)	3.96	4.03	4.05	0.29
Total cholesterol (mmol/L)	4.53[a]	3.16[b]	3.16[b]	0.19
High density lipoprotein (mmol/L)	1.26[a]	0.89[b]	0.90[b]	0.14
Triglyceride lactatedehydrogenase (mmol/L)	1.60	1.28	1.30	1.00
Low density lipoprotein (mmol/L)	2.40	2.92	2.16	2.81
Alkaline phosphatase (u/l)	24.75	26.92	26.83	1.75
Alanine aminotransferase (u/l)	14.25	31.33	31.25	3.79
Aspartate aminotransferase (u/l)	36.50[b]	105.60[b]	105.44[a]	0.63
Biluribin Total (g/L)	12.00[a]	1.45[b]	4.42[b]	0.63
Biluribin Direct (g/L)	5.25[a]	1.93[b]	1.9[b]	0.26
Total protein (g/l)	66.08	67.83	67.58	3.76
Globulin (g/l)	30.67[b]	35.58[a]	34.83[a]	0.11
Calcium (mmol/l)	2.09	2.14	2.12	0.08
Inorganic phosphate (mmol/L)	1.42	1.43	1.40	1.05
Cortisol (mmol/L)	337.25	303.25	301.20	44.37

[ab] Means within the same rows with different superscript are significantly($P < 0.05$), different, SEM = Standard error of mean

Table 18 Interactive Effects of Feeding Regimes and Season Bon Blood Serum Chemistry of Kano Bucks

Parameters	LOS
Sodium (mmol/L)	*
Hydrogen cabonate (mmol/L) (mmol/L)	***
Chloride (mmol/L)	*
Glucose (mmol/L)	**
Total cholesterol (mmol/L)	**
High density lipoprotein (mmol/L)	**
Glucose (mmol/L)	***
Alkaline phosphate (u/l)	***
Aspartate amino transferase (u/l)	***
Total bilirubin (mmol/L)	*
Total protein (g/l)	***
Albumin (g/L)	**

LOS = Level of Signficance

4.2 DISCUSSION

4.2.1 Growth Performance of Kano Brown Bucks as Influenced by Main and Interactive Effect Season and Feeding Regime

Increased supplementation level significantly improved final body weight of the bucks. Bucks under morning and evening supplementation recorded highest mean for final body weight compared to other treatments. This report was similar with the finding of Osuhur, Tanko, Dung, Muammad and Odunze, (2005). Afolayat, Adeyinka and Lakpini (2006); Adama, Ajanusi, Chiezey and Lawal (2011) who observed an increase in live weight changes as the level of supplementation increased for yearlings rams. Similarly, FAOSTAT (1982) reported that body weight and other growth parameters are positively correlated with quantity of feeds intake. Bucks on zero browsing had the lowest mean values for final body weight. This could be attributed to the bucks feeding habit, goat preferred browsing on shrubs and edible grasses than confirment. This report was in agreement with the findings of several other workers (Kalla, Vasudev & Arora 1981; Zahid, Lodhi, Qureshi, Rehman & Akhtar 2003; Cunha, Gonzalez, DeCarvalho & Soares, 2012) who reported that goat performance could be improved under semi-intensive management practice. However, the increased in body weight is associated with increased body dimensions such as chest circumference, heart girth, body length and scrotal circumference. The result for chest circumference was below the values reported by Eghahi, Dim and Mabram (2011) for West African Dwarf goats offered three times supplementation in the day. This report is also in agreement with the findings of Zahid *et al.* (2003) who considered body growth parameters as primary contributor to body weight. This report was similarly supported by the findings of Holter, West, McGilliard and Pell (1996) that high level of supplementation in yearlings *Eldarum* significantly increasesd body measurements of experimental bucks.

4.2.2 Scrotal Circumference

Increase in supplementation had a significant effect on testicular measurements. This report was in agreement with the findings of Land *et al.* (1982); Bilaspuri and Singh (1993) using Red Sokoto bucks fed graded levels of cotton seed cake diets. Similarly Tegegne, Kassa and Mukassa-Mugerwa (1995) Adedeji and Gbadamasi (1999) indicated an increase in testicular growth rate of bull, from 0.31 to 0.38 mm/day, as a result of increased protein supplementation the scrotal circumference of bucks fed concentrate diet alone was reduced and might be possibly attributed to loss of fat from scrotal tissues of bucks (Caller & Kozub, 1984). Bangso, Jainudeen and Sitizahrah (1982) reported that scrotal circumference is positively correlated with testicular development.

4.2.2 Effect of Season and Feeding Regime on Seminal Characteristics of Kano Brown bucks

Figure 5, 6, 7, 8 and 9 showed the interactive effects of seasons and feeding regimes on seminal traits of Kano Brown bucks. The color of ejaculate of the present study ranges from creamy to colorless. This report was at variance with the findings of Hassan (2010) who reported the ejaculate color of bucks fed groundnut haulms to be creamy to milky. This disparity could be attributed to the level of protein in the diets, time and method of semen collection. The ejaculate color is positively correlated with diets (Garner & Hafez, 1980; Pineda, 2003 & Ptazynska, 2009) who reported that high protein diets provide highly concentrated semen and negatively correlated with semen volume.

The volume of ejaculate was higher in animals under morning supplementation. This is probably due to the fact that semen volume was negatively correlated with high level of protein. This report agreed with the findings of Negussie, Azage and Teshome (2000) who obtained an increase in seminal volume as the level of *Leucaena* supplementation increased. The lower semen volume obtained in bucks under zero supplementation was probably due to lower level of protein

resulted in retarded growth, development of reproductive organs and lowered sexual desire (*libido*) among bucks in this group. Rekwot *et al.* (1987) reported that bull fed low protein diets have poorer semen quality than those fed high level of protein. Similarly, Jibril, Ate, Rekwot and Osuhor (2011) reported the mean ejaculate volume lower than those reported by Chiboki (1980) in bucks supplemented with low protein diets.

Semen pH is significantly influenced by the level of supplementation. The mean of semen pH reported in this study ranges from 6 to 7. This report agreed with the findings of Hassan (2010) that pH of yearling bucks semen fed graded level of groundnut haulms was in the range of 6 to 7.

The percentage of sperm motility of in the study was influenced by the level of supplementation and season. This report was consistent by the findings of Oyeyemi and Obiogoro (2005). Bucks under morning and evening supplementation recorded the highest mean of sperm motility. This report agreed with the findings of Negussie *et al.* (2000) that increased supplementation of 100g/animal/day increased the level of motile spermatozoa. Similarly, this was reported by Nasir, Njidda and Hassan (2014a) in his work using Red Sokoto bucks fed cotton seed cake in semi-arid zone of northern Nigeria supported the result of this work.

Sperm concentration in this study was influenced by season and feeding regime. This observation was earlier confirmed by the report of Osinowo, Bale and Eduvie (1982) and Negussie *et al.* (2000). Hassan (2010) reported that sperm concentration was higher in animals offered high level of protein diets. Semen concentration in this work was slightly higher compared to the range of 1.6 to $6x10^9$ and 2 to $3x10^9$/ml in rams (Foote, 1972). The disparities could be attributed to morning, evening supplementation in addition to browsing. Garner and Hafez (1980) reported that semen concentration was determinant of sperm quality. Nasir *et al*. (2014a) reported that an

increase sperm concentration is generally considered to be beneficial because it allows insemination of a large number of females (Taylor & Thomas, 2001).

Jibril, Ate, Rekwot and Osuhor (2011) reported an increase in semen concentration in rams fed high protein diets. Sperm concentration is positively correlated with semen color Osinowo *et al*. (1982). Nutrition affects all phases of sperm production including live spermatozoa and sperm morphological abnormalities. The result obtained in this study for live spermatozoa was higher in animals under morning and evening supplementation during rainy season. This could be attributed to the level of supplementation since high level of protein diet increases sperm concentration and color. This report was supported by the findings of Edens (1993); Mc Daniel, Bramwell, Wilson and Howarth (1996); Obidi, Onyeanusi, Rekwot, Ayo and Dzenda (2008) and Hassan (2010). That there is a positive correlation between sperm concentration and live spermatozoa in yearling rams supplemented with 300g/day/animal dietary protein. Chiboki (1980) report live spermatozoa of 40% in West African Dwarf rams grazing on dry roughages which was later increased to 59% with increased grazing conditions Osinowo *et al*. (1982).

The sperm morphological abnormalities of Kano Brown bucks decreased as the levels of supplementation increased. This could be attributed to level of supplementation that subsequently stimulated testicular growth and development. This report agreed with the findings of Osinowo *et al.* (1982) and Negussie *et al.* (2000) reported that a significantly greater proportion of abnormalities (34%) is observed in spermatozoa of rams fed chick pea alone.

4.2.4 Gonadal Sperm Reserves of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

Gonadal sperm reserves of Kano Brown bucks was significantly influenced by feeding regime and season. Bucks under morning and evening supplementation had higher mean compared to others. This report agreed with the findings of Tibbo (2006) and Nasir *et al.* (2014a). This

observation was also consistent with the previous findings of Coulson, Snell and Prase (1980); Sakesena and Salmonse, (1982); Velesquez-Pereira *et al.* (1998); Taha, Shaaban, El-Mahdy, El-Nouty and Salem (2006). Highest value of spermatozoa concentration was observed during dry season. This could possibly be attributed to optimum environmental temperature for spermatogenesis. This report was in agreement with the findings of previous workers Oyeyimi, Davies, Ajala and Akusu (1998); MacMillan, Hafs, Ayo, Rekwot & Dzenda (1999); Ahmad (1984); Ahmad *et al.* (1985); Pubery and Choudhury (1995); Ali (1989) and Siddiqui, Ahmad and Khan (2005) who reported that environmental temperature had a significant effect in the process of spermatogenesis.

Previous reports indicated that extra gonadal sperm reserves is a clear picture of gonadal sperm reserves (Igboeli & Rakha, 2007; Vilakazi, 2003; Nasir, Njidda & Hassan 2014c). The reports of this work indicated that extra gonadal sperm reserves increased with an increase in supplementation as presented in Table 7. This report is confirmed earlier by the findings of Cameroon, Murphy and Oldman (1998); Bah, Chaudhari andAl-Amin (2001); Hassan (2010); Nasir, Njidda, Duwa, and Chibuogu, (2014) reported that increase in dietary protein significantly increased spermatozoa concentration. This report was consistent with the findings of Butswat and Zahraddeen (1998) Kano brown bucks Butswat and Zaharaddeen (1998) Red Sokoto bucks.

Season had a significant effect on extra-gonadal sperm reserves in the present study. The result obtained in this study for extra gonadal sperm reserves favored the dry season. This report agreed with the findings of Martin, Rodger and Blanche (2004), Samuel and Salako (2008) who observed highest value of sperm concentration in rams fed graded levels of protein diets during dry season. 12 and 13 respectively. However, the interactive effects of seasons and feeding regimes

showed that bucks under browsing during dry season had the highest mean values as showed in Figure 12 and 13 respectively.

4.2.6 Testicular Morphometry of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

Testicular morphometry of Kano Brown bucks significantly influenced by the levels of supplementation and season Oyeyemi, Fayomi, Adeniji and Ojo (2012). Increased protein diet significantly increased testicular growth and development (Oyeyemi *et al.*, 1998). This report was supported by the previous findings of Mac Macmillan *et al.* (1999); Ahmad *et al.* (1985); Nasir *et al.* (2014b). The result of the present study revealed that testicular weight and length of Kano Brown buck were influenced by the level of supplementation. This claim was supported by the findings of Nasir *et al.* (2014b) who reported lowest mean of testicular weight and length of un-supplemented Red Sokoto bucks. Left testis are heavier than to right testis (Shoyonbo, Fasanya, Bunjah & Yakubu, 2012). The result obtained was contrary to previous findings of Shoyonbo *et al.* (2012). The disparities could be attributed to the level of supplementation since nutritional level had a positive correlation with testicular growth and development (Menzies, 2011).

Season has a significant effect on testicular morphometry of Kano Brown bucks. The result showed that harmattan season had the highest value of testicular weight and length. This report agreed with the repot of Dunn (1980) that this could possibly be due to high rate of consumption of feed during harmattan season to meet the nutritional requirement of animals and their response of body to environmental temperature.

Feeding regime and season significantly affected epididymal morphmetry. The report of this work was in agreement with the findings of Kessler (1992) and Amao, Adejumo and Togun (2012) who reported similar observations on testicular morphometry of rabbits fed graded level of cotton seed cake diets. Bucks under morning and evening supplementation during rainy season

tended to have highest mean of testicular and epididymal morphometry of Kano Brown bucks. In this case, animals would have adequate feeds and exercise by allowing them to go out for grazing. Exercise is known to improve reproductive efficiency of goats (Raji, Igwebuike & Aliyu 2008).

4.2.7 Testicular and Epididymal Homogenate and Filtrate Volume (ml) of Kano Brown Bucks as Influenced by Main and Interactive Effect of Season and Feeding Regime

Testicular homogenate and filtrate volume are important parameters for the determination of gonadal and extra gonadal sperm reserves (Bitto, Akusu, Egbunike & Akpokodje, 2000). The result obtained showed that feeding regime and season significantly influenced testicular homogenate and filtrate volume. This report agreed with the findings of Nasir *et al*. (2014b). Bah *et al.* (2001) reported that heavier testes might have high testicular homogenate and filtrate volume. Testicular homogenate and filtrate volume were higher in animals under morning and evening supplementation. This report was at variance with the findings of Mohammad (2014). The disparities could be attributed to the differences in testicular growth and development.

This study observed significant effects of season and feeding regime on epididymal homogenate and filtrate volume of Kano Brown bucks. The result of this investigation was supported by the findings of Fadison (2001) for Red Sokoto bucks. The only difference between epididymides homogenate and filtrate volume is the tissue and its rate of absorbing water Dunn (1980).

4.2.10 Haematological Parameters of Kano Brown Bucks as Influenced by Main and Interactive Effects of Season and Feeding Regime

Blood may be termed as a specialized and circulating tissue composed of cells suspended in a fluid intracellular substance which circulate through a close system of blood vessels due to pumping action of heart (Olayemi, Faroimi & Fagbohun, 2000; Addass, Perez, Midau, Lawan & Tizhe, 2010; Adelokun *et al.,* 2012 and Aye, 2013). Feeding regime and season significantly

influenced haematological parameters of Kano Brown bucks this report was earlier supported by the findings of Oladele, Ogondupe, Ayo and Esievo (2001, 2003). This report agreed with the findings of Al-Haidary (2004) who observed that season on heamatological parameters of Red Sokoto bucks during rainy season. The packed cells volume increased as the level of supplementation increased. This could possibly indicated that level of nutrition stimulate the production of blood cells. This report agreed with the findings of Haold and Amstutz (2012) observed increase in PCV level with an increase in dietary protein. High packed cell volumes had been reported to be an adapted mechanism that provide optimum water for evaporative cooling process. High level of white blood cells differentials indicates high level of immunity (Addas *et al.,* 2010; Garba & Abubakar, 2012). The life span of white blood cells varies considerably from few hours for granulocytes to potentially month for monocytes and years for lymphocytes (Solaiman, 2007; Amao, Adejumo, & Togun 2012). The mean values of white blood cell in this investigation confirmed earlier report of Amao *et al*. (2012a) who observed normal mean values of white blood cells in ram supplemented with groundnut haulms. This report was consistent with the findings of Tambuwal, Agale and Bangana (2012) in Red Sokoto bucks.

Blood urea could be attributed to the presence of some anti-nutritional factor which might have lowered the quality of protein that indicated inadequate of amino acid in the diets and causes elevated blood urea concentration (Bello & Tsado, 2013). The results obtained in this study for blood urea were within the range (3.7 to 9.3) reported by Njidda, Hassan and Olatunde (2013). The total blood protein serves as an important blood parameters. High level of blood protein indicates better utilization of dietary protein (David, 1988). The present study was influenced by feeding regime and season for sodium and chloride. The values obtained were within the reference values reported by Brown-Del (1990), Creatinine contents have been shown to depend upon

quality and quantity of feeds and environmental temperature (Ewuola *et al.,* 2004). The result of creatinine was influenced by feeding regime. This report agreed with the findings of Olayemi *et al.* (2006). Globulin and albumin are component of blood plasma (Guache, Lemoullac, Bleiberg-Diniel, Aubert & Flament, 1991). The values were higher as the level of supplementation increases. This could possibly indicated the role of dietary nutrients on blood production. This report agreed with the findings of Boyd (1984).

Hyper or hypoglycaemia can lead to death (Bello & Tsado, 2013). Normal blood glucose indicates the physiological stage of animals. The results of this study were within the reference values reported by Boyd (1984) and Njidda *et al.* (2013). Aspartate aminotranferase (AST) and alanine aminotransferase (AST) are indicators of liver function (Sandhu *et al.,* 2009). Enzymatic activities could be affected by so many factors such as nutritional levels, age, liver function, genetic and environment. The results obtained in the present study for alkaline phosphatase, alanine amino traaseferase and aspartate aminotransferase were within the reference values reported by Boyd (1984) and Njidda *et al*. (2013). This indicated normal liver function of the experimental animals.

5.0 CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The results of this study is summarized as follows: The result obtained for growth performance showed that rainy season had the highest mean for body weight (18.10 kg) in animals under morning and evening supplementation followed by harmattan season (17.20 kg) under the same feeding regime whereas dry season recorded the lowest value (16.25 kg). No significant ($P > 0.05$) difference was observed for neck length (cm), even though highest mean value (20.85 cm) was obtained during harmattan season whereas rainy season recorded the lowest values (19.89 cm) in animals offered morning and evening supplementation. No significant ($P > 0.05$) different was observed for semen color and sperm motility (%) in animals under different feeding regime. The result of gonadal sperm reserves (x 10^6 /g/testis) of Kano Brown bucks differed significantly among the feeding regime. Animals offered morning and evening supplementation had the highest mean values (3199.70 x10^6 /g/testis) for gonadal and extra gonadal sperm reserves during rainy season. No significant ($P > 0.05$) difference was observed for Hb (g/dl), PCV (%), MCV (fl), MCHC (g/dl), and neutrophils (%). Similarly, no significant ($P > 0.05$) difference was observed for cortisol hormone among the feeding regime, even though animals during dry season recorded the highest mean values (361.00 mmol) whereas harmattan season had the lowest mean values (351.10 mmol) in animals under zero supplementation.

5.2 CONCLUSION

Based on the result of this study, the followings conclusions were made;

i. Morning and evening supplementation significantly increases body growth parameters, final body weight and body weight gain

ii. Seminal traits were significantly improved when the animals were supplemented

twice daily during rainy and harmattan seasons

iii. Testicular epididymal morphometry, gonadal and extra-gonadal sperm reserves were significantly increased as the level of supplementation (Morning and evening supplementation) increases during rainy and harmattan seasons.

iv. Heamatological parameters and blood serum chemistry were better in bucks offered morning and evening supplementation during rainy.

5.3 RECOMMENDATIONS

Based on the results of this study the followings recommendations were made;

i. It is recommended that bucks should be offered morning and evening supplementation.

ii. Bucks should be allowed to go for grazing throughout the three seasons, this could affect its performance.

iii. Bucks should not be confined especially during breeding season.

iv. Bucks perform well in terms of body dimensional parameters and other reproductive parameters during harmattan season.

v. Further studies should be conducted to evaluate the effects of feeding regimes on growth performance and other reproductive traits of Kano Brown goats.

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