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Original Article

Nutrient requirements of the indigenous and crossbred goats in Nigeria

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Abstract
The goats are multipurpose animals that are often referred to as the "poor man's cow" because they thrive in places where other animals usually struggle to survive. They exist in almost all regions of the world. Prominent Nigerian breeds of goat include the West African dwarf (WAD), the Red Sokoto, Sahel goats and *KALAWAD*. *KALAWAD* goats are the crossbred between WAD doe and the Kalahari Red buck. The Kalahari Red goat was imported to Nigeria by the Federal University of Agriculture for multiplication and improvement of local breeds in 2011. It is indigenous breed of South African sub-region in the Kalahari Desert across the South Africa, Namibia and Botswana. The indigenous goat breeds in Nigeria have received inadequate attention to unveil their potential as milk-producing animal. The attentions have always been on meat production and probably some by-products such as skins and fibres. Nutrient requirements of these indigenous breeds and their crosses in Nigeria have also been undermined. Hence, the full potential of the breeds has not been harnessed. The essential nutrients required by goats to meet their daily needs for maintenance and productivity are water, energy, protein vitamins and minerals. Understanding and the knowledge of these breeds and their nutritional requirements are needed to harness the full potential of the Nigerian breeds of goats and their crosses for adequate milk production and other products. The aim of this review is to identify Nigerian breeds of goats with their crosses and their nutrient requirements.

INTRODUCTION

OVERVIEW OF THE GOAT BREEDS IN NIGERIA

The goat or domestic goat (*Capra hircus*) is a species of goat-antelope that is mostly kept as livestock. It was domesticated from the wild goat (*C. aegagrus*) of Southwest Asia and Eastern Europe. The goat is a member of the family Bovidae, meaning it is closely related to the sheep. It was one of the first animals to be domesticated, in Iran around 10,000 years ago. Goats have been

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used for milk, meat, wool, and skins across much of the world. Milk from goats is often turned into cheese. In 2022, there were more than 1.1 billion goats living in the world, of which 150 million were in India. (Chungsiriwat, 1995; Akintunde *et al*., 2024)

Goat is a multipurpose animal which provides meat, milk, clothing, fertilizer, loyalty and companionship. The animal is alert, intelligent and socially inclined (Daramola, 2025). Goat forms an important economic and ecological niche in agricultural systems throughout the developing countries and provides savings bank for smallholder farmers in rural areas (Aina, 2012). Thus, goats are an important livestock component in all agro-ecological zones in the developing nations.

The recent survey studies by the National Agricultural Sample Census (NASC, 2022) indicates a varied average number of goats per household in Nigeria, with approximately 5 to 9 goats being the typical range for a significant portion of agricultural households. Some of the indigenous goat breeds in Nigeria include the West African Dwarf goat, the Red Sokoto goats, the Sahel goat and the *KALAWAD* goats. Importance of the present review on the indigenous goat breeds in Nigeria will enable individuals to have understanding of the breeds and their nutrient requirements for breeding and production.

West African Dwarf goat

The West African Dwarf (WAD) goats are a small bodied breed of animal native to humid tropics. WAD goats are widely distributed across the rainforest belt of southern Nigeria. They are short-legged and small bodied animals. They also present variable coat colours, ranging from black, brown, gray, pied, red and white, and sometimes combinations of these in a variety of patterns (Ozoje and Mgbere, 2002; Rotimi *et al*., 2017). They thrive in hot, humid climates and have resistance to many local diseases, such as trypanosomiasis which had its vector as tsetse flies. Although these goats are typically black, individuals with patched, pied, or entirely white coats colour are also found, even in coastal areas. Epstein(1971); Barbara and Dafydd, 2007; Valerie *et al.,* 2016 suggest that the presence of distorted forms and very short legs indicates achondroplasia (a genetic condition affecting a protein in the body called the fibroblast growth factor receptor). Their small size is likely an adaptation to their environment, although the exact selective force remains unclear. In semi-arid zones, WAD goats resemble the Sokoto Red breed. However, physiological studies have demonstrated that WAD goats do not exhibit particular adaptation to high ambient temperatures; for instance, conditions around 30˚C with 60% relative humidity result in reduced food intake (Montsama *et al*., 1985; Kalio and Oko, 2005).

The WAD goat is one of the popular goat breeds kept by families in Nigeria and West African sub-region with a population of about 11 million in the South- Eastern part of Nigeria alone (Chiejine *et al*., 2015; Rotimi *et al*., 2015). The WAD goats are adapted better to tropical environment of the region of West Africa than any other breed of goats (Shittu *et al*., 2016). The Nigerian Dwarf goat has been internationally recognized as dairy and companion animal since 1854 (Aina, 2012).

For Nigerians to improve their animal protein intake, sustainable production of livestock had been suggested by livestock researchers (Chidebelu, 1998). Of these livestock, goat production is recommended due to its beneficial effects, some of which include provision of important products (meat, milk, skin and hair) as a form of investment, assurance against crop failure, prestige, sources of income and employment (Ayoade, 2010). Disease tolerance wise, WAD goats are among the few important trypanotolerant livestock species of humid Nigeria.

The Red Sokoto goats

The Red Sokoto goat (RSG) or Maradi is the most predominant breed and accounts for about 70% of Nigeria's total goat population. It is commonly found with the agro-pastoralist mainly within the northern sub-humid and semi-arid zones of the country (Akpa *et al*., 2001).

The Sokoto red goat is probably the most widespread and well known in Nigeria (Haumesser, 1975; Isaac and Ibrahim, 2006). It is the usual village goat in northern two-thirds of the country, although it is less common with transhumant pastoralists. The most complete overview of the breed is in the report of Robinet (1967) and (Ijomanta (2012) comprehensive survey which integrates data from Nigeria and Niger Republic sub-region. The Red Sokoto goat is the only Nigerian breed for which there is a record of systematic attempts to stabilize a particular type of breed (Yakubu *et al*., 2010). The Red Sokoto goat was the source of "Morocco leather" known in Europe from the medieval periods onwards. It acquires this name because it was transported across the Sahara by caravans controlled by Moroccans merchants as the time. The Sokoto red is still known for its suitability for fine leathers (Yakubu *et al.,* 2010). The skins have coarse, thinly-spaced outer hairs and small sweat and wax glands and that they lack back fat. This breed of goat is one of the few well-defined breeds and characterized by its uniform dark-red coat colour. A relatively small sized goat (60 cm height and 27 kg weight) but are generally larger in Niger Republic; fine head with prominent forehead; mucous membrane is black; both sexes have short to medium horns; ears are short and usually carried horizontally, but longer and semi-pendulous in Niger Republic; toggles are rare; beard of profuse hair in males but usually absent in female counterparts; forehead often covered with hair which is often longer, bushier and darker in males than in females; males carry a light mane extending to the shoulders; neck is short, thin and very mobile; coat colour is usually red in Nigeria but lighter and occasionally almost chestnut in red Sokoto; males are invariably darker than females and may have a black back stripe; tail hair usually black; known for good quality skin (Wilson, 1991; Habibu *et al*. 2016; Ka'oje, and Bello, 2021).

The Sahel goat

The Sahel goat is found along the northern border of Nigeria particularly Borno state where it is often known as "Balami", although the name has not been adopted as it would lead to confusion with the better known sheep breed of the Balami. Though, there is close genetic relationship between the Sahel and Red Sokoto goats (Murital *et al*., 2015; Shoyombo *et al*., 2015; Ojo *et al*; 2018). Wilson (1991) uses "Sahel", which seems appropriate, as this race is distributed from Senegal to Sudan, in the northern part of Nigeria. The Sahel goats are generally

the breed preferred by pastoralists, the goat breed is best suited to living in arid, dry, desert conditions, and would not survive for long in a forest zones. They are known for their ability to travel long distances in search of food, water and can feed on abundance of different vegetation (Iheanacho and Ali, 2010). Sahel goats are similar in appearance to the sheep with which they are often herded. The coat colour is white or dappled, the ears pendulous and the legs are notably longer than other breeds of goat. Wilson *et al*.(1984); Arenas-Báez *et al*. (2023) studied the productivity of goats and traditional management in the republic of Niger and also included a valuable table of comparative data from other studies. Wilson and other researchers also studied the productivity of Sahel goats in republic of Mali (Wilson and Durkin, 1983).

The Sahel goats are a dual-purpose breed and they are raised mainly for meat and skin production purposes in their native Mali, while they are also sometimes raised for their milk, but not often. At full maturity, a buck weighs up to an average of 56.7kg at a height of between 70-85cm. The breed is best known for their thin narrow frame. They are found in a variety of colours from cream, to reddish brown, black, pure white, grey, pied, brown, or mixture of colours. Their hair is short and stuff, while their ears are semi-pendulous (Kwari *et al*., 2004; Murital *et al*., 2015). A horned breed, Sahel goat also has long, narrow legs. What is usual about Sahel breed of goat is that the udders are split in half in females, and so are the scrotums of bucks. They are very strong animals, due to where they reside, they can survive very hot conditions. Does make for excellent mothers and tend to kid at 18 months old. They can produce up to two kids at a time, but usually have only one. Their lactation period lasts 5-6 months (Yakubu *et al*., 2010)

The *KALAWAD* Goat

The Kalahari Red goat in Nigeria was imported from South Africa by the management of Federal University of Agriculture, Abeokuta for the purpose of multiplication and improvement of Nigerian local breeds of goat. One of the achievements of the purpose is the *KALAWAD*. The *KALAWAD* goat is the crossbred resulting from the crossing of pure Kalahari Red bucks and West African Dwarf (WAD) female (Does). The crossbreeding programme began in the Livestock Production Research Programme (LPRP) of the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture Abeokuta, Ogun State, Nigeria in year 2013. The crosses were better in terms of live weight and growth than WAD goats. The first filial generation of the crosses were better in terms of birth weight and growth (Oderinwale *et al*., 2017a and 2017b). The survivability of the kids are better than their grant parents (Toviesi *et al*., 2019). The male crosses are bigger and higher than the female counterpart. Their skin coat colours can be pure brown; brown with black patches; black with brown patches and amalgamation of more than two colours just like WAD goats (Toviesi*, et al*., 2024) .But in most cases predominant coat colour is the pigmentation red coat colour of the Kalahari red goat (Shittu *et al*., 2016). *KALAWAD* goats adapt well to the tropical environment and also trypanotolerant. In nutritional study carried out by Olalere *et al*. (2024) reported that the *KALAWAD* bucks performed well when fed with

Brachiaria ruziziensis and *Panicum maximum* and the mixture of the two forages.

Though, the Kalahari red is not one of the Nigerian breeds of goat. This is the breed of goat that was imported from South Africa to Nigeria by the management of the Federal University of Agriculture, Abeokuta in 2011 (Okwelum *et al*., 2018). The Kalahari Red is regarded as an indigenous goat breed originating from South Africa in the Kalahari Desert which cut across South Africa, Botswana and Namibia. Records indicated that the goats have been selected from lop-eared animals that migrated with various tribes of people to the southern part of Africa more than 2000 years ago (Epstein, 1971; Okwelum *et al*., 2018). Breeders from the Northern Cape Province in South Africa and the southern part of Namibia, specifically the Kalahari Desert area, selected animals slightly smaller than the red and white improved Boer goat, but with uniform red pigmentation. The Kalahari Red was recognized as a landrace breed in 1998 with the establishment of a breeder's organization (Kotze *et al*., 2004). Today, this breed of goat is an important meat-producing animal in South Africa with characteristics such as adaptation to arid and semi-arid savannah, good foraging and excellent mothering abilities (Toviesi, 2015). It is regarded as a "minimum care/maximum profit" breed (Ramsay *et al*., 2001). Kalahari red goats have adapted to tropical climate of Nigeria been breeds of goat brought from the subtropical climate (Shittu *et al.,* 2016). The aim of the crossbreeding programme was to combine the qualities of both the indigenous and exotic breeds to achieve quality meat production (Oderinwale *et al.*, 2017a; Toviesi *et al*., 2019).

NUTRITIONAL REQUIREMENTS OF GOAT

Goats require nutrients for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk and hair. The groups of nutrients that are essential in goat nutrition are water, energy, protein, minerals and vitamins (Coral, 1996; Oduguwa and Adu, 2010). The daily nutrient requirements are different for bucks, young goats and does with a high production potential and at various stages of development and production. Weanling goats, followed by Does during the last month of gestation and high lactating Does, and yearlings, require a higher quality diet than average lactating Does, adult bucks and dry does (Haenlein, 1980; Little, 1981; CSIRO, 2007). In order to feed them adequately, goats should be grouped according to their nutritional needs (Underwood, 1981 and 1999; Castagnino *et al*., 2015).

Therefore, weanling goats, high lactating does and yearlings should be grouped and fed separately from the rest of the herd having lower nutritional needs. In a grazing situation, animals having the highest nutritional requirements should have access to lush, leafy forage or high quality browse (Oduguwa *et al.,* 2005; Caja *et al.,* 2020). In a stall-feeding situation the animals should be offered the highest quality hay available. Whether grazed or stall fed, goats should be supplemented with a concentrate feed when either the forage that they are grazing or the hay that they are fed do not contain the necessary nutrients to cover their nutritional requirements (Perdomo *et al*., 1976; NRC, 1981; NRC, 2007)

Water Requirement

Goats should be provided unlimited access to fresh, clean, and freely accessible water (Ahmed and El Kheir, 2004; Alamer, 2009: Abioja *et al*. 2010). Goats are among the most efficient of domestic animals in their use of water; however, only ~10% of body water loss may prove fatal. They appear to be less subject to high temperature stress than other species of domestic livestock. In addition to a lesser need for body water evaporation to maintain comfort in hot climates, goats can conserve body losses of water by decreasing losses in urine and faeces. Factors affecting water intake in goats include lactation, environmental temperature, moisture content of forage consumed, amount of exercise, stage of production (growth, maintenance, lactation, etc), salt and mineral content of the diet. Goats grazing lush pastures may consume much lower quantities of water than those feeding on dry hay. Still, it is imperative to allow free access to water for all goats regardless of age, breed, purpose, stage of life cycle, or environment (Abioja *et al.,* 2007).

Energy Requirement of Goat

Energy requirement in goats is imperative for several biological purposes which include production and physiology. Energy requirement depends on the purpose of raising ruminant animal. The energy need of the ruminant animal is mostly derived from fibrous plant materials which cannot be utilized by the non-ruminant animal. These fibrous materials are acted upon by rumen microorganisms through fermentation processes. This process makes energy and other nutrients available to the animal in question. Energy limitations may result from inadequate feed intake or from poor diet quality; excessive moisture content of the feedstuffs also may become a limiting factor (Härter *et al*., 2017; Lima *et al*., 2020). Energy requirements are affected by age, body size, body condition, stage of production (growth, maintenance, pregnancy, and lactation), and concurrent health conditions (e.g, parasitism, dental disease, arthritis etc).

Furthermore, Energy requirements may be affected by the environment, hair growth, activity, and relationship with other nutrients in the diet (Madsen, 1976; Arigbede, 2005; NRC, 2007). Increased temperature, humidity, sunshine, and wind velocity may decrease energy requirements. Shearing mohair from Angora goats and pashmina from Cashmere goats decreases insulation and results in increased energy needs (at least in colder environments). Goats exhibit a wide range of grazing activity, ranging from light activity for goats under intensive management, through moderate activity on semi-arid land, to great activity for goats grazing on sparsely vegetated grassland and on mountainous pastures that necessitate long distance travel daily (Edwards, 1997; Chebli *et al*., 2022).

The best assessment of energy intake adequacy in goats is proper body condition or fat covering the loin, brisket, inner thigh, and ribs. Using herd/individual medical record systems, a standardized body condition score (1–5, with 1 being extremely thin, to 5 being extremely obese) should be used to monitor body fat changes and make less subjective decisions with respect to long-term dietary energy adequacy (Asaolu *et al*., 2012; Omoniyi *et al*., 2013). If animals are parasite and disease-free (healthy animal), yet under-conditioned, then they are usually being fed

an energy-deficient diet; the reverse is true for obese animals. The energy values required for growth and lactation are very minimal comparable to the numbers used for sheep and cattle respectively. Therefore, sheep nutrition principles from an energy standpoint will probably suffice when dealing with all classes of goats, except for lactating dairy goats (Carro, 2000; Araújo *et al.*, 2017).

Protein Requirement

Protein is one of the vital nutrients required for most biological functions of the animal body. It is a complex organic compound made of amino acids which are linked together by peptide bonds. Ramirez *et al.* (2004) reported that protein is required for most normal functions of the body, including maintenance, growth, reproduction, lactation, and hair production. Martins *et al*. (2021) reported that protein deficiencies in the diet deplete the stores in the blood, liver, and muscles and predispose animals to a variety of serious and even fatal ailments. Feed intake and dietary digestibility are reduced if dietary crude protein is <6%, further compounding an energy-protein deficiency; thus, for maintenance of mature, healthy animals, the diet should have a minimum of 7% crude protein. Dietary crude protein requirements are higher for growth, gestation, and lactation. Most forages (pasture) contain adequate amounts of dietary protein for maintenance, but lactating, growing, sick, or debilitated animals may require diets fortified with legumes or protein supplements (e.g, soybean meal, cottonseed meal, groundnut cake meal, palm kernel cake meal, etc). Feeding adequate to slightly greater amounts of protein than required appears to aid in the control (both resistance and resilience) of internal nematode parasites.

Minerals Requirement of Goat

For optimum production, health status, and physiological functions, minerals are needed in the diet of goats in required quantity and combination (Goff, 2018); however, mineral bioavailability and balance are more important than how much the animal ingested from diet (Mamiro *et al*, 2016). Though, mineral requirements have not been standardized definitively for goats at either maintenance or production levels. Research has been conducted with goats in mineral metabolism studies, especially with calcium and phosphorus. In general, these data support assumptions that several mineral requirements for goats are similar to those for sheep. Feeding to meet the goat's needs will maximize its production, reproduction, and immune system. The addition of specific minerals (phosphorus for dry season forages, selenium in deficient areas, etc) to salt (NaCl), preferably in granular form and offered free choice helps prevent most mineral deficiencies and improves performance (Ejoh *et al.,* 2005).

The advantage of mineral supplementation in enhancing the performance of grazing animals has been established (Houtert and Leng, 1991; Araújo *et al*., 2017). However, in the traditional ruminant production systems, mineral premix is not normally included in the diets of the animals. This could be due to ignorance on the part of ruminant livestock owners who may not be aware of the importance of such mineral source, or unavailability and high costs of mineral premix (Adeleye *et al*., 2004).

Local potash known as (a) Trona in geological sector (b) Saline lake deposit in

form of hydrated sodium bicarbonate (c) evaporation product and efflorescent on arid soil (d) a product of salt industry in West and North Africa (RMRDC, 1996; Dorigan *et al*., 2015) and popularly called (e) "Kan-un" in most West and North Africa communities (Adeleye *et al*., 2004) is a common household item and readily available in all local markets. It is traditionally added to vegetable as a tenderizer and enhancer of green colouration of vegetable, used in energizing horses for effective transportation of goods over a considerable distance, used locally to fatten up rams towards festive periods (Gbodi and Ikwuegbu, 1982) and is a repository of various essential mineral elements required by grazing animals (Idowu, 1994; Ranjhan, 1997; Castagnino *et al*., 2015). There is however, scarcity of information on the effects of 'Kan-un' on the performance of goats in general and West African Dwarf goat in particular.

Calcium: Calcium requirements are generally met under grazing conditions with either Angora or meat-type goats, but levels should be checked in high-producing dairy goats because a deficiency can lead to reduced milk production (Playne *et al*., 1978; Teixeira, 2018). Adequate levels of calcium for lactating goats are necessary to prevent parturient paresis (milk fever). In browsing or grain-fed goats, the addition of calcium supplement (dicalcium phosphate, limestone, etc) to the feed or to a salt or trace mineral–salt mixture usually meets calcium requirements. Legumes (e.g, clover, alfalfa, kudzu) are also good sources of calcium (Ward *et al.,* 1979).

Phosphorus: Deficiency phosphorus results in slow growth, unthrifty appearance, and occasionally a depraved appetite (Härter *et al*., 2017). Goats can maintain milk production on phosphorus-deficient diets for several weeks by using phosphorus from body reserves, but during long periods of phosphorus deficiency, milk production was shown to decline by 60%. The "calcium to phosphorus ratio" should be maintained between 1:1 and 2:1, preferably 1.2–1.5:1 in goats because of their predisposition for urinary calculi. Phosphorus deficiency in grazing goats is more likely than a calcium deficiency. In cases of struvite calculi, the ratio should be maintained at 2:1.

Magnesium: Deficiency is associated with hypomagnesemic tetany (grass tetany), but ordinarily this condition is less common in grazing goats than it is in cattle. Goats do have marginal ability to compensate for low magnesium by decreasing the amount of magnesium they excrete (Sowande, *et al.,* 2000 and 2001).

Salt (NaCl): Sodium Chloride (NaCl) also known as 'common salt' or 'table salt' is usually recognized as a necessary dietary component but is often forgotten. Goats may consume more salt than is required when it is offered *ad libitum*; this does not present a nutritional problem but may depress feed and water intakes in some arid areas where salt content of the drinking water is quite high. Salt formulations (salt-licks) are used as carriers for trace minerals, because goats have a clear drive for sodium intake (Aina, 2002).

In a developing country like Nigeria, goats are seldom given sodium (Na) in their diets. The most likely reasons include the fact that range management system is the norm where the animals have access to different sources of salt from browsing. However,

with the increase in demographic growth and the consequent introduction of intensive paddock management system, animals may no longer have access to such benefit. Animals obtain Na in the form of NaCl (Cardoso *et al*., 2021). Cattle or sheep deprived of NaCl for short periods consume lethal quantities when confronted with large amounts (West *et al*., 1966). Deficiency of Na has been reported to precipitate retardation of growth, impaired digestion, lack of appetite and reduced efficiency of feed utilization in growing animals (Steele, 1996). It has been recommended (Van Horn and Haenlein, 1983; Costa *et al*., 2021) that the concentrate diet of goats should contain 1% common salt. There is, however, some paucity of information on Na requirements for maintenance and growth of WAD goats.

Loose salt is a common and cheap household item which can used by rural farmers to feed their goats while salt lick which is about 90% common salt (NaCl) is very expensive and not easy to come by, hence the use of salt lick in the developing countries is highly limited. Dietary salt shortages reduced feed intake and induced dirt chewing, poor hair coat, and heat stress, all of which indirectly affect their reproductive efficiency (Church and Pond, 1988; Kaliber *et al*., 2016). Cattle and sheep are known to travel a great distance to find "salt lick" if they are otherwise deprived of such (Boumgardt, 1969). Dietary salt requirements in WAD goats for optimum performance have not been sufficiently studied in Nigeria, yet WAD goats occupy an important place in the socio-economic life of the people. The general convention is to impose recommendations determined for temperate breeds of cattle and sheep on goats in general and the WAD goats in particular.

There is thus an urgent need for a meaningful and realistic recommendation on salt requirements in WAD goat production in the humid tropics, particularly in Nigeria. In a 70-day feeding trial (Aina, 1999 and 2002) on sodium requirements of WAD goats for maintenance and growth using common table salt (NaCl) as Na source at 4 dietary levels (0, 5, 10 and 15g) in the concentrate diets (sun-cured cassava peels (1kg), Gmelina leaves (1.5kg), and water (2 litres), it was found that increasing dietary NaCl levels increased total DMI, average daily weight gain and water intake. Animals offered 5g salt/day recorded the fastest growth rate (58.6g/d), optimum DMI (2.90% BW) and highest serum Na concentration (200mmol/L). Goats on higher dietary NaCl however, depicted a decline in growth rate. The data suggested that WAD goats would require 5g/animal/day common salt in the concentrate diet for maximum growth rate and 0.52 ppm $Na/KgW^{0.75}$/day for maintenance. When the effects of dietary salt levels on the performance of WAD goats were estimated (Aina, 2002) it was established that increasing common salt level also increased average daily gain and feed conversion ratio in both dry and fresh cassava peels based diet. Goats fed dry cassava peels based diets significantly consumed more water as the salt level increased in the diet. It was concluded that application of 5g common salt/kg dry cassava peels promoted highest daily gain, optimum DMI and FCR in WAD goat production (Okeniyi *et al.*, 2020).

Potassium: Potassium has an important role in metabolism. However, forages generally are quite rich in potassium, so a deficiency in grazing goats is extremely

rare (Whitehead *et al.,* 1986; Schonewille *et al.,* 1999; Okeniyi *et al.*, 2020). Marginal potassium intake is seen only in heavily lactating does fed diets composed predominately of cereal grains. Excessive potassium intake (particularly in late gestation) may be associated with hypocalcemia in dairy goats. If hypocalcemia is a herd problem, attention should be paid to reducing or monitoring potassium-rich feed stuff such as alfalfa.

Iron: Iron deficiency is seldom seen in mature grazing goats. Such deficiency might be seen in young kids because of their minimal stores at birth, plus the low iron content of the dam's milk. This is more commonly seen in kids fed in complete confinement and heavily parasitized animals. Iron deficiency can be prevented by access to pasture or a good quality trace mineral salt containing iron. In severe cases, and for kids reared in confinement (Intensive management system), iron *dextran* injections at 2 to 3 week intervals (150 mg, IM) for the first few months may be curative. In the cases of mixed iron/selenium deficiencies, caution should be used when injecting iron dextran until the selenium deficiency is also corrected (Salah *et al*., 2023).

Iodine: Iodine deficiency in the soil, and in the crops produced thereon, is seen in some areas of the USA and some other part of the world. Therefore, iodine should be provided in stabilized salt or salt-lick for goats. Conditional iodine deficiency may develop with normal to marginal iodine intake in goats consuming goitrogenous plants. Deficiency of iodine results in an enlarged thyroid, poor growth, small, weak kids at birth, and poor reproductive ability.

Zinc: Deficient of Zinc results in parakeratosis, stiffness of joints, smaller testicles, and lowered libido. A minimal level of 10 ppm of zinc in the diet, or a trace mineral salt mixture of 0.5%–2% zinc, prevents deficiencies. Excessive dietary calcium may increase the likelihood of zinc deficiency in goats (Yusuf *et al*., 2022).

Copper: The deficiency may result in microcytic anaemia, poor production, lighter or faded hair color, poor fiber quality, infertility, poor health and slowed growth, some forms of metabolic bone disease, diarrhea, and possibly a greater susceptibility to internal parasites (Aina *et al*., 2000 and 2011) Copper deficiency in a diet may be caused by inadequate copper intake, a lowered copper-molybdenum ratio, or excessive dietary sulphure. Goats appear to be much more resistant to copper toxicity than sheep. Studies on Copper (Aina and Akinsoyinu, 1996; Aina *et al.*, 2000; Aina, 2001; Sowande *et al*., 2007); Magnesium (Aina, 1997; Sowande *et al*., 2000; Sowande and Aina, 2001; Adeleye *et al*., 2004; Sowande *et al*., 2008; Aina and Mensah, 2007) and Sodium (Aina, 1999, 2002) compounds can be used as dietary supplements to overcome deficiencies caused by naturally low concentrations of these minerals in feeds and forages; or deficiencies induced by elevated dietary levels of the minerals. The implications of these studies include the fact that we do not need to impose values determined for both indigenous or exotic sheep and cattle on WAD goats henceforth. In an experiment which monitored the effects of different dietary copper salts on the performance of WAD goat (Aina, 2000), copper acetate significantly promoted the fastest growth rate (67.35g/d) and copper balance (8.83ppm) but the least serum Cu

concentration (0.01mmol/d), followed by copper sulphate (57.14g/d) while the control group (zero dietary Cu salt) exhibited the least growth rate (20.41g/d). Water intake and serum Cu concentration were not affected by the type of copper salt in the diet.

Vitamins: Vitamins are needed by the body in very small quantities. The vitamins most likely to be deficient in the diet are vitamin A and D. All B and K vitamins are formed by bacteria found in the rumen of the goat and are not considered dietetically essential. Vitamin C is synthesized in the body tissues in adequate quantities to meet needs. Vitamin A is not contained in forages, but carotene found in green leafy forages is converted into vitamin A in the body. In addition, vitamin A is stored in the liver and fat of goats during times when intake exceeds requirements. Goats consuming weathered forages or forages that have undergone long-term storage should be fed a mineral mix containing vitamin A, or should receive vitamin A injections. Vitamin D may become deficient in animals raised in stalls. Animals should have frequent access to sunlight because it causes vitamin D to be synthesized under their skin, or they should receive supplemental vitamin D. Good quality sun-cured hays are excellent sources of vitamin D. A deficiency in vitamin D results in poor calcium absorption leading to rickets, a condition where the bones of young animals and joints grow abnormally (Georgievsk, 1982; Oduguwa *et al*., 2001).

Goats are ruminants with unique nutritional requirements which must be met to ensure their health, productivity, and well-being. Their nutritional requirements vary based on factors such as maintenance, age, live weight, physiological status and health condition. By consistently meeting these nutritional needs and monitoring goats' overall health, goat owners can ensure better productivity, reproduction, and longevity of their animals.

CONCLUSION

From this review, it is concluded that the Nigerian breeds of goats such as the WAD, the Red Sokoto, the Sahel and the *KALAWAD* goats neglected over centuries about their nutrient requirements to harness their potential for milk and other by-products rather than the meat alone. Understanding and knowledge of the nutrient requirements addressed in this review would provide the needed information to unveil the full benefits of these breeds of goat.

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REFERENCES

Abba, Y. and Igbokwe, I.O. (2015). Testicular and related size evaluations in Nigerian Sahel goats with optimal cauda epididymal sperm reserve. *Veterinary Medicine International* 2015 Article ID 357519, 5, http://dx.doi.org/10.1155/2015/357519.

Abioja, M.O., Osinowo, O.A., Adebambo, O.A., Bello, N.J. and Abiona, J.A. (2010). Water restriction in goats during hot-dry season in the humid tropic: feed intake and weight gain. *Annales de Zootechnie*, 59: 195–203.

Abioja, M.O., Osinowo, O.A., Adebambo, O.A., Bello, N.J. and Abiona, J.A. (2007). Physiological response of West African Dwarf and Red Sokoto goats to water restriction in the humid tropics of South-western Nigeria. *Abstract book of the Annual Conference of Animal Science Association of Nigeria (ASAN).* September, 2007. Obafemi Awolowo University, Ile-Ife, Nigeria

Adamu, H., Ma'aruf, B.S., Haruna, K., Salihu, A.M. and Sani, M.G. (2021). Quantitative traits of

indigenous breeds of goat in Nigeria: A review. Nigerian Society for Animal Production (NSAP) 46th Annual Conference –Dutsin-Ma, March 2021 Book of Proceedings. pp. 481-485

Adeleye, A. M., Aina, A.B.J., Adu. I.F. (2004). The use of "kaun" (Local potash) as a mineral source in the diet of West African Dwarf Sheep. *Nigerian Journal of Animal Production*. 31(2): 220-229.

Adogla-Bessa, T. and Aganga, A.A. (2000). Responses of Tswana goats to various lengths of water deprivation. *South African Journal of Animal Science*, 30: 87-91.

Aganga, A. A., Umunna, N.N., Oyedipe., O.E., Okoh, P.N. and Aduku, O.A. (1988). Influence of inter-nutrient watering on milk yield and milk composition of Yankasa ewes. *Thai Journal of Agricultural Science*, 21: 173-177.

Ahmed, M.M.M. and El Kheir, I.M. (2004). Themoregulation and water balance as affected by water and food restrictions in Sudanese desert goats fed good-quality and poor-quality diets. *Tropical Animal Health and Production* 36: 191–204.

Aina, A.B. J. and Mensah, J.J. (2007). Copper salts utilization for growth performance of West African Dwarf sheep. B.Sc. Agric. Project of Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Aina, A.B.J. (1997). Effect of dietary magnesium supplementation on serum Magnesium concentration and performance of Female West African Dwarf goats. *Indian Journal of Animal Science,* 67 (10): 890-893.

Aina, A.B.J. (1999). Sodium requirements for maintenance and growth of West African Dwarf goats. *Tropical Journal of Animal Science* 1 (2): 119-123.

Aina, A.B.J. (2012). Goat (*Capra hircus*): a misunderstood animal. 35th in the inaugural lecture series of the Federal University of Agriculture, Abeokuta, Nigeria.

Aina, A.B.J., Edafe, G. and Oyebisi, T**.** (2000). Effects of dietary copper salts on the performance of West African Dwarf goat. *Journal of Sustainable Agriculture and Environment*. 2(1): 79-83.

Akpa. G.N, Alphonsus, C., Usman, N. (2013). Association of haemoglobin types with age and coat colour and head profile in Red Sokoto goats of Abuja *Nigeria. Journal of Animal Science Advances*; 3 (4): 171-175.

Alamer, M. (2009). Effect of water restriction on lactation performance of Aardi goats under heat stress conditions. *Small Ruminant Research,* 84:76–81.

Akintunde, A.O., Mustofa, I., Ndubuisi-Ogbonna, L.C., Oyekale, O.O. and Shobo, B.A. (2024). Exploring the genetic diversity: A review of germplasm in Nigerian indigenous goat breeds. *Small Ruminant Research*, *234*, 107236. https://doi.org/10.1016/j.smallrumres..107236

Amills, M., Capote, J. and Tosser-Klopp, G. (2017). Goat domestication and breeding: a jigsaw of historical, biological and molecular data with missing pieces. *Animal Genetics*, 6 (48): 631–644.

Anya, M.I., Ozung, P.O., Okah, U., Ayuk, A.A. and Igwe, P.A. (2018). Blood Profile of West African dwarf (WAD) Goats Fed Cassava Peel Meal Based-Diets Supplemented with African Yambean Concentrate. *Canadian Journal of Agriculture and Crops*, 3(2): 55–63.

Araújo, M.J., Medeiros, A.N., Teixeira, I.A.M.A., Costa, R.G., Marques, C.A.T., Resende, K.T., Melo, G.M.P. (2017). Trace mineral requirements for growth of Moxotó goats grazing in the semiarid region of Brazil. *Revista Brasileira De Zootecnia*, 46: 231–239. https://doi.org/10.1590/s1806-92902017000300008.

Arenas-Báez, P., Torres-Hernández, G., Castillo-Hernández., G., Hernández-Rodríguez, M., Sánchez-Gutiérrez. R.A., Vargas-López, S., González-Maldonado. J., Domínguez-Martínez., P.A., Granados-Rivera, L.D. and Maldonado-Jáquez, J.A. (2023). Coat color in local goats: Influence on environmental adaptation and productivity, and use as a selection criterion. *Biology*; 12(7): 929.https://doi.org/10.3390/biology12070929

Asaolu, V.R., Binuomote, A., Akinlade, O.A. Aderinola and Oyelami, O. (2012). Intake and growth performance of West African Dwarf goats fed *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* dried leaves as supplements to cassava peels. *Journal of Biology*, *Agriculture and Healthcare*, 2 (10): 76- 88.

Ayoade, J.A. (2010). Poor Man's cow: Sheep and

goats. Inaugural Lecture Series 11, August 25th 2010. University of Agriculture, Makurdi, Nigeria.

Barbara, R. and Dafydd, P. (2007). List of breeds documented in the Global Databank for Animal Genetic Resources, annex to: The State of the World's Animal Genetic Resources for Food and Agriculture. Rome: Commission on Genetic Resources for Food and Agriculture, Food and Agriculture Organization of the United Nations.

Barkai, D., Landau, S., Brosh, A., Baram, H. and Molle, G. (2002). Estimation of energy intake from heart rate and energy expenditure in sheep under confinement or grazing condition. *Livestock Production Science.* 73: 237–246.

Boumgardt, B.T. (1969). Voluntary feed intake. In: *Animal Growth and Nutrition*. Ed. E.S.E. Hafez and I.A. Dyer Lea and Febiger, Philadephia. pp. 134-136.

Brosh, A., Aharoni, Y., Shargal, E., Choshniak, I., Shair, B., Holze, Z. and Gutman, M. (2001). The use of heart rate to measure energy expenditure and energy balance of cattle. In: Chwalibog, A., Jakobsen, K. (Eds.), Proceedings of the 15th Symposium on Energy Metabolism in Animals, Wageningen Pers, Wageningen, The Netherlands, pp. 19–22.

Caja, G., Castro-Costa, A., Salama, A.A.K., Oliver, J., Baratta, M., Ferrer, C., Knight, C.H. (2020). Sensing solutions for improving the performance, health and wellbeing of small ruminants. *Journal of Dairy Research* 87: 34–46. https://doi.org/10.1017/S0022029920000667.

Cardoso, E.A., Furtado, D.A., Ribeiro, N.L., Medeiros, A.N., Saraiva, E.P., Nascimento, J. W.B. (2021). Biochemical and hormonal parameters of goats kept in a controlled environment consuming water with different levels of salinity. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* :73 (4): 853–860. doi:10.1590/1678-4162-12186

Carro, M.D., Vades, C., Ranilla., M.J. and Gonzalez, J.S. (2000). Effect of forage to concentrate ratio in the diet on ruminal fermentation and digesta flow kinetics in sheep offered food at a fixed and restricted level of intake. *Journal of Animal Science*. 70: 127-134.

Castagnino, D.S., Härter, C.J., Rivera, A.R., Lima, L.D., Silva, H.G.O., Biagioli, B., Resende, K.T. and Teixeira, I.A.M.A. (2015). Changes in maternal body composition and metabolism of dairy goats during pregnancy. *Revista Brasileira De Zootecnia,* 44: 92–102. https://doi.org/10.1590/S1806-92902015000300003.

Cervantes, A., López, G., Monge, F.J., Estrada, A. and Plascencia, A. (2024). Importance of water quality in small ruminants' productivity. *The Iranian Journal of Applied Animal Science*; 14 (1): 1–9.

Chang, T.K. and Landauer, W. (1950) Observation on the skeleton of African Dwarf goats. *Journal of Morphology,* 86: 367-369.

Chebli, Y., El Otmani, S., Hornick, J.L., Bindelle, J., Cabaraux, J.F. and Chentouf, M. (2022). Estimation of grazing activity of dairy goats using accelerometers and GPS. *Sensors*, 22(15): 5629.

Chidebelu, S.A.N.D. and Ngo, N.M. (1998). The economics of goat production in south Eastern Nigeria: Implications for the future. *Nigerian Journal of Animal Production*. 25(1): 93-99.

Chiejine, S.N., Behnke, J.M. and Fakae, B.B. (2015). Haemoncho tolerance in West African Dwarf Goats: contribution to sustainable antihelmintics-free helminth control in traditionally managed Nigerian dwarf goat. *Parasite,* 22: 345-352.

Chungsiriwat, P. (1995). Chemical and sensory characteristics of emulsion goat meat sausages containing pork fat or shortening. *ASEAN Food Journal. Malaysia. Vol. 10, 57–61*

Coral, l. (1996). Trace mineral requirements of grazing cattle. *Animal Feed Science and Technology.* 59: 61-70.

Costa, R.G., Freire, R.M.B., de Araújo, G.G.L., Queiroga, R., Paiva, G.N., Ribeiro, N.L. (2021). Effect of increased salt water intake on the production and composition of dairy goat milk. *Animals*, 11 (9): 2642. doi:10.3390/ani11092642

CSIRO (2007). *Nutrient Requirements of Domesticated Ruminants*. In: Commonwealth Scientific and Industrial Research Organisation. CSIRO Publishing, Collingwood, Australia.

Daramola, J.A. (2025). Stubbornness and the goat: A romantic paradox. 98th in the inaugural lecture series of the Federal University of

Agriculture, Abeokuta, Nigeria

Dorigan, C.J., Vargas, J.A.C., Härter, C.J., Resende, K.T., Vitti, D.M.S.S., Abdalla, A.L. and Teixeira, I.A.M.A. (2018). Dynamics of body calcium and net calcium requirements for maintenance of Saanen goats. *The Journal of Agricultural Science*, 156: 1–6. https://doi.org/10.1017/S0021859618000321.

Edwards, J.H., Jackson, W.A., Beaty, E.R and McCreary, R.A. (1997). Element concentration of forage and non-soluble cell wall fraction of coastal Bermuda grass. *Agronomy Journal,* 69: 617-619.

Ejoh, A.R., Tanya, A.N., Djuikwo, N.V. and Mbofung, C.M. (2005). Effect of processing and preservation methods on vitamin C and total carotenoid levels of some *Vernonia* (bitter leaf) species. *African Journal of Food Agriculture*. *Nutritional Development,* 5: 105-117.

Epstein, H. (1971). The origin of the domestic animals of Africa. Volume II. Africana Publishing Corporation, Leipzig, Germany. pp 573-719

Fernandes, M.H.M.R., Resende, K.T., Tedeschi, L.O., Teixeira, I.A.M.A., Fernandes, J.S. (2012). Macromineral requirements for the maintenance and growth of Boer crossbred kids. *Journal of Animal Science*, 90: 4458–4466. https://doi.org/10.2527/jas.2011-4954

Forbes, J.M. (2007). Voluntary Food Intake and Diet Selection in Farm Animals. CAB International, Wallingford, UK. https://doi.org/10.1079/9781845932794.0000

Gbodi, T.A. and Ikwuegbu, O.O. (1982). Chemical composition of native mineral licks. *Nigerian Veterinary Journal,* 2 (2): 89-92.

Georgieva, R., Donath, E. and Glaser. R. (1989). On the determination of human erythrocyte intracellular conductivity by means of electrorotation influence of osmotic pressure *Studia Biophysica*, Vol.133: 185-197.

Goff, J.P. (2018). Invited review: Mineral absorption mechanisms, mineral interactions that affect acid-base and antioxidant status, and diet considerations to improve mineral status. *Journal of Dairy Science*, 101(4): 2763-2813.

Gordon, J.G. (1965). The effect of water deprivation upon the rumination behaviour of housed sheep. *Journal of Agricultural Science*s. 64: 31-35.

Habibu, B.; Kawu, M.U. Makun, H.J., Aluwong, T., Yaqub, L.S. (2016). "Seasonal variation in body mass index, cardinal physiological variables and serum thyroid hormones profiles in relation to susceptibility to thermal stress in goat kids". *Small Ruminant Research*. 145: 20–27. doi:10.1016/j.smallrumres.2016.10.023.

Haenlein, G.F.W. (1980). Mineral Nutrition of Goats. A Review: *Journal Dairy Science.* 63: 1729 - 1748.

Härter, C.J., Lima, L.D., Castagnino, D.S., Rivera, A.R., Nunes, A.M., Sousa, S.F., Liesegang, A., Resende, K.T. and Teixeira, I.A.M.A. (2017). Mineral metabolism of pregnant goats under feed restriction. *Animal Production Science*, 57: 290–300.

Haumesser, J.B. (1975). Some aspects of reproduction in the Sokoto Red Goat. Comparison with the tropical and some subtropical breeds. *La Revue d'élevage et de médecine vétérinaire des pays tropicaux* (REMVT*),* 28*:* 225-223.

Hussein, A. H., Puchala, R., Gipson, T. A., Tadesse, D., Wilson, B. K. and Goetsch, A. L. (2020). Effects of water restriction on feed intake, digestion, and energy utilization by mature female St. Croix sheep, *Veterinary Animal Science*. 10 100132. doi:10.1016/j.vas.2020.100132.

Idowu, A.O. (1994). A comparative study of the effect of kaun‟ (local salt) and okan‟leaf. B. Agric. project, University of Agriculture, Abeokuta, Nigeria

Igbokwe, I.O, Ikpo A. E, Grema, H. A, Mshelbwala, F .M, Igbokwe, N. A. (2011). Bilateral testicular hypoplasia among mature Sahel bucks. *Turkish Journal of Veterinary and Animal Sciences*; 35(2):111-115 doi:10.3906/vet-0909-108

Iheanacho, A.C. and Ali, E.A. (2010). Marketing of sahelian goats in north-eastern Nigeria: experience from Borno State. *Sahel Journal of Veterinary*. 9(1): 25-31

Ijomanta, E.O. (2012). Genetic Profile of Morphological Traits and their association with production capacity of Red Sokoto Goat in Katsina State. M.Sc. Thesis*,* Ahmadu Bello University, Zaria. pp 22-26.

Ikhatua, U.J., Dede, T.I. and Apumami, A.S. (1992). Water and feed utilization relationship in

WAD (forest) goats of southern Nigeria. *Nigerian Journal of Animal Production,* 19: 120-124

Isaac, A.A. and Ibrahim, D.M. (2006). Accuracy of body weight prediction in Nigeria Red Sokoto goats raised in North Eastern Nigeria using linear body measurements. *Pakistan Journal of Biological Sciences* 9(15): 2828 – 2830.

Jahnke, H.E., Tacher, G., Keil, P. and Rojat, D. (1998). Livestock Production in Tropical Africa with special references to the tsetse-affected areas of Africa. Proceedings of the meeting on trypanotolerant Livestock Network. pp34-36

Joemat, R., Goetsch, A.L., Horn, G.W., Sahlu, T., Puchala, R., Min, B.R. and Luo, J. (2004). Growth of yearling meat goat doelings with changing plane of nutrition. *Small Ruminant Research,* 52: 127–135.

Ka'oje, A.B. and Bello, A. (2021). Goat (*Capra aegagrus hircu*) Production in Nigeria. *Scholarly Journal of Agricultural Science,* 11(3): 33- 41.

Kaliber, M., Koluman, N. and Silanikove, N. (2016). Physiological and behavioural basis for the successful adaptation of goats to severe water restriction under hot environmental conditions. *Animal*, 10 (1): 82–88. doi:10.1017/S1751731115001652.

Kotze, A., Swart, H., Grobler, J.P.G. and Nemaangani, A. (2004). A genetic profile of the Kalahari Red goat breed from southern Africa. *South African Journal of Animal Science*, 34(5): 10–12.

Kwari, H.D., Sivachelvan M.N. and Chibuzo, G.A. (2004). Characterization of Sahel goat in Borno state, Nigeria, for certain qualitative traits. *Nigerian Journal of Experimental and Applied Biology,* 5: 151- 154.

Lachica, M. and Aguilera, J.F. (2003). Estimation of energy needs in the free-ranging goat with particular reference to the assessment of its energy expenditure by the 13 C-bicarbonate method. *Small Ruminant Research,* 49: 303–318.

Lima, A.R.C., Fernandes, M.H.M.R., Silveira, R.F., Biagioli, B., Teixeira, I.A.M.A. and Resende, K.T. (2020). Energy expenditure of Saanen and Anglo-Nubian goats at different temperatures. *Small Ruminant Research* ,193: 106-256.

Little, D.A. (1981). Utilization of minerals. In: Nutritional limits to Animal Production from pastures. Proceedings of an International Symposium held at St Lucia, Queensland, Australia, pp.228

LPRP. (2013). Livestock Production Research programme herd record book.

Madsen, F.C., Lentz, D.E., Miller, J.R., Lowery-Harden, D. and Hansard, S. L. (1976). Dietary carbohydrate upon magnesium metabolism in sheep. *Journal of Animal Science,* 42:1316-1325.

Malau-Aduli, B. S., Eduvie, L.O., Lakpini, C.A.M. and Malau-Aduli, A.E. (2003). Variations in live weight gains, milk yield and composition of Sokoto Red goats fed crop residue based supplements in the sub humid zone of Nigeria. *Livestock Production Science*. 83:63-71.

Mamiro, P., Mwanri, A., Mamiro, D., Martha, N. and Ntwenya, J. (2016). *In-vitro* bioavailability of selected minerals in dry and green shelled beans. *African Journal of Agricultural Research*, 11: 730-737. doi:10.5897/AJAR2012.883.

Martins, A.A., Härter, C.J., Batista, N.V., Carvalho, G., Bernardes, G.M.C., Macari, S., Kozloski, G.V. and Pires, C.C. (2021). Protein requirements for maintenance and growth of Corriedale lambs. *Livestock Science,* 244: 104395.

Matthewman, R.W. (1979). Small ruminant production in the humid tropical zone of Southern Nigeria. *Tropical Animal Health and Production*. 12: 234–242. https://doi.org/10.1007/BF0223662

Monstama, G., Luiting, P., Verstegen, M.W.A., van der Hel, W., Hofs, P. and Zijiker, J.W. (1985). Effects of high ambient temperature on the metabolism of West African Dwarf goats. II. *International Journal of Biometeorology,* 29: 23-35

Murital, I., Afolayan, O., Bemji, M.N., Dadi, O., Landi, V., Martínez, A., Delgado, J.V., Adebambo, O.A., Aina, A.B.J. and Adebambo, A.O. (2015). Genetic Diversity and Population Structure of Nigerian Indigenous Goat Using DNA Microsatellite Markers. *Archivos de Zootecnia*, 64: 93-98.https://doi.org/10.21071/az.v64i246.382

NASS (2011). National Bureau of Statistics/Federal Ministry of Agriculture and Rural Development Collaborative Survey on National Agriculture Sample Survey.

Njidda, A.A., Ikhimioya, I. and Muhammad, I.R. (2010). Feed potential of *Ziziphus mauritiana* as browse to goats in Sudano-Sahelian Region of Nigeria. Proceedings of. 35th Annual Conference of Nigerian Society for Animal Production. pp. 473- 476.

NRC (National Research Council). (1981). *Nutrient Requirement of Goats: Angora, Dairy and Meat in Temperate and Tropical Countries*. National Academy Press, Washington, D.C., p. 23.

NRC(National Research Council). (2007). *Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids*. National Academy Press, Washington, DC, USA.

Oderinwale, O. A., Oluwatosin, B.O., Amosu, S.D., Sanusi,G.O. and Adeyemo, A.J. (2017b). Haematology, Serum Biochemistry and Growth Performance of Pregnant Kalahari Red Goats fed concentrate diets at three protein levels in Nigeria. *Bulletin of Animal Health and Production,* 65(3): 515-625

Oderinwale, O.A., Oluwatosin, B.O. Sowande, O. S., Bemji, M. N. Amosu, S. D. and Sanusi, G. O. (2017a). Concentrate supplementations of grazing pregnant Kalahari Red goats: Effects on pregnancy variables, reproductive performance, birth types and weight of kids. *Tropical Animal Health and Production*, 49:1125-1133. DOI 10.1007/s11250-017-1303-y

Oduguwa, B.O. and Adu, I.F. (2010). Feeding value of shrimp waste meal for WAD sheep fed soybean stover basal diet. *Nigerian Journal of Animal Science*. 37(2): 71-84.

Oduguwa, O.O, Jalaosho, A.O., Babayemi, O.J., Aina, A.B.J. and Adu, I.F. (2005). Nutritive value of malted sorghum sprout in WAD sheep fed soybean stover based diets. *Nigerian Journal of Animal Science.*33 (2): 254-267.

Ojo. O.A., Akpa, G.N., Orunmuyi, M., Adeyinka, I.A., Kabir, M. and Alphonsus, C. (2018). Genetic analysis of Nigerian indigenous goat populations using microsatellite markers. *Iranian Journal of Applied Animal Science*, 8 (2): 287-94

Okeniyi, F. A., Olawoye, S.O., Animashahun, R.A., Alabi. O.O., Shoyombo, A. J., Falana, M.B., Aina, A.B.J., Onwuka, C.F.I. and Sowande O.S. (2020). Mineral balance, nutrient intake and digestibility of West African dwarf (Wad) goats fed urea mixed milled maize stover diets. *Association of Deans of* Agriculture *in Nigeria Universities* (*ADAN*) *Journal of Agriculture,* 1 (1): 149-159. DOI:10.36108/adanja/0202.10.0171

Okwelum, N. Mustapha. W. Famakinde, S.A., Shittu, O.O., Toviesi. P.D. Odeyemi, A.J. and Oluwatosin, B.O. (2018). Haematology and Serum Biochemical Profile of Kalahari Red Goats Reared in South-West Nigeria. *Proceedings of 43rd Annual Conference of the Nigerian Society for Animal Production*, pp. 299-300.

Olalere, J.O., Toviesi, D.P., Oderinwale, O.A., Akinneye, K.A., Oluwatosin, B.O., Shittu, O.O., Sanusi, G.O. and Taiwo, S.F. (2024). Serum biochemistry and hormonal indices of KALAWAD bucks fed *Brachiaria ruziziensis* and *Panicum maximum*. *Proceedings of the 49th Conference of the Nigerian Society for Animal Production*. University of Ibadan, Oyo State, Nigeria. pp 618-621.

Omoniyi, L.A., Isah, O.A., Olorunsola, R.A. Osofowora, O.A., Akinbode, R.M., Yusuf, K.O. and Olanite, J.A. (2013). Nutrient and anti-nutritional constituents of *Pennisetum purpureum* and four indigenous tree legumes of South-Western Nigeria: A potential ruminant feed. *Nigerian Journal of Animal Production,* 40 (1): 152-160.

Omotoso, O. B., Ale, O. M., Fajemisin, A. N. and Alokan, J. A. (2024). Dietary effect of copper sulphate on blood and serum biochemical indices of growing goats. *Proceedings of 49th Conference, Nigerian Society for Animal Production*, University of Ibadan, Nigeria. pp. 580–583. https://doi.org/10.51791/njap.vi.5190

Ozoje, M.O. and Mgbere, O.O. (2002). Coat pigmentation effect in WAD Goats. Live weights and body dimensions. *Nigerian Journal of Animal Production*, 29: 5-10

Perdomo, J. T., Shirley, R.L. and Chicco, C.F. (1976). Availability of nutrient minerals in four tropical forages. First International Symposium, Feed Composition, Animal Requirement and Computerization of Diets. (Edited by P.V Fonnesbeck., L. E Harris and L. C Kearl) Utah Agricultural Experimental Station. Utah State University, Logan, Utah, USA.

Playne, M.J., Echeverria, M.G. and Megarrity, R.G

(1978). Release of nitrogen, sulphur, phosphorus, calcium magnesium, potassium and sodium from four tropical hays during their digestion in nylon bags in the rumen. *Journal of Food Science and Agriculture,* 29: 520 – 526.

Ramirez, R.G., Haenlen., G.F.W., Garcia-Castillo., C.G. and Nunez-Gonzalez, M.A. (2004). Protein, lignin and mineral contents and *in situ* dry matter digestibility of native Mexican grasses consumed by range goats. *Small Ruminant Research,* 52: 261-269.

Ramsay, K., L., Harris and Kotze, A. (2001). *Landrace Breeds: South Africa's Indigenous and Locally Developed Farm Animals*. Farm Animal Conservation Trust, South Africa, ISBN: 9780620254939, pp: 112.

Ranjhan, S.K. (1997). *Mineral Nutrition and Metabolism*. In: Animal Nutrition in the Tropics. Vikas. Publishing House PVT Ltd. pp. 131 – 157.

Raw Materials Research and Development Centre (RMRDC). (1996). *Priority Investment Project in the Solid Minerals Sector*. Published by RMRDC, Abuja. pp. 81-87.

Ribeiro, L.P.S., Medeiros, A.N., Carvalho, F.F.R., Pereira, E.S., Souza, A.P., Santos Neto, J.M., Bezerra, L.R., Santos, S.A. and Oliveira, R.L. (2018). Performance and mineral requirements of indigenous Canindé goats. *Small Ruminant Research*, 169: 176–180. https://doi.org/10.1016/j.smallrumres.2018.10.005.

Robinet, A. H. (1967) The Maradi Red Goat. Its exploitation and its place in the economy and livestock of the Republic of Niger. *Journal of Animal Husbandry and Veterinary Medicine of Tropical Countries,* 20: 129-186.

Rotimi, E. A., Egahi, J. O. and Adeoye, A. A. (2017). Body characteristics of West African Dwarf (WAD) goats in Bassa Local Government Area of Kogi State. World Scientific News 69.

Salah, N. M., Dogon Daji, A. Y., Umar, R., Umar, A. and Sarkingobir, Y. (2023). Proximate and Some Micronutrients (Zn, Se, Fe and I) Proximate and Some Micronutrients (Zn, Se, Fe and I) Assessed in Goat Milk, and Cattle Milk in Sokoto, Nigeria. *International Islamic Medical Journal,* 04: 2. 20-27

Salako, A.E. and Ngere, L.O. (2002). Application of multifactorial discriminant analysis in the morphometric structural differentiation of West African Dwarf (WAD) and Yankasa sheep in South West Nigeria. *Nigerian Journal of Animal Production* 29: 163-167

Sanni, M.T., Okpeku, M., Onasanya, G.O., Adeleke, M.A., Wheto, M., Adenaike, A.S., Oluwatosin, B.O., Adebambo, O.A. and Ikeobi, C.O.N. (2018). Genetic morphometry in Nigerian and South African Kalahari Red goat breeds. *Agricultura Tropica Et Subtropica,* 51(2): 51-61.

Sauvant, D. and Nozière, P. (2013). Integrative model of the digestive tract including the interactions involved in energy and protein digestion in ruminants. In: Oltjen, J. W., Kebreab, E., Lapierre, H. (Eds.), Energy and Protein Metabolism and Nutrition in Sustainable Animal Production. Wageningen Academic Publishers, Wageningen, NL, pp. 317–318. https://doi.org/10.3920/978-90-8686-781-3_109.

Shittu, O.O., Amole, T.A., Okwelum, N., Odeyemi, J.A., Toviesi, D.P., Ojo, V.I.O., Oluwatosin, B.O., Smith, O.F. and Osinowo, O.A. (2016). Haematological and Serum Bio-Chemical Parameters of West African Dwarf and Kalahari Red Goats in the Humid Tropics. *Nigerian Journal of Animal Science* 18(2):305- 314.

Shoyombo, A.J, Animashahum, R.A, Izebere, J., Olawoye S.O., Yakubu, H., Musa, A.A. (2015). Genetic distance andrelationship among indigenous goats using biochemical polymorphism. *Asian Journal of Science and Technology;* 6(9): 1746-1749

Simela, L. and Merkel, R. (2008). The contribution of chevron from Africa to global meat production. *Meat Science*, 80 (1): 101-109.

Souza, A.P., Vargas, J.A.C., Fernandes, M.H.M.R., Almeida, A.K., Resende, K.T., Teixeira, I.A.M.A.(2021). Metabolizable protein: 2. requirements for maintenance in growing Saanen goats. *Frontiers in Veterinary Science,* 8: 650203. https://doi.org/10.3389/fvets.2021.65020.

Sowande, O.S and Aina, A.B.J. (2001). Magnesium nitrate as dietary additive in the nutrition of West African Dwarf goat. *Archivos de Zootecnia.* 50: 335-341.

Sowande, O.S. and Sobola, O.S. (2008). Body measurements of West African dwarf sheep as parameters for estimation of live weight. *Tropical Animal Health Production,* 40: 433–439. DOI 10.1007/s11250-007-9116.

Sowande, O.S., Aina, A.B.J., Oduguwa, O.O., Biobaku, W.O. and Abiola, S.S. (2000). The performance of West African Dwarf goat on dietary magnesium sulphate supplements. *Tropical Journal of Animal Science,* 3(2): 21-25.

Sowande, O.S., Fasae, O.A., Ojedokun, O.J. Okunola, O.S. and Aina, A.B.J. (2007). Comparative evaluation of the blood mineral status of West African Dwarf Sheep and Goats managed under extensive and semi-intensive systems of Management. *Nigerian Journal of Animal Production*, 34(1): 94-99.

Steele, M. (1996). The Tropical Agriculturalist (goats). MacMillan Education Ltd. London and Basingstoke. pp. 4, 14, 111-112.

Tedeschi, L.O., 2023. Review: Harnessing extant energy and protein requirement modelling for sustainable beef production. *Animal,* 17 (Suppl 3): 100835. https://doi.org/10.1016/j.animal.2023.100835.

Teixeira, I.A.M.A., Härter, C.J., Vargas, J.A.C., Souza, A.P., Fernandes, M.H.M.R. (2023). Update of nutritional requirements of goats for growth and pregnancy in hot environments. *Book of Abstracts of the 74th Annual Meeting of the European Federation of Animal Science*, 26 August – 1 September 2023, Lyon, France, p.506

Toviesi, D.P, Shittu, O.O., Oderinwale, O.A, Okwelum, N., Famakinde, S.A., Oluwatosin, B.O, Adewumi, O.O, Olalere, J.O., Sulaiman, T.O. and Adebambo, E.O. (2024). Haematology and serum biochemical parameters of *KALAWAD* weaner goats fed diets containing *Moringa oleifera* leaf meal. Proceedings of the 49th Conference of the Nigeria Society for Animal Production (NSAP), Abu *et al*. (Eds.) pp. 411-414.

Toviesi, D.P. (2015). Linear body Morphometric parameters to predict liveweight of Kalahari Red goats in Southwest, Nigeria. (M. Agric. Thesis: Department of Animal Production and Health, Federal University of Agriculture, Abeokuta).pp 3-5

Toviesi, D.P., Shittu, O.O., Odeyemi, A.J., Okwelum, N., Famakinde, S.A., Yusuff, M.A. and Oluwatosin, B.O. (2019). Effects of birth weight, sex and type of birth on pre-weaning kid mortality in Kalahari Red Goat. *Journal of Agriculture and Food Environment*, 6(2): 6-12,

Underwood, E.J. (1981). *The Mineral Nutrition of Livestock*. Commonwealth Agriculture Bureaux. London, England.

Underwood, E.J and Suttle, N.F. (1999). *The Mineral Nutrition of Livestock*. 3rd edition, CAB International, Wallinford, U.K.

Valerie, P., Lawrence, A., Stephen J.G., Hall, D. and Phillip, S. (2016). *Mason's World Encyclopedia of Livestock Breeds and Breeding* (sixth edition). Wallingford: CABI.

Van Horn, H. H. and Haenlein, G.F.W. (1983). Nutritional causes of reproductive losses. In: G.F.W. Haenlein and D. L. Ace (Eds). In: *Extension Goat Handbook IV* @ 1-5, Department of Animal Science and Biochemistry, University of Delaware Network

Houtert, M.V. and Leng, R. (1991). A note on the effects of high levels of dietary calcium, phosphorus and sodium on nutrient utilization by sheep offered a roughage-based diet. *Animal Production,* 53: 249-252.

Ward, G, Harbers, L.H. and Blaha, J. J. (1979). Calcium containing crystals in alfalfa: Their fate in cattle. *Journal of Dairy Science,* 62: 715-722.

West, F.S., Todd, W.R., Mason. H.S. and Bruggen, J.T.V. (1966). Textbook of Biochemistry. 4th edition. The Macmillan, Canada Ltd. Toronto Ontario. pp 1387-1388.

Wilkens, M.R., Breves, G. and Schröeder, B. (2014). A goat is not a sheep: physiological similarities and differences observed in two ruminant species facing a challenge of calcium homeostatic mechanisms. *Animal Production Science,* 54: 1507–1511. https://doi.org/10.1071/AN14349

Wilson, R. T. (1991). *Small Ruminant's Production and Small Ruminant Genetic Resources in Tropical African*. FAO (Food and Agricultural Organisation of the United Nations), Rome, Italy.

Wilson, R.T. and Durkin, J.W. (1983) Livestock production in central Mali: Reproductive components in traditionally managed sheep and goats. *Livestock Production* Science,19: 523-529.

Yakubu, A., Salako, A. E., Imumorin, I. G., Ige, A. O. and Akinyemi, M. O. (2010). Discriminant analysis of morphometric differentiation in the West African Dwarf and Red Sokoto goats. *South African Journal of Animal*

Science, 40 (4): 381-387.

Yusuf, A.O., Adeyi, T. K., Sowande, O.S., Oni, O.A. and Olowokere, V.O. (2022). Nano zinc oxide supplementation improves growth performance and health of West African Dwarf goats. *Egyptian Journal Animal of Production*, 59(2): 69-78.