

## Comparative evaluation of lactation performance of West African dwarf and red sokoto goats raised in a hot-humid environment

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### Abstract

*The milk yield and compositions of twelve lactating does comprising six each of West African Dwarf (Fouta djallon) and Red Sokoto (Maradi) were compared in a 21-week study. The does in their second parity were monitored over a full lactation. The goats received daily basal grass and browse fodder in addition to a concentrate supplement in a 2 × 3 factorial experiment. The does were hand milked and milk yield (g/d) was quantified daily. Milk samples were analyzed weekly for total solids (TS %), butter fat (BF %), solids-not-fat (SNF %), crude protein (CP %) and total ash (TA %). Lactose concentration (LC %) was analyzed daily immediately after sampling. Macro-minerals in milk samples were determined by dry ash extraction method specific for each mineral element. Milk yield was influenced significantly ( $p < 0.05$ ) by both breed and stage of lactation. The WAD produced more milk (97.34 g/d than RS (87.01 g/d). For both breeds, the average mid lactation milk yield (119.04 g/d) was significantly ( $p < 0.05$ ) different than either early (88.35 g/d) or late (69.14 g/d). The highest milk production was by WAD does in mid lactation (125.10 g/d) and the least was by RS in late lactation (47.07 g/d). The TS, BF, SNF, CP and LC concentrations in milk were not influenced ( $P > 0.05$ ) by breed. The TA was significantly ( $P < 0.05$ ) higher in WAD milk (0.89 %) relative to RS milk (0.88 %). Also, stage of lactation significantly ( $P < 0.05$ ) influenced the concentrations of TS, BF, TA and LC in WAD and RS goats milk. Total solids was significantly ( $P < 0.05$ ) higher in late (13.47 %) than in early (12.53 %) lactation for both breeds. The BF and LC in milk followed similar trend, recording 4.45, 3.89 and 4.13 and 3.98 % in late and early stages of lactation respectively. On the other hand, The TA decreased with advancing lactation and the highest value was obtained in the early (0.92 %) than in mid (0.89 %) and late (0.86 %) lactation in both WAD and RS goat milk. TA was highest in WAD milk in early lactation (0.92 %) and least in RS milk in late lactation (0.85 %). All macro minerals were influenced ( $p < 0.05$ ) by lactation stage and breed differences, except potassium (K) and sodium (Na) which were only influenced by the stage of lactation. The milk of both WAD and RS goats yielded more calcium (Ca) than K, which was attributed to the nutrients in the diets.*

**Keywords:** West African Dwarf goats, Red Sokoto goats, milk yield, milk composition, milk macro-mineral concentration.

### Introduction

The nutritional role of milk and milk products in human diet is well documented (Ibeawuchi and Daylop, 1995; Slačanac *et al.*, 2011). This has become pertinent owing to the deficiencies of protein and mineral nutrients especially in sub-Saharan Africa

where the inhabitants consume foods that consist more of starch and oil. If sufficiently available, milk and milk products from goat could be efficiently used to promote good health in humans (Okunlola *et al.*, 2015). There is growing awareness of the importance of goats as a source of milk for

man (Malau-Aduli *et al.*, 2001). The contribution of goat milk to the nutritional and economic well-being of humanity is immense. The high nutrient composition in the milk of goat such as its high crude protein contents (Ahamefule *et al.*, 2012; Okunlola *et al.* 2015) made it crucial in improving the nutrition and health of an average Nigerian whose animal protein consumption has fallen below acceptable levels (Akinmutimi, 2007). Globally, goats produce only about 2 % of the world's total annual milk supply (Park, 2005). However, the estimated population of goats in Nigeria is about 57,600,000 (FAOSTAT, 2012). Red Sokoto (RS), West African Dwarf (WAD) and Sahel goats are the major goat breeds in Nigeria. The most common breed in Northern Nigeria is the RS while the WAD is widely distributed in Southern Nigeria. Due to breed, age, parity, plane of nutrition, season, lactation stage and environmental differences, milk yield and composition may differ among different ruminant species (Malau-Aduliet *al.*, 2001; Ogunbosoye and Babayemi, 2010). Records of the dairy potential of these small ruminant breeds in their natural environment are available (Akpa, 2003; Ahamefuleet *al.*, 2007). The performance of Nigerian breeds of goats outside their natural environment is scantily available in literature (Mbaet *al.*, 1975; Akinsoyinet *al.*, 1981; Ahamefuleet *al.*, 2012). Milk yield and composition are important attributes that determine the nutritive value and consumer acceptability of milk. This study was therefore designed to compare the milk yield, compositions and mineral constituents of lactating RS goats at different stages of lactation outside its natural environment, in relation to the WAD goats raised in its natural

environment (hot humid environment) in South East Nigeria.

## **Materials and methods**

### ***Experimental site***

The study was conducted in the Sheep and Goat Unit of the University Teaching and Research Farm of the Michael Okpara University of Agriculture, Umudike, Abia state. Umudike is located on latitude 05° 29' N, longitude 07° 29' E and at an altitude of 122 meters above sea level. It lies within the humid rainforest zone of West Africa which is characterized by long duration of rainfall (April – October) and short dry season (November –March). The average rainfall of the area is 2,169.80 mm in 148 –155 rain days. The ambient temperature is 26 °C with a range of 22 °C and 30 °C. Its relative humidity ranges from 50 to 90 %.

### ***Experimental animals and management***

A total of 12 lactating does consisting of 6 Red Sokoto (RS) and 6 West African dwarf (WAD) in their second parity were used. The goats were housed under intensive system of management. They were fed basal sward of browse plants and grasses *ad libitum* with supplemental concentrate. The browse/grass sward consisted mainly of *Panicum maximum*, *Andropogontectorum*, *Andropogon gayanus*, *Calopogonium mucunoides*, *Asphiliaafricana*, *Maniphytonfluvum*, *Gmelinaarborea* and *Centrosemamolle*. Each goat received 2 kg of concentrate supplement in the morning, based on 3 % body weight before milking. The concentrate ration was compounded as a straight diet fortified with by-products of energy and protein concentrate. The nutrient composition of the concentrate diet is as indicated in Table 1.

Table 1: Ingredients composition (%) of the concentrate diet

Ingredients	
Palm kernel cake	15.00
Maize offal	56.00
Wheat offal	26.00
Bone meal	2.00
Salt	1.00
Total	100.00

The goats were conditioned for experiment by vaccination against *Pests des Petite Ruminant* (PPR), dewormed and treated against ectoparasites. Water was supplied *ad libitum*. The experiment lasted for 21 weeks. The kids were allowed to stay with their dams and suckle up to 6 0'clock (1800 h) in the evening of the day preceding milking. Thereafter, the kids were withdrawn and put in separate pens where they were fed reconstituted cow milk via feeding bottle and creep feed. The kids were returned to their dams the next day immediately after milking.

#### **Milk sampling and analyses**

Data were collected on milk yield and composition for the two goat breeds within and between lactation phases. The animals were hand milked once every week for 21 weeks except for the first three days of colostrum collection. Milk measurement was carried out according to the procedure described by Ahamefule *et al.* (2012). During milking, the two halves of the udder of lactating does were hand milked daily from 06:00 to 08:00 h. The udder and teat of each doe was washed with lukewarm water and cleaned with cotton wool soaked with disinfectant. The does were milked by gently palpating the udder until milk letdown. Milking continues until the udder was dried. The yields of each milk sample harvested from the does were measured using a graduated glass cylinder and its weight (g/d) determined by using a sensitive laboratory scale. The total amount of milk yield per day was recorded as the morning daily yield of the doe. The daily

milk yield was then estimated for each doe on the assumption that actual daily production of does can be met if the animals were milked twice a day. Thereafter, based on the concept of fixed milk yield responses to changing milking frequency (Erdman and Verner, 1995), the constant 0.6596 was used as a weighting factor on the morning milk yield. Each day's milk yield (S) was estimated as follows:

$$S = M + 0.6596 M$$

Where M: is the morning milk yield (Once-a-day milking).

The experimental design was a 2×3 factorial experiment in a completely Randomized Design (CRD). The factors were the two goat breeds (WAD and RS) and the three lactation stages (early, mid and late).

The proximate composition of the forage sward and concentrate diet was determined according to the method of AOAC (1990). The milk samples collected from each replicate were subjected to laboratory analysis immediately after collection for the composition of lactose by the Marrier and Boulet (1959) procedure. Milk samples were refrigerated (-5 °C) and bulked weekly for the determination of other milk constituents. Total solid was determined by drying about 5 g of milk samples to a constant weight at about 105 °C for 24 hours (AOAC, 1990). Butter fat was determined by the Roesse Gottlieb cold extraction method (AOAC, 1990; Pearson 1976). Solids-not-fat was calculated as the difference between the Total solids (TS) and butter fat (BF) content. Milk protein (N×6.38) was determined by the semi-micro distillation method using Kjeldahl and Markham's apparatus. Total ash was determined by evaporating 10 g of milk sample to dryness and ashed in a muffle furnace at 600 °C for 3 hours (AOAC, 1990). The milk samples were also analyzed for their macro minerals contents.

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The mineral contents were determined by the dry ash extraction method, following which specific mineral element was determined. Phosphorus was determined by the vanadomolybdate (yellow) spectrophotometry method (AOAC, 1980). Calcium and magnesium were determined by the Versanale EDTA compleximetric titration method (Pearson, 1976). Potassium and sodium were determined by flame photometry (AOAC, 1990).

### Statistical analysis

Data collected were analyzed according to the statistical analysis system package (SAS, 1999). Significant means were separated using Duncan Multiple Range Test of the same package.

### Results and discussions

The proximate composition of the concentrate diet and grass/browse sward fed to the goats is shown in Table 2.

**Table 2: Proximate composition (%) of the concentrate diet and forage sward**

Parameters	Concentrate	Forage Sward
Dry matter	90.10	50.02
Crude protein	14.12	8.62
Crude fibre	8.60	5.50
Ether extract	5.16	2.16
Ash	6.14	2.56
Nitrogen free extract	59.18	28.08

The crude protein (14.12 %) of the concentrate diet met the 14 – 18 % range recommended for in-does and lactating goats in early lactation (NRC, 1981). This shows that the dietary protein requirements of the experimental animals were adequately satisfied. The forage sward also had crude protein content which

nevertheless satisfied the minimum CP (7 %) required for rumen motility and function.

### Milk yield and composition

The mean milk yield (MY) and composition of the small ruminant species as influenced by breed and lactation stage are presented in Table 3.

**Table 3: Effect of breeds of goat (B), lactation stage (L) and their interactions (L× B) on milk yield and composition of West African dwarf (WAD) and Red Sokoto (RS) goats**

Breeds	Milk Yield (g/d)				Total Solids (%)				Butter Fat (%)			
	Early	Mid	Late	Mean	Early	Mid	Late	Mean	Early	Mid	Late	Mean
WAD	75.71 <sup>a</sup>	125.10 <sup>b</sup>	91.21 <sup>b</sup>	97.34 <sup>b</sup>	12.46	12.75	13.75	12.99	3.82	4.13	4.67	4.21
RS	100.98 <sup>b</sup>	112.98 <sup>a</sup>	47.07 <sup>a</sup>	87.01 <sup>a</sup>	12.59	12.80	13.19	12.86	3.96	4.18	4.22	4.12
Mean	88.35 <sup>b</sup>	119.04 <sup>c</sup>	69.14 <sup>a</sup>		12.53 <sup>a</sup>	12.78 <sup>a</sup>	13.47 <sup>b</sup>		3.89 <sup>a</sup>	4.16 <sup>ab</sup>	4.45 <sup>b</sup>	
SEM												
L	7.364 <sup>*</sup>				0.274 <sup>*</sup>				0.667 <sup>*</sup>			
B	7.008 <sup>*</sup>				0.153 <sup>ns</sup>				0.028 <sup>ns</sup>			
L×B	5.212 <sup>*</sup>				0.651 <sup>ns</sup>				0.120 <sup>ns</sup>			

**Table 3: continued**

Breeds	Solid-Not-Fat (%)				Crude protein (%)				Total Ash (%)			
	Early	Mid	Late	Mean	Early	Mid	Late	Mean	Early	Mid	Late	Mean
WAD	8.64	8.62	9.08	8.78	3.73	3.86	4.08	3.89	0.92 <sup>ab</sup>	0.89 <sup>ab</sup>	0.87 <sup>b</sup>	0.89 <sup>b</sup>
RS	8.63	8.62	8.97	8.74	3.75	3.85	4.00	3.89	0.91 <sup>a</sup>	0.88 <sup>a</sup>	0.85 <sup>a</sup>	0.88 <sup>a</sup>
Mean	8.64	8.62	9.03		3.74	3.86	4.04		0.92 <sup>c</sup>	0.89 <sup>b</sup>	0.86 <sup>a</sup>	
SEM												
L	0.138 <sup>ns</sup>				0.039 <sup>ns</sup>				0.005 <sup>*</sup>			
B	0.133 <sup>ns</sup>				0.629 <sup>ns</sup>				0.007 <sup>*</sup>			
L×B	0.071 <sup>ns</sup>				0.815 <sup>ns</sup>				0.004 <sup>*</sup>			

Table 3: continued

Breeds	Lactose (%)			Mean
	Early	Mid	Late	
WAD	3.99	3.87	4.13	4.00
RS	3.97	3.89	4.12	3.99
Mean	3.98 <sup>b</sup>	3.88 <sup>a</sup>	4.13 <sup>c</sup>	
SEM				
L	0.031 <sup>*</sup>			
B	0.024 <sup>ns</sup>			
L×B	0.019 <sup>ns</sup>			

<sup>a,b,c</sup> means on the same column and row with different superscripts are significantly different ( $p < 0.05$ ).

<sup>ns</sup> = not significant; <sup>\*</sup> = significant at 5 %.

The WAD goat produced significantly ( $P < 0.05$ ) more milk per day (97.34 g/d) than the RS (87.01 g/d). This contradicts the result of Ahamefule *et al.* (2012) who reported higher milk yield for RS (132.5 g/d) than the WAD (92.5 g/d) goat during dry season in the same environment. This disparity may be due to nutrition and season of study. The RS goats thrive well in arid environment; therefore studies carried out in the dry season in south-east Nigeria tend to simulate the climatic conditions of their natural habitat, hence the relatively higher lactation yield recorded for this animal. Also, acclimatizing to the greener less drier forages of Southern Nigeria may have negatively influenced lactation yield. Meanwhile, higher daily milk yields of 467, 468 and 664 g/d have been reported by Akpa *et al.* (2003), Akinsoyinu *et al.* (1981) and Akpa (1999) respectively for RS goats elsewhere. Ahamefule and Ibeawuchi (2005) also reported a milk yield of 253 g/d for WAD goats in a similar hot-humid environment.

Milk yield (g/d) was influenced by stage of lactation in both breeds. Milk yield increased significantly ( $P < 0.05$ ) from early (88.35) to mid (119.04) before declining rapidly in late (69.14) lactation stage. This observation corroborates the findings of Mba *et al.* (1975) and Ahamefule *et al.* (2012) who reported higher milk yield in mid than in early or late lactation in both WAD and RS goats.

The interaction between breed and lactation

stage was also significant ( $P < 0.05$ ) in milk yield. The WAD does recorded a significantly ( $P < 0.05$ ) higher milk yield (125.10 g/d) than RS (112.98 g/d) in mid lactation. The least milk yield was recorded in RS in late lactation (47.07 g/d) which was significantly lower ( $P < 0.05$ ) to the value of 91.21g/d obtained for WAD does in the same lactation stage. Similarly, in early stage of lactation, milk yield tended to be higher for WAD goats relative to the RS goats. This observation is contrary to the observation of most researchers (Mba *et al.*, 1975; Akinsoyinu *et al.*, 1981; Ahamefule *et al.*, 2012) who reported higher milk yield in RS goats than WAD goats in all of the lactation stages. The environment of the study as well as plane of nutrition may have been responsible for the low lactation performance of the RS goat in the hot humid environment. Animals are known to perform best in their natural environment.

Total solids (TS) concentration in milk was not influenced ( $P > 0.05$ ) by breed. The range of TS values observed for WAD (12.46 – 13.75 %) and for RS (12.59 – 13.19) were consistent with the findings of Ahamefule *et al.* (2004) and Akpa (1999) for both breeds. However, lactation stage significantly ( $P < 0.05$ ) influenced TS production in milk of both species with the early (12.53 %) and mid (12.78 %) lactation values similar and lower than the late lactation value (13.47 %). Zahraddeen *et al.* (2007) also reported increased TS in milk with advancing lactation in both WAD and



RS goats. However, this observation is at variance with the findings of Ahamefule *et al.* (2004) who reported higher TS in milk in mid lactation in WAD goat, relative to early and late stages of lactation. Also the TS values recorded for the three lactation stages are higher than the value (11.53 %) reported by Zahraddeen *et al.* (2007), but lower than the values (16.58 %, 15.70 %) reported by Midau *et al.* (2010) and Akinsoyinu *et al.* (1981) for RS goat milk. The present values also compare favourably with the results of Ahamefule *et al.* (2012) for WAD and RS goats managed intensively.

Percentage butter fat (BF) also followed similar pattern with TS. This milk constituent was not influenced by breed even though values tended to be more appreciated for WAD (4.21 %) than RS (4.12 %). The range of values reported for BF in this study are comparable with the results of Midau (2010) and Ahamefule *et al.* (2012), but lower than values reported by Ahamefule *et al.* (2004), Akpaet *et al.* (2004) and Zahraddeen *et al.* (2007) for similar breeds. Various factors influence the composition of milk depending on the prevailing circumstances. Animals of same breed may record differentials in milk composition. For both breeds however, BF in milk was significantly higher ( $p < 0.05$ ) in late (4.45 %) than in early (3.89 %) lactation stage. Nevertheless, BF concentration in mid lactation (4.16 %) did not differ significantly ( $P > 0.05$ ) from values recorded for either early or late lactation stage. Mba *et al.* (1975) reported similar findings for WAD, RS and Saneen goats. Okunlola *et al.* (2015) also reported a steady increase (3.0, 4.05, 4.60 and 5.78%) in BF of RS goats fed 0, 10, 20 and 30% baobab fruit in the diet. Ahamefule *et al.* (2004) observed a decline in BF in late lactation (5.16, 5.25 and 4.91 %) in WAD goats. Zahraddeen *et al.* (2007) however recorded a steady decline in the BF

of WAD and RS goats with advancing lactation. Even though not significant ( $P > 0.05$ ), RS recorded higher BF in early and mid-stages of lactation while WAD had higher BF in the late lactation stage. Ahamefule *et al.* (2012) recorded similar findings which were significantly different for both breeds in early and mid-stages of lactation.

Solids-not-fat (SNF) concentration in milk was neither influenced by breed nor lactation stage. The mean values (8.78, 8.74 %) obtained for WAD and RS goats respectively for the different stages of lactation were fairly comparable. This corroborates the findings of Ahamefule *et al.* (2004; 2012), but differed with the observations of Ogunbosoye and Babayemi (2010) who recorded a steady decline in SNF (12.39 – 11.78 %) in WAD goats fed forage based diets. The values reported in this study are lower than the values (11.79, 13.42 %) reported by Midau *et al.* (2010) for RS goats in the wet and dry season respectively.

The percentage crude protein (CP) was not affected by breed or lactation stage. The mean value of 3.89 % reported for both WAD and RS goats milk is comparable to values recorded by Mba *et al.* (1975) for both breeds and Ogunbosoye and Babayemi (2010) for WAD (3.10 – 3.92 %) goats. The CP increased with advancing lactation in both breeds. Zahraddeen *et al.* (2007) on the other hand reported a steady decline in the CP concentration in the milk of RS, WAD and Sahel goats with advancing lactation.

Total ash content in milk was influenced by both breed and lactation stage. Generally, ash level was significantly higher ( $P < 0.05$ ) in WAD milk (0.89 %) than in RS milk (0.88 %). The observed TA range values (0.85 - 0.92 %) were within range of values reported for RS (Ahamefule *et al.*, 2012; Okunlola *et al.*, 2015) and WAD goats

(Ahamefule *et al.*, 2004; Ogunbosoye and Babayemi, 2010). Ash levels are indicators of mineral composition of milk. Zahraddeen *et al.* (2007) and Ahamefule *et al.* (2012) reported higher TA values in milk of RS goats relative to WAD which disagrees with the findings of this study. Variations in milk constituents may arise even within breed due to nutrition, climate, management and milking frequency. Milk ash within both breeds differed significantly ( $P<0.05$ ) among lactation stages. Milk ash was highest in early lactation (0.92 %) than mid (0.89 %) and late (0.86 %) lactation stages. It is however in variance with the reports of Ahamefule *et al.* (2000) where the TA values increased from early (1.02 %) to mid (1.13 %) before declining at the late (0.78 %) lactation stage for WAD goats. The interaction between breed and lactation stages was also significant ( $P<0.05$ ). The highest milk ash (0.92 %) was produced by WAD goat in early lactation. This value which is statistically similar ( $P>0.05$ ) to the

milk ash of RS in early lactation, differed significantly ( $P<0.5$ ) from milk ash of RS in mid (0.89 %) and late lactation (0.86 %) stages.

The lactose content for both WAD and RS goats milk generally declined significantly ( $P<0.05$ ) from early (3.98 %) to mid (3.88 %) before rising again at the late (4.13 %) lactation stage. This result contrasts with the findings of Ahamefule *et al.* (2000), Zahraddeen *et al.* (2007) and Ogunbosoye and Babayemi (2010) who obtained a steady decline of lactose from early through mid to late lactation stages for both breeds of goat. It also disagrees with Ahamefule *et al.* (2012) who reported a fairly constant lactose contents (4.46, 4.42, 4.60 %) in the milk of WAD and RS goats in early, mid and late lactation stages.

#### Macro mineral constituents

The macro mineral constituents in the milk of WAD and RS goats at the different lactation stages are presented in Table 4.

**Table 4 : Effect of lactation (L), breeds of goat (B) and interaction (L x B) on the macro mineral constituents of milk**

Breeds	% Phosphorus (P)				% Calcium (Ca)				% Magnesium (Mg)			
	Early	Mid	Late	Mean	Early	Mid	Late	Mean	Early	Mid	Late	Mean
WAD	0.12 <sup>a</sup>	0.26 <sup>b</sup>	0.21 <sup>a</sup>	0.20 <sup>a</sup>	0.14 <sup>a</sup>	0.26 <sup>b</sup>	0.23 <sup>b</sup>	0.21 <sup>b</sup>	0.11 <sup>a</sup>	0.17 <sup>b</sup>	0.14 <sup>a</sup>	0.14 <sup>a</sup>
RS	0.19 <sup>b</sup>	0.12 <sup>a</sup>	0.23 <sup>b</sup>	0.18 <sup>b</sup>	0.20 <sup>b</sup>	0.16 <sup>a</sup>	0.22 <sup>a</sup>	0.19 <sup>a</sup>	0.16 <sup>b</sup>	0.10 <sup>a</sup>	0.20 <sup>b</sup>	0.15 <sup>b</sup>
Mean	0.16 <sup>a</sup>	0.19 <sup>b</sup>	0.22 <sup>c</sup>		0.17 <sup>a</sup>	0.21 <sup>b</sup>	0.23 <sup>c</sup>		0.14 <sup>a</sup>	0.14 <sup>a</sup>	0.17 <sup>b</sup>	
SEM:												
L	0.011 <sup>*</sup>				0.009 <sup>*</sup>				0.006 <sup>*</sup>			
B	0.007 <sup>*</sup>				0.006 <sup>*</sup>				0.005 <sup>*</sup>			
LxB	0.009 <sup>*</sup>				0.007 <sup>*</sup>				0.006 <sup>*</sup>			

**Table 4: continued**

Breeds	% Potassium (K)				% Sodium (Na)			
	Early	Mid	Late	Mean	Early	Mid	Late	Mean
WAD	0.08 <sup>a</sup>	0.21 <sup>b</sup>	0.17 <sup>a</sup>	0.15	0.08 <sup>a</sup>	0.22 <sup>b</sup>	0.17 <sup>a</sup>	0.16
RS	0.14 <sup>b</sup>	0.08 <sup>a</sup>	0.21 <sup>b</sup>	0.14	0.16 <sup>b</sup>	0.09 <sup>a</sup>	0.21 <sup>b</sup>	0.15
Mean	0.11 <sup>a</sup>	0.15 <sup>b</sup>	0.19 <sup>c</sup>		0.12 <sup>a</sup>	0.16 <sup>b</sup>	0.19 <sup>c</sup>	
SEM								
L	0.010 <sup>*</sup>				0.009 <sup>*</sup>			
B	0.057 <sup>ns</sup>				0.006 <sup>ns</sup>			
LxB	0.031 <sup>*</sup>				0.009 <sup>*</sup>			

<sup>a,b,c</sup> means on the same column and row with different superscripts are significantly different ( $p<0.05$ ).

<sup>ns</sup> = not significant; <sup>\*</sup> = significant at 5 %.

Phosphorus (P) concentration (0.12 – 0.23 %) in milk was influenced ( $P<0.05$ ) by breed and lactation stage. The percentage phosphorus content was significantly higher ( $P<0.05$ ) in the milk of WAD (0.20 %) than RS (0.18 %). These were higher than the values for WAD (0.14 %) and RS (0.13) reported by Ahamefule *et al.* (2012), but within the range reported by Midau *et al.* (2010) and Okunlola *et al.* (2015). Also, the percentage phosphorus was significantly higher ( $P<0.05$ ) in late (0.22 %) compared to values obtained in mid (0.19 %) and early (0.16 %) lactation stage for both breeds. Similar P concentrations with advancing lactation stage were reported by Ahamefule *et al.* (2012). The interaction between breed and lactation stage was also significant ( $P<0.05$ ). The highest concentration of P was obtained in WAD milk in mid lactation (0.26 %); this was followed by P contents in RS goat milk in late lactation (0.23 %). The least value (0.12 %) was recorded in WAD and RS goat milk in early and mid-lactation stages respectively.

Percentage calcium (Ca) in milk (0.14 – 0.26 %) was significantly different ( $P<0.05$ ). Okunlola *et al.* (2015) also recorded similar range for RS goats fed varying levels of Baobab fruit meal. Percentage Ca values for WAD milk (0.21 %) was significantly higher ( $P<0.05$ ) than that recorded for RS milk (0.19 %). On the contrary, Ahamefule *et al.* (2012) reported higher calcium Ca in milk of RS (0.15 %) than WAD (0.12 %) goats. Alawa and Oji (2008) and Midau *et al.* (2010) reported higher calcium concentration of 0.20 and 0.29 % respectively in RS goat milk. Milk calcium also increased significantly from early (0.17 %) through mid (0.21 %) to late lactation (0.23 %) for both small ruminant species. This result disagrees with Ahamefule *et al.* (2012) who reported a decrease from early to mid and an increase

in late lactation. The interaction between breed and stage of lactation was also significant ( $P<0.05$ ) with the highest Ca contents in the milk of WAD at mid lactation (0.26 %). The lowest Ca value of 0.14 % was recorded for WAD milk at early lactation stage.

Magnesium (Mg) contents (0.10 – 0.20 %) in milk was affected significantly ( $P<0.05$ ) by breed and stage of lactation. Midau *et al.* (2010), Ahamefule *et al.* (2012) and Okunlola *et al.* (2015) reported similar range for Mg. Mg concentration in milk was higher for RS milk (0.15 %) than WAD milk (0.14 %), corroborating the result of Ahamefule *et al.* (2012). Alawa and Oji (2008) recorded 0.13 % magnesium in the milk of RS which is slightly lower than the value obtained for same breed in this study. The Mg contents in early and late lactation milk which were similar for WAD and RS goats (0.14 %) was however significantly lower ( $P<0.05$ ) than the value (0.17 %) obtained in late lactation for both breeds. The interaction between breed and lactation stage ( $P<0.05$ ) shows that Mg concentration was highest in RS goat milk obtained in late lactation (0.20 %). The WAD goat recorded higher Mg concentration (0.17 %) in milk at the mid lactation stage, which nevertheless did not differ ( $P>0.05$ ) from the value (0.16 %) in early lactation for RS goat. The least value was obtained in RS milk in mid lactation (0.10 %). This was also similar to the value obtained for WAD milk in early lactation (0.11 %).

Potassium (K) level in milk was not influenced by breed. However, the stage of lactation affected the concentration of this mineral in the milk of both goat breeds. K in milk increased significantly ( $P<0.05$ ) from early (0.11 %), through mid (0.15 %) to late (0.19 %) lactation stage. This observation nevertheless disagrees with the findings of Ahamefule *et al.* (2012) who recorded



decreased K in the mid lactation stage relative to early, before subsequently rising in late lactation. The present mean values of 0.15 and 0.14 % in the milk of WAD and RS goats respectively are higher than what was reported (0.09, 0.11 %) by Ahamefule *et al.* (2012) for RS and WAD goats respectively, but lower than the values reported by Okunlola *et al.* (2015) for RS goats fed 10 (0.20 %K), 20 (0.30 %K) and 30 % (0.33 %K) baobab fruit meal. The interaction between breed and lactation stages show that K contents were significantly higher (0.21 %) in late lactation stage of RS and in mid lactation of WAD goats, corroborating the report of Ahamefule *et al.* (2012).

The percentage sodium (Na) concentration in the milk of WAD and RS goats raised in a humid environment also followed a similar pattern with K. Na contents in milk (%) was not influenced ( $P>0.05$ ) by breed, but values in milk of WAD and RS goats were affected significantly ( $P<0.05$ ) by stage of lactation. The range of Na concentration in this study (0.08 – 0.22 %) are similar to values reported by Ahamefule *et al.* (2012) and Okunlola *et al.* (2015) for both breeds. However, mean values reported in the present study for the milk of WAD (0.16 %) and RS (0.15 %) are higher than those reported (0.11, 0.09 %) for RS and WAD by Ahamefule *et al.* (2012). The Na concentration in the milk of WAD and RS goats increased significantly ( $P<0.05$ ) with advancing lactation, recording values of 0.12, 0.16 and 0.19 for early, mid and late lactation stages respectively. Ahamefule *et al.* (2012) also recorded highest Na concentration in late lactation in both RS and WAD goats. The interaction between breed and lactation stage shows that the highest significant ( $P<0.05$ ) concentration of Na in milk was recorded in WAD milk in mid lactation, which was similar to the value obtained in RS milk in late lactation

(0.21 %). The least value of 0.08 % in the milk of WAD in early lactation was similar to the 0.09 % Na obtained in the milk of RS in mid lactation.

Ahamefule *et al.* (2012) reported that the mineral composition of goat milk is between 0.7 – 0.8 %. Among the milk macro minerals, calcium and phosphorus are of paramount attention because of their importance in bone formation and tissue metabolism. Generous levels of calcium in milk of lactating ruminants will generally forestall any incidence of milk fever. In this study, K accounts for the greatest percentage in milk, followed by Ca, P, Na and Mg in that order. Ca concentration in milk in this study was higher than K. This finding which is not consistent with existing reports could be linked to deficiency of the mineral in the forages fed. Tropical pastures are prone to seasonal variations in mineral and nutritional composition. Minerals in milk are sourced from ingested minerals in feed. Therefore, mineral levels in feed would determine to a very large extent the quantity of any mineral deposited in milk. Factors influencing intra species variations in mineral compositions in milk may derive from environmental conditions, physiological status of the animal and the level of management. Inter species variations would be influenced by breed or genetic makeup of the animals.

### Conclusion

The study showed that the West African dwarf goats produced more milk than the Red Sokoto goats which was attributed to the influence of environment. The milk constituents tended to be generally and marginally higher in the milk of West African dwarf than Red Sokoto goat. The West African dwarf goat milk was richer in macro mineral contents compared to the milk of Red Sokoto. The Ca contents of the

milk of both West African dwarf and RS were however higher than its composition of K, due likely to increased level of Ca in the diet.

## References

- Ahamefule, F. O., Ibeawuchi, J. A. and Okonkwo, C. I. 2004.** Comparative evaluation of the colostrum and milk of the West African Dwarf sheep in a humid tropical environment. *Nigerian Agric. J.* **35**: 118 - 126.
- Ahamefule, F. O., Ibeawuchi, J. A. and Nwachinemere, G. C. 2007.** Comparative evaluation of milk yield and compositions of West African Dwarf goats raised in the village and university environment. *J. Anim. Vet. Adv.* **6(6)**: 802 - 806.
- Ahamefule, F. O. and Ibeawuchi, J. A. 2005.** Milk yield and composition of West African Dwarf (WAD) does fed pigeon pea-cassava peel based diets. *J. Anim. Vet. Adv.* **4(12)**: 991 - 999.
- Ahamefule, F. O., Odilinye, O. and Nwachukwu, E. N. 2012.** Milk Yield and Composition of Red Sokoto and West African Dwarf Does Raised Intensively in a Hot Humid Environment. *Iranian Journal of Applied Animal Science.* **2(2)**: 143 - 149.
- Akinmutimi, A. H. 2007.** Effect of cooking periods on the nutrient composition of velvet beans (*Mucunapruriens*). Proc. 32<sup>nd</sup> Annual Conference of Nig. Society for Anim. Production. University of Calabar, Calabar, Cross River State, Nigeria. March 18 - 21. Pp. 23 - 32.
- Akinsoyinu, A. O., Tewe, O. O., Ngere, L. O. and Mba, A. U. 1981.** Milk composition and yield of Red Sokoto (Maradi) goats. *Trop. Anim. Prod.* **6**: 186 - 187.
- Akpa, G. N. 1999.** Evaluation of dairy characteristics and lactation curves of small holder Red Sokoto (Maradi) goats. Ph. D. Thesis. Ahmadu Bello University, Zaria, Nigeria.
- Akpa, G. N., Edino, O. and Yashim, S. 2004.** Influence of milking frequency on lactation characteristics of Red Sokoto goats. *Animal Research International.* **1(3)**: 140 - 143.
- Akpa, G. N., Osuhor, C. U., Olugbemi, T. S. and Nwani, P. I. 2003.** Milk flow rate and milking frequency in Red Sokoto goats. *Pakistan J. Nutr.* **2(3)**: 192 - 195.
- Alawa, J. P. and Oji, U. I. 2008.** Effect of pendulous udder enlargement on yield of Red Sokoto goats. *J. Anim. Vet. Adv.* **7**: 870 - 87.
- AOAC. 1980.** Official methods of Analysis, 13<sup>th</sup> edition. Association of Official Analytical Chemists, Washington, D.C. 19: 132 - 136.
- AOAC. 1990.** Official Methods of Analysis. Vol. I. 15<sup>th</sup> Ed., Association of Official Analytical Chemists, Arlington, Virginia.
- Erdman, R. A. and Verna, R. A. 1995.** Fixed yield responses to increasing milking frequency. *J. Dairy Sci.* **78**: 1198 - 1203.
- Food and Agriculture Organization of the United Nations (FAO) Statistics. 2010.** <http://faostat.fao.org/site/291/default.aspx>. Retrieved on 21/1/15.
- Ibeawuchi, J. A. and Dalyop, D. M. 1995.** Composition and quality of fresh cow milk offered for sale in parts of Plateau State of Nigeria. *Nig. J. Anim. Prod.* **22(1)**: 81 - 84.
- Malau-Aduli, B. S., Eduvie, I. O., Lakpini, C. A. M. and Malau-Aduli, A. E. O. 2001.** Effects of supplementation on the milk yield of Red Sokoto does. Proceedings of the

- 26th Annual Conference of Nigerian Society for Animal Production. March 2001, ABU, Zaria, Nigeria. Pp. 353 – 355.
- Marrier, J. and Boulet, M. 1959.** Direct analysis of lactose in milk and serum. *J. Dairy Sci.* **42**: 1390 - 1391.
- Mba, A. U., Boyo, S. S. and Oyenuga, V. A. 1975.** Studies on the milk composition of West African Dwarf, Red Sokoto and Saanen goats at different stages of lactation. *J. Dairy Res.* **42**: 217 - 226.
- Midau, A., Kibon, A., Morumpa, S. M. and Augustine, C. 2010.** Influence of season on milk yield and milk composition of Red Sokoto goats in Mubi area of Adamawa state, Nigeria. *J. Dairy Sci.* **5**: 135 - 141.
- National Research Council (NRC). 1981.** Nutrient Requirement of Domestic Animals, Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries. National Academy Press, Washington, DC.
- Ogunbosoye, D. O. and Babayemi, O. J. 2010.** The effect of forage based diets on milk composition, lactation stages and growth rate of kids from West African Dwarf (WAD) goats in South West Nigeria. Conference on International Research on Food Security, National Resources Management and Rural Development. ETH Zurich. September 14 – 16, 2010. Pp. 1 – 9.
- Okunlola, D. O., Olorunnisomo, O. A., Amuda, A. J., Nuga, H. A. Akinloye, A. M. and Balogun, N. O. 2015.** Milk Yield and Composition of Red Sokoto Goats Fed Varying Levels of Baobab (*Adansoniadigitata*) Fruit Meal Supplement in the Diet. *Journal of Biology, Agriculture and Healthcare*. **5**: 17: 121 – 126.
- Park, Y. W. 2005.** Goat Milk: Composition, Characteristics. In: *Encyclopedia of Animal Science*. Pond, W.G. and N. Bell (Eds.). Marcel Dekker Inc., New York. Pp. 474 - 477.
- Pearson, D. A. 1976.** Chemical Analysis of Foods. 7<sup>th</sup> Ed. Churchill Livingstone. Edinburgh, London and New York. Pp. 114 – 117.
- SAS. 1999.** Statistical Analysis System, SAS/STAT User's guide, SAS Institute Inc. Cary, North Carolina, USA.
- Slačanac, V., Hardi, J., Lučan, M., Komlenić, D. K., Krstanović, V. and Jukić, M. 2011.** Concentration of nutritional important minerals in Croatian goat and cow milk and some dairy products made of these. *Croat. J. Food Sci. Technol.* **3** (1): 21 – 25.
- Zahraddeen, D., Butswat, I. S. R. and Mbap, S. T. 2007.** Evaluation of some factors affecting milk composition of indigenous goats in Nigeria. *Livestock Research for Rural Development*. Volume 19, Article #166. Retrieved July 7, 2016, from <http://www.lrrd.org/lrrd19/11/zahr19166>.

Received: 25<sup>th</sup> August, 2016

Accepted: 12<sup>th</sup> March, 2017