

Milk Yield and Composition of Red Sokoto and West African Dwarf Does Raised Intensively in a Hot Humid Environment

Research Article

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ABSTRACT

Six Red Sokoto (RS) and West African Dwarf (WAD) does, raised intensively in livestock farm of Michael Okpara University were evaluated for milk yield and composition in a ten-week study. The animals in their first parity were fed cut-and-carry forages in a cafeteria arrangement between 07:00-08:00 h daily and also were allowed access to concentrate supplementation by 14:00 h. The forage consisted of a sward of *Panicum maximum*, *Centrosema pubescens*, *Calapogonium mucunoides*, *Emilia sanchifolis*, *Tridax procumbens* and *Urenia lobata* while the supplement was a 14.8% CP concentrate ration formulated from wheat, soya bean meal, maize offals, palm kernel cake. Drinking water was provided *ad libitum*. The does were hand milked daily from 6-8 am prior to feeding and yield determined for each group. Milk samples were bulked per animal per week and analyzed for total solids (TS), butterfat (BF), crude protein (CP), solids-not-fat (SNF) and total ash. Lactose was, however, determined daily from fresh milk samples and data obtained was analyzed using T-test. Results showed that lactose, CP and ash were not influenced ($P>0.05$) by species; however, butterfat, TS, SNF and milk yield differed significantly ($P<0.05$) between the small ruminant breeds. RS had relatively higher BF (4.81%) in milk than WAD goat (4.72%), but TS and SNF concentrations (%) were lower in the milk of RS (12.82, 8.22, respectively) than WAD (13.16, 8.59, respectively) goat. Macrominerals content of milk (calcium, potassium, magnesium, sodium and phosphorus) were also affected ($P<0.05$) by species. Calcium, magnesium and sodium concentrations (%) in milk were significantly higher ($P<0.05$) for RS (0.15, 0.11, 0.11, respectively) than WAD (0.12, 0.09, 0.09, respectively) goat; phosphorus and potassium levels in milk were, however, higher ($P<0.05$) in WAD (0.14, 0.11, respectively) than RS (0.13, 0.09, respectively) goat. Lactation performance for WAD and RS goats in the current investigation were relatively low when compared with existing records. Differences in yield and milk composition within and between species in this study, relative to earlier reports, were attributed to genetic make up, management and environmental factors.

KEY WORDS macrominerals, milk composition, milk yield, Red Sokoto, West African Dwarf.

INTRODUCTION

Goat production plays a very vital role in the livelihood of rural populations in Nigeria as it contributes significantly to improvement of family nutrition and health. Also, sales of animals and their products help to stabilize household income. Goat husbandry, therefore, is considered as a form of

food security and source of independent income for rural households and subsistent farmers.

The demand for chevron and other products including milk have informed the need to raise indigenous goats even outside their natural habitat/environment; this practice helps in performance evaluation of animals in locations outside their domain. The tropical environment, with its character-

istic, i.e., harsh weather conditions, adversely affect meat and dairy performance in animals (El-Hassan *et al.* 2009). Implicates management and poor genetic resource as the main reasons for the abysmal performance of ruminants for either beef or milk production in Nigeria. The nutritional role of milk and milk products in human diet especially in developed countries has been well documented (Ibeawuchi *et al.* 2000). Globally, cattle are the principal milk producers followed by goats and sheep. In most developing countries like Nigeria where animal protein consumption needs to be improved (Akinmutimi, 2004), milk from these ruminant species could be used to augment animal protein intake. In Nigeria, most of the milk and milk products consumed by the populace are imported. Nevertheless, the rural communities especially those in northern Nigeria maintain traditional herds of cattle, sheep and goats which serve as a source of meat, milk, skin and income (Okereke, 2003). The West African Dwarf and the Red Sokoto goats are indigenous goat breeds found in southern and northern Nigeria, respectively. Records of their dairy performance in their natural environment exist (Ahamefule and Ibeawuchi, 2005; Akpa *et al.* 2002). However, their potentials for milk and meat production outside their natural ecology are continuously under survey (Akpa, 1999; Akpa *et al.* 2003; Ahamefule and Ibeawuchi, 2005). It is possible that these small ruminant breeds can do well, or even better, outside their natural habitat baring acclimatization difficulties if well managed. Efforts, therefore, were made in this study to compare the milk yield and composition of the Red Sokoto goat (RS)- a northern breed- and West African Dwarf goat (WAD) which thrives naturally in the south. The result of this study will indeed pioneer activities in the full acclimatization and integration of the Red Sokoto goat in the south, as well as generate relative dairy performance records of the two small ruminant breeds in the rain forest belt of Nigeria.

MATERIALS AND METHODS

Environment of study

This study was conducted between April-June, 2010 at the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike located in Abia state on latitude 05° 29' north, longitude 33° east at altitude of 122 meters or 400 feet above sea level. It falls within the humid rain forest zone of West Africa, which is characterized by long duration of rainfall (April-October) and short period of dry season (November-March). Average rainfall is 2169.8 mm in 148-155 rain days. Average temperature is 26 °C with maximum of 32 °C and minimum of 22 °C. Relative humidity ranges from 50-95%.

Animals and management

A total of twelve lactating does, six within each of WAD and RS, aged between 10-12 months, in their first parity and early lactation stage, were used in this study. These does were randomly drawn from the University flock raised intensively at the Michael Okpara University of Agriculture Teaching and Research farm, Umudike. The animals were fed cut-and-carry forages consisting mainly of *Panicum maximum* and others (*Centrosema pubescens*, *Emilia sanctifolia*, *Tridax procumbens*, *Urena lobata*). They were also fed a supplement concentrate ration of 14.8% CP formulated from wheat, maize offals, soya meal, palm kernel cake, bone meal and common salt, at the rate of 1 kg per doe per day. Drinking water was provided liberally. The concentrate regimen lasted for 11 weeks, being initiated on the last week of pregnancy and terminated after the 10th week of lactation. The contents and proximate compositions of the supplement are given in Table 1.

Kid management

At birth, each kid had its umbilical cord cleansed with disinfectant and cut at a distance of about 2 cm away from the naval flap and a tincture of iodine added to aid healing and prevent entry of pathogens. Kid weights were recorded immediately after parturition using a 5 kg capacity sensitive top loading 'Salter' scale. The dates of kidding, parity and litter sizes and compositions for does were recorded. Thereafter, newborn kids were left to suckle their dams freely for the first 7 days. Prior to each milking day, kids were separated from their dams at 1800 h on the evening preceding the day of milking. Within this period of separation, kids were fed milk with the aid of feeding bottle. Dams were allowed to nurse their kids in the morning after milking and in the afternoon before separation at 1800 h daily.

Milk measurements

During milking, the two halves of the udder of lactating does were hand milked daily from 06:00 to 08:00 h. The quantity of milk harvested from each doe was measured using graduated glass cylinder (500 mL capacity) and weighed back to the nearest gram on 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).

Milk sampling

Lactation length for each doe was based on 135 days. Milk sampling was initiated post colostrums on the 8th day post-partum, and terminated on the 70th day post-partum, for each lactating doe. Sample from daily milk yield for each doe was analyzed daily for lactose content before being bulked and analyzed weekly for total solids, butterfat, crude protein, solids-not-fat, ash and energy. The bulked samples were then stored in a refrigerator (-5 °C) until required for analysis. Average daily milk yield and compositions were also determined for each doe.

Analytical procedure

The milk samples were analyzed for lactose, TS, BF, CP (Nx6.38), SNF and ash. TS was determined by drying about 5 g of milk sample to a constant weight at 105 °C for 24 hours. Lactose content was determined from fresh samples by the [Marrier and Boulet \(1959\)](#) procedure. Butterfat was obtained by the Roese- Gottlieb method ([AOAC, 1980](#)). Milk protein (Nx6.38) was determined by the semi-micro distillation method using Kjeldahl and Markhamps apparatus. SNF was determined as the difference between TS and BF. Proximate composition of the concentrate supplement was determined according to [AOAC \(1990\)](#) procedure.

Statistical analysis

The data on milk yield and compositions of the two groups of does were analyzed using chi-square. Means and averages of daily and weekly milk yield and compositions for the two treatment groups were computed; Student T-test was used to declare significance between means.

RESULTS AND DISCUSSION

The contents and the proximate composition of the experimental diet are given in Table 1. The crude protein (14.8%) and the energy (3.45 kcal/g) contents of the diet are nutritionally adequate and within recommended range for lactating goats ([Akinsoyinu, 1974](#); [Mba *et al.* 1975](#)).

Milk yield and composition

The milk yield and compositions of RS and WAD does are summarized in Table 2. There were significant differences ($P < 0.05$) in the BF, TS and SNF) constituents of the milk of the two small ruminant species. RS does had significantly ($P < 0.05$) higher butterfat content in milk (4.81%) than the WAD (4.72%). Conversely, WAD does manifested significantly higher ($P < 0.05$) TS and SNF concentrations in milk

(13.16, 8.59%) than the RS.

The BF recorded for RS goat in the present study (4.81%) compared favorably with the value of 5.01% reported by [Midau *et al.* \(2010\)](#), elsewhere for same species. Similarly, [Ahamefule *et al.* \(2007\)](#) also obtained a BF value in WAD milk (4.84%) which is within the range recorded for WAD goat (4.72%) in the present study.

Table 1 The contents and proximate composition of the concentrate diet

Ingredients	Composition (%)
Wheat meal	30
Maize offal	30
Palm kernel cake	30
Soya bean meal	7
Bone meal	2
Common salt	1
Total	100
Analyzed composition (%)	
Dry matter	88.55
Crude fiber	14.8
Ether extract	5.85
Nitrogen free extract	4.76
Ash	55.90
Energy (Kcal/g)	3.45

Table 2 Milk yield and composition of RS and WAD goats

Constituents (%)	RS	WAD	t-value	Significance
Crude protein	3.70	3.91	0.11	ns
Butterfat	4.81	4.72	0.02	*
Lactose	4.41	4.43	0.52	ns
Total solids	12.82	13.16	0.04	*
Solids-not-fat	8.22	8.59	0.04	*
Ash	0.88	0.86	0.42	*
Milk yield (g/d)	132.5	92.5	0.29	*
Milk yield (g/kg bw)	4.42	3.70	0.22	*

* Significant ($P < 0.05$); ns= non significant; WAD= West African Dwarf goat; bw= body weight.

Furthermore, [Midau *et al.* \(2010\)](#) reported higher TS (16.58%) and SNF (11.79%) in milk of RS relative to present values of 12.82 and 8.22%. [Akinsoyinu *et al.* \(1981\)](#) had earlier also obtained higher TS in the milk of RS goats (15.7%). For ruminant animals and indeed RS goats, intra species variability in milk constituents may arise due to management and environment/location of study ([El-hassan *et al.*, 2009](#)). The RS goat is a medium sized small ruminant breed which is well adapted to arid northern Nigeria. Coming from a different habitat, acclimatizing to rain forest belt could have posed both physiological and nutritional threats; new location would entail changes in diet in both form and composition, which could influence milk composition, hence variations in milk constituents were observed ([Ibeawuchi, 1985](#)). For WAD goats, however, variations in milk constituents, even with animals within same location, would tend to highlight the high genetic variations within the species; this differences tend to occur because the WAD

goat has not been improved for yield and constituents of milk. TS (%) was significantly higher ($P < 0.05$) in the milk of WAD goat (13.16) relative to RS (12.82). SNF concentration followed similar pattern as TS with 8.59 and 8.22% values for WAD and RS goats, respectively. The present TS and SNF values (%) of WAD compared with values reported by [Ahamefule et al. \(2007\)](#) for village reared WAD (13.55, 9.91) showed that higher values were nevertheless obtained by the same investigators for intensively managed WAD (14.77, 9.97). This observation underscores the influence of management and indeed of nutrition on milk constituents. [Midau et al. \(2010\)](#) had also obtained higher SNF in milk of RS goat relative to values obtained in this study, in an experiment carried out in both dry (13.42%) and rainy (11.79%) seasons, at Mubi area of Nigeria considered to be the natural habitat for this small ruminant breed. Milk protein was slightly higher for WAD compared to RS goat, even though not significantly ($P > 0.05$).

The values were 3.91 and 3.70%, respectively. [Jenness \(1980\)](#) also made a similar observation. Higher milk protein values of 4.25% ([Ahamefule and Ibeawuchi, 2005](#)), 4.31 and 4.40% ([Ahamefule et al. 2007](#)) have been reported for WAD goat. [Ahamefule et al. \(2003\)](#) even also obtained milk protein values of 4.26, 4.23 and 4.34% for WAD goat in early, mid and late lactation stages. Similarly, higher milk protein values have been reported ([Jenness, 1980](#); [Akinsoyinu et al. 1981](#)) for RS goat (4.38, 4.70%) in related investigations. Lactose composition was fairly comparable ($P > 0.05$) in milk of both ruminant species. [Jenness \(1980\)](#), however, reported higher lactose concentration in milk of WAD goat (5.58%) relative to RS goat (4.72%). The concentration of lactose in milk is relatively constant and averages 4.6% in goat milk ([Schmidt, 1971](#)). Unlike fat, the concentration of lactose in milk cannot be easily altered by nutrition. [Ahamefule et al. \(2003\)](#) recorded lactose concentrations of 4.46, 4.62 and 4.60% in early, mid and late lactation stages in WAD goat which affirm the relative consistency of lactose in milk. Lactose is a disaccharide synthesized in the udder. It is composed of a molecule of galactose joined to a molecule of glucose. Ash values were not influenced ($P > 0.05$) by species; the values were 0.86 and 0.88% for WAD and RS goats, respectively. The present values were fairly consistent with the values of 0.90 and 0.86% obtained by [Ahamefule et al. \(2004\)](#) and [Ibeawuchi et al. \(2003\)](#) for WAD and RS goats, respectively.

Milk yield was significantly higher ($P < 0.05$) for RS than WAD goat both in g/d (132.5 vs. 92.5) and g/kg bw (4.42 vs. 3.17), present values though, were much lower than production figures previously reported for each of the species. Observed an average production range of 450-550 g/d for Nigerian indigenous goats which nevertheless was not

consistent with the present report. Higher daily milk yields of 467, 468 and 664 g have been reported by [Akpa et al. \(2003\)](#), [Akinsoyinu et al. \(1981\)](#) and [Akpa \(1999\)](#), respectively for Red Sokoto goats, elsewhere. Similarly, [Ahamefule and Ibeawuchi \(2005\)](#) and [Ahamefule et al. \(2007\)](#), respectively, obtained 122 and 253 g daily milk yield for WAD goats placed on forage and forage-concentrate regimen. Factors ranging from nutrition, season and environment of study could be implicated for the variations in milk yield within these small ruminants ([Ibeawuchi and Dagut, 1996](#)).

Weekly milk yield and composition

The weekly milk yield and compositions of WAD and RS goats are summarized in Table 3. Milk protein was highest for WAD (4.57%) and RS (4.04%) in weeks 1 and 10, respectively. [Ahamefule and Ibeawuchi \(2005\)](#) made a similar observation for WAD goat in a related experiment. The least CP values were obtained for WAD (3.59%) and RS (3.54%), respectively, in weeks 2 and 9. Milk protein differed significantly ($P < 0.05$) between the species in weeks 2, 3 and 6 through 10. The values were significantly higher ($P < 0.05$) for WAD in weeks 3 and 6-10, and, however, higher for RS in week 2.

Butterfat composition of milk (%) differed significantly ($P < 0.05$) between species in all but the 4th week. The highest values for WAD (4.84%) and RS (4.95%) were recorded in the 10th week of the experiment. Ignoring the weeks 6 and 7, butterfat percent was relatively higher in milk of RS relative to WAD in weeks 1-3, 5 and 8-10. Lactose (%) was fairly and evenly distributed within the weeks for each of the species, there were, however, significant differences ($P < 0.05$) between species in weeks 3, 5, 6 and 9 with WAD goat having had higher values in weeks 3 and 5; RS had higher lactose concentration in weeks 6 and 9. TS differed significantly ($P < 0.05$) between the species in all except in weeks 7 and 10.

The highest values of 15.38% and 15.25% were obtained, respectively, for RS and WAD goats in weeks 1 and 2. TS were higher ($P < 0.05$) in WAD milk in weeks 2, 3, 5, 6 and 8. The reverse was the case for weeks 1, 4 and 9. The concentration of SNF (%) was significantly different ($P < 0.05$) in the milk of WAD and RS in all weeks of the experiment barring weeks 7 and 10.

Similarly, the highest values were obtained in week 1 for RS (10.63%) and week 2 for WAD (10.58%). SNF values were superior ($P < 0.05$) for WAD goat in weeks 2, 3, 5, 6 and 8; and conversely for RS goat in weeks 1, 4 and 9. Milk ash (%) was fairly and evenly distributed within the milks of the two ruminant species, differing ($P < 0.05$) only in weeks 3 and 6, while the highest values were recorded in week 10 for both species.

Table 3 Weekly milk yield and composition of WAD and RSgoats

Week	CP (%)		BF (%)		Lactose (%)		TS (%)		SNF (%)		Ash (%)		Yield (g/d)	
	WAD	RS	WAD	RS	WAD	RS	WAD	RS	WAD	RS	WAD	RS	WAD	RS
1	4.57	3.62	4.44 ^b	4.72 ^a *	4.41	4.45	14.74 ^b	15.38 ^a *	9.96 ^b	10.63 ^a *	0.83	0.85	496.71 ^b	656.73 ^a *
2	3.59 ^b	3.65 ^a *	4.70 ^b	4.82 ^a *	4.42	4.44	15.25 ^a	14.06 ^b *	10.58 ^a	9.24 ^b *	0.87	0.86	510.00 ^b	766.72 ^a *
3	3.75 ^a	3.71 ^b *	4.73 ^b	4.82 ^a *	4.37 ^a	4.31 ^b *	14.08 ^a	13.27 ^b *	9.35 ^a	8.48 ^b *	0.85 ^b	0.88 ^a *	673.33 ^b	823.30 ^a *
4	3.73	3.74	4.60	4.81	4.38	4.25	12.47 ^b	13.61 ^a *	8.64 ^b	9.87 ^a *	0.81	0.84	836.70 ^b	1266.73 ^a *
5	3.85	3.55	4.77 ^b	4.90 ^a *	4.31 ^a	4.20 ^b *	14.06 ^a	12.73 ^b *	10.20 ^a	8.93 ^b *	0.82	0.82	760.05 ^b	1116.74 ^a *
6	3.73 ^a	3.66 ^b *	4.80 ^a	4.71 ^b *	4.39 ^b	4.60 ^a *	13.06 ^a	11.73 ^b *	8.24 ^a	7.02 ^b *	0.85 ^b	0.89 ^a *	743.35 ^b	1080.07 ^a *
7	3.85 ^a	3.73 ^b *	4.84 ^a	4.60 ^b *	4.68	4.67	12.39	11.79	7.54	7.19	0.79	0.83	730.26 ^b	1046.28 ^a *
8	3.89 ^a	3.75 ^b *	4.68 ^b	4.77 ^a *	4.63	4.64	13.05 ^a	12.47 ^b *	8.42 ^a	7.61 ^b *	0.89	0.91	586.26 ^b	1033.72 ^a *
9	4.08 ^a	3.54 ^b *	4.75 ^b	4.93 ^a *	4.33 ^b	4.40 ^a *	11.58 ^b	12.06 ^a *	6.82 ^b	7.14 ^a *	0.91	0.92	580.35 ^b	763.41 ^a *
10	4.09 ^a	4.04 ^b *	4.84 ^b	4.95 ^a *	4.44	4.44	10.95	11.07	6.11	6.11	0.92	0.93	523.41 ^b	720.30 ^a *

* Significant means (P<0.05); WAD= West African Dwarf Goat; RS= Red Sokoto Goat.

Milk yield (g/d) progressively increased from week 1 for the two ruminant species and attained peak production in week 4. The peak values were 836.70 g and 1266.73 g for WAD and Red Sokoto goats. In earlier experiments, Ahamefule and Ibeawuchi (2005) and Akpa *et al.* (2003) similarly observed peak production in WAD and RSgoats at the 4th week of lactation; though their values were correspondingly higher. The differences in milk yield may be attributed to season, environment of study and system of management (Ibeawuchi and Dagut, 1996). Meanwhile, milk yield differed significantly (P<0.05) and was higher for RS goat in all weeks of study relative to WAD, thereby buttressing the supremacy RS over the WAD goat in milk production.

Mineral composition

The mineral compositions in the milk of RSand WAD goats are summarized in Table 4.

Table 4 Mineral composition in milk of RS and WAD goats

Minerals (%)	Re Sokoto	WAD	t-value	Significance
Calcium	0.15	0.12	0.006	**
Potassium	0.09	0.11	0.02	*
Magnesium	0.11	0.09	0.005	**
Sodium	0.11	0.09	0.001	***
Phosphorus	0.13	0.14	0.02	*

* Significant (P<0.05); ** Highly significant (P<0.01); *** Very highly significant (P<0.001).

WAD= West African Dwarf goat.

There were differences in milk concentrations of calcium, potassium, magnesium, sodium and phosphorus between the two ruminant species at different significant levels (potassium and phosphorus P<0.05, calcium and magnesium P<0.01, sodium P<0.001).

Calcium, magnesium and sodium concentrations were significantly higher (P<0.05) in the milk of RS goat relative to WAD. The present Ca (0.15%) and Mg (0.11%) values obtained for RS milk are lower than values of 0.29% and 0.15% reported, respectively, for the same species elsewhere (Midau *et al.* 2010). The present results are, however, comparable to the values of 0.20% (Ca) and 0.13%

(Mg) obtained by Alawa and Oji (2008) for RS goat. Potassium and phosphorus (%) in milk were significantly higher (P<0.05) for WAD (0.11, 0.14) than for RS goat (0.09, 0.13); Midau *et al.* (2010) and Alawa and Oji (2008) reported 0.14 and 0.13%, respectively, for Red Sokoto goat which compares favorably with the results obtained in this study.

Generally, the mineral composition of goat milk is between 0.7-0.8%; among macrominerals, potassium accounts for the greatest percentage in milk, followed by calcium, phosphorus, sodium and magnesium in that order. Calcium concentration in milk in this study was observed to be higher than potassium; this finding, which is not in consonance with existing reports, could be linked to deficiency of the mineral in the fodder fed. Tropical pasture are prone to seasonal variations in mineral and nutritional composition. Minerals in milk are sourced from ingested minerals in feed; therefore 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.

Weekly mineral composition in milk

Milk calcium (%) decreased with lactation and attained least concentration in week 5 for both species (WAD=0.7; RS=0.09) before rising progressively to week 10. Peak values were observed in week 1 for both ruminant species (WAD=0.14; RS=0.16). Weekly composition differed significantly (P<0.05) between species in weeks 1, 2, 4, 5, 8 and 9, with RShaving relatively higher (P<0.05) concentration of the mineral in all the designated weeks. Calcium is vital for the formation of strong bones and teeth and is also important in the maintenance of regular heartbeat and the transmission of nerve impulses. It is needed for muscle growth and contraction and for the prevention of muscle cramps.

Table 5 Weekly mineral composition in milk of WAD and RS goats

Week	Ca (%)		K (%)		Mg (%)		Na (%)		P (%)	
	WAD	RS	WAD	RS	WAD	RS	WAD	RS	WAD	RS
1	0.14 ^b	0.16 ^a *	0.13	0.11	0.10	0.11	0.08 ^b	0.12 ^a *	0.17	0.14
2	0.11 ^b	0.15 ^a *	0.11 ^a	0.08 ^b *	0.08	0.10	0.08 ^b	0.11 ^a *	0.15 ^a	0.11 ^b *
3	0.10	0.12	0.08	0.06	0.07	0.08	0.05 ^b	0.08 ^a *	0.12 ^a	0.10 ^b *
4	0.08 ^b	0.10 ^a *	0.06 ^a	0.04 ^b *	0.05	0.06	0.06	0.07	0.11 ^a	0.08 ^b *
5	0.07 ^b	0.09 ^a *	0.05	0.04	0.06	0.06	0.04 ^b	0.07 ^a *	0.09 ^a	0.05 ^b *
6	0.10	0.12	0.08 ^a	0.06 ^b *	0.06 ^b	0.08 ^a *	0.07	0.07	0.12 ^a	0.10 ^b *
7	0.12	0.14	0.10	0.09	0.08	0.10	0.09 ^b	0.11 ^a *	0.14 ^a	0.12 ^b *
8	0.14 ^b	0.17 ^a *	0.12	0.10	0.10 ^b	0.12 ^a *	0.11	0.11	0.15	0.14
9	0.15 ^b	0.20 ^a *	0.14 ^a	0.12 ^b *	0.14 ^b	0.16 ^a *	0.12	0.13	0.16	0.17
10	0.18	0.22	0.15 ^a	0.13 ^b *	0.15 ^b	0.18 ^a *	0.12	0.14	0.19	0.21

* Significant means (P<0.05); WAD= West African Dwarf Goat; RS= Red Sokoto Goat.

Potassium in milk (%) also followed similar pattern as Ca, decreasing with progressing lactation; the least values were observed in week 5 for both animal species (WAD=0.05; RS=0.04) before rising gradually to week 10. There were also significant differences (P<0.05) in potassium concentration in the milk of both species in weeks 2, 4, 6, 9 and 10 with WAD having relatively higher (P<0.05) values in the listed weeks.

Contrary to the results for Ca, the highest potassium values were recorded in week 10 for both ruminants (WAD=0.15; RS=0.13). Potassium is important for a healthy nervous system and a regular heart rhythm. It aids in proper muscle contraction, and works with sodium to control the body's water balance.

Magnesium concentration in milk (%) was highest in week 10 for both species; the values were 0.15% and 0.18% for WAD and RS goats, respectively.

The least value of 0.5% for WAD and 0.6% for RS were obtained in week 4. Weekly milk concentration of the mineral, however, differed significantly (P<0.05) between the species in weeks 6, 8, 9 and 10 with RS goat having significantly higher (P<0.05) concentrations in the designated weeks.

Magnesium is vital to enzyme activity. It assists in potassium uptake. A deficiency interferes with the transmission of nerve and muscle impulses, causing irritability and nervousness. It plays a role in the formation of bone and in carbohydrate and mineral metabolism.

Sodium in milk (%) also decreased with progression of lactation in WAD and RS goats; the least and the highest values for WAD goat was obtained in weeks 5 and 10, respectively (0.04, 0.12). Similarly, RS goat also had the least and the highest values in weeks 5 and 10 (0.07, 0.14). Relatively higher (P<0.05) concentration of the mineral existed in the milk of RS goat over the WAD in weeks 1, 2, 3, 5, and 7. Sodium is necessary for maintenance of proper water balance and blood pH. It is also needed for stomach, nerve, and muscle function.

Milk phosphorus differed significantly (P<0.05) in the milk of the two ruminant species in weeks 2-7 with WAD goat having superior concentrations (P<0.05) in all the designated weeks. The least and the highest values for both species were obtained in weeks 5 and 10, respectively.

Phosphorus is needed for bone and tooth formation, cell growth and contraction of the heart muscle. It also assists in the utilization of vitamins and the conversion of food to energy. In conclusion, inter species differences in milk yield and composition observed in this study could be traced to interplay or combination of such factors as genetic constitution of the animals, management and environment of study. Variations in weekly milk yield and composition could be exploited to produce milk of different constitutions to meet targeted needs of the populace. There is a growing awareness in the consumption of goat milk in Nigeria probably because of its smaller fat globules that renders it more digestible than cow milk.

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