Influence of Mineral Supplementation on the Composition of Goat Milk.

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Abstract

Eighteen monoparous lactating West African dwarf (WAD) does, with average weight of 25 ± 0.80 kg were used in a 12-week feeding trial to examine the effects of dietary mineral supplementation (Dicalcium phosphate and $MgSO_4 \cdot 7H_2O$) on milk production and composition of Ca, P, and Mg. The does were grouped into three of six animal replicate/group and randomly assigned to each of the three isonitrogenous (15% CP) and isoenergetic (9.81MJ/kg ME) supplementary diets (A, B, and C) respectively. The supplementary diets contained graded levels (0.5, 1, and 1.5%) of Dicalcium phosphate and $MgSO_4 \cdot 7H_2O$ and fed with a basal diet of *Cynodon nlemfuensis* grass in a completely randomized design. Results showed that treatment effects on dry matter intake (DMI) (g/day/kgBW^{0.75}), circulating levels (mg/100 ml) of Ca, P, and Mg in milk and sera of WAD does were significant ($P < 0.05$). Variations observed on milk total solids were not significant ($P > 0.05$). Significant ($P < 0.05$) dry matter intake DMI (g/day/kgBW^{0.75}) values of 155.55, 174.77, and 193.34 were obtained for does on diets A, B and C respectively; while corresponding significant ($P < 0.01$) mean milk yield values of 185.30, 301.20, and 340.05 g/day were obtained. Significantly different ($P < 0.05$) mean values of Ca, P, and Mg levels obtained in milk of WAD does on diets A, B and C were: Ca: 121.0, 127.0 and 132.0; P: 84.5, 89.78 and 94.08; and Mg: 18.90, 41.82 and 47.61 (mg/100ml); while corresponding values in serum were Ca: 9.75, 10.00 and 10.13, P: 7.15, 7.57 and 7.79; and Mg: 3.20, 3.52 and 4.54 (mg/100ml) respectively. Significant ($P < 0.05$) positive correlations ($r = 0.99, 0.97$ and 0.73) existed between milk and serum Ca, P and Mg contents respectively, suggested that blood is a secondary source of milk mineral secretion in lactating animals. The general trend was that increasing dietary mineral supplementation resulted in concomitant increase in dry matter consumption, milk yield and milk mineral (Ca, P, and Mg) contents, with does on diet C recording the best performance. Consequently, dietary Ca, P, and Mg levels (%DM) in supplementary lactation diet for indigenous WAD goats seemed to be best at 0.43, 0.35, and 0.17 respectively.

Key words: WAD goat, lactation, milk mineral, milk yield.

Introduction

The importance of milk and milk products in the nutrition of man cannot be over emphasized. From time immemorial cow has been the major provider of these products. There is now an increasing interest in goat milk production in tropical countries to reduce the demand pressure for cow milk. Goat milk has unique qualities over those of other animals. It is nearest to human milk in its composition and its globules and protein (Singh and Moore, 1962), well serves as a good dietary source of minerals which makes it a complete food for the neonates. According to the authors ripened goats cheese has a good image as a food for festive occasions while fresh goat milk begin to take a significant share of the animal product market in developing countries. Among other factors affecting milk production, nutrition has a major influence on goat milk secretion rate and composition especially in butterfat percentage (Chamberlain, 1989). According to the author major components of milk are manufactured in the udder from blood precursors, while other constituents including vitamins and minerals pass unchanged from blood. Regrettably however, despite the undeniable qualities of goats' milk, the knowledge of its mineral contents still remains fragmentary in literature. Apart from some reports with exotic goats (Kessler, 1987; Sawaye *et al.*, 1984; Pfeffer and Keuncke, 1986) the available data on the milk mineral composition of the indigenous WAD goats are very scanty in literature, consequently, making estimation of daily requirements for lactation difficult. For instance magnesium, (Mg) and potassium, (K) concentrations in milk have been reported

(Kessler, 1991) as criteria for their requirements for lactating goats.

Since milk is high in calcium (NRC, 1981) and potassium identified as mineral element present in highest concentration in milk (McDowell, 1992), lactating goats should have higher dietary requirements than non-lactating ones. The knowledge of milk mineral composition particularly, the major ones, is a prerequisite in estimating the mineral nutritional needs of the lactating animals. Therefore, this study was designed as part of a general trial to study mineral utilization with a view to examining the effects of dietary mineral supplementation (Dicalcium phosphate and $MgSO_4 \cdot 7H_2O$) on goat's milk production and composition of Ca, P, and Mg as a guide towards the provision of relevant information on requirements for lactation.

Materials and methods

Animal Management and Design

Eighteen monoparous lactating WAD goats averaged 25.0 ± 0.80 kg body weight were used in a 12-wk feeding trial which commenced fifth day postpartum. The kids were separated from their dams fourth day after parturition and subsequently bottle fed. The lactating does were transferred to the individual pens for feeding trial which was done in three phases: early lactation (2 – 4 weeks), mid lactation (5 – 8 weeks) and late lactation (9 – 12 weeks) respectively. Does were randomly allotted to one of the three isonitrogenous (15% CP) and isoenergetic (9.81 MJ/kg ME) supplementary concentrate diets (A, B, and C) respectively (Table 1), in addition with a basal diet of *Cynodon*

nlemfuensis grass in a completely randomized design. Animals were fed 4% of their body weights twice daily at 08.00 and 16.00h and had free access to drinking water.

Samples collection and chemical analysis

Blood samples were collected from each doe via jugular veinpuncture at wks 2, 4, 6, 8, 10 and 12 postpartum. The blood samples were centrifuged and serum harvested and stored in a frozen cabinet at -20° C till when required for analysis. Samples of colostrum were collected on the second day of parturition (pre-lactation days). With handmilking method, milk collection was done twice daily before feeding, in the morning at 7.00h and in the evening at 17.00h throughout the 12 week - lactation period. A measuring cylinder was used to measure daily milk collection. Following the recording of daily milk yield, 10% of daily milk collection were bulked to give a sample for 2 weeks, stored in clean plastic bottles with lid and kept together with the samples of colostrum in a frozen cabinet.

Thawed colostrum, milk and serum (2 ml each), and feed (2 g) were digested in individual flasks with 5 and 20 mls of perchloric and concentrated trioxo nitrate (v) acid acids respectively. The mixture was heated until clear solution was formed. Each of the digests was washed into 100 ml capacity volumetric flask and then made up to the mark. Content of Ca, Mg and K in the digest were determined using the Perkin Elmer atomic absorption spectrophotometer model 413 (McDowell, 1992). Phosphorus in the digest was determined by vanadomolybdate method. Proximate composition and fibre fractions (ADF and NDF) of the diets as well as

milk total solids were determined according to A. O. A. C. (1990), Van Soest and Robertson (1985) and Shirlaw (1967) methods, respectively.

Statistical analysis

Collected data were subjected to general linear model procedures of SAS (SAS, 1995). The statistical model used was:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Where, Y_{ij} is a parameter of interest; μ the overall mean for the parameter of interest; τ_i the treatment effect; and ε_{ij} the experimental error. Treatment means were separated using Duncan's Multiple Range Tests (Duncan, 1955). The simple linear correlations (Gomez and Gomez, 1984) between serum (mg 100ml⁻¹) Ca, P, and Mg contents (X) with corresponding contents of milk (Y) were determined.

Results

Chemical composition of the diets

The composition of the diets and grass is shown in Table 1. The diets were isonitrogenous (15%CP) and isoenergetic (9.81MJ/kg ME). While other proximate components were similar in values including the fibre fractions, the diets contained varied Ca, P, Mg and K values, with diet A having the least values of 0.20, 0.17, 0.07 and highest value of 0.54 respectively (Table 2). Grass contained less crude protein (8.07%) and higher metabolisable energy (10.05 MJ/kg) than the supplementary diets.

DM intake, milk yield and composition

The daily DM intake (Table 3) (g/d) varied significantly ($P < 0.05$). DM intake increased with increasing levels of dietary mineral supplementation (MS) with goats on diets B (1% MS) and C (1.5% MS) having significantly higher ($P < 0.05$) values of 820.00 and 910.00 than those on diet A (0.5% MS) with 700.00.

Table 1: Ingredient composition (%) of the diets fed lactating WAD goats.

Ingredient	DIETS		
	A	B	C
Cassava flour	49.0	47.5	46.0
Dussa*	10.0	10.5	11.0
Fishmeal	7.0	7.0	7.0
Groundnut cake	11.0	11.0	11.0
Wheat bran	20.0	20.0	20.0
Common salt	1.0	1.0	1.0
Vit/mineral premix	0.5	0.5	0.5
Oyster shell	0.5	0.5	0.5
Dicalcium phosphate	0.5	1.0	1.5
MgSO ₄ .7H ₂ O	0.5	1.0	1.5
Total	100.0	100.0	100.0

*Dussa – a by-product of fermented sorghum

Mean milk yield values (g/d) followed similar trend with does on diet A (0.5% MS) having significantly ($P < 0.01$) least value of 185.30. Increases in the milk yield as the MS was increased were appreciable for each of the two supplemental mineral sources, although does on highest MS had significantly highest value of 340.05. Variations observed due to treatment effect on milk composition (protein, fat, lactose and ash) were not significant ($P > 0.05$).

Milk Ca, P, and Mg contents

Treatment effects on milk Ca and P were significantly ($P < 0.05$) lower with does on diet A (0.5% MS) when compared with those on diet C respectively. However, the P value of diet A was not different from the mean lactation value

of diet B. While the Ca content of mature milk appeared to increase with advancing lactation (except for does on diet A) the P content had no definite trend. Milk P content of does on diet C (1.5% MS) however, declined with advancing lactation. There were no significant differences ($P > 0.05$) in the mean milk P values of does fed diets A (0.5% MS) and B (1% MS), while does on diet C (1.5% MS) had a higher ($P < 0.05$) milk P value than does on diets A and C, respectively. However, Mg content of colostrums of does appeared to be lower than the corresponding contents of Ca and P; with animals fed diet A recorded the least value of 27.67 mg/100ml. The Mg concentration in milk has been reported as a criterion for goats' lactation requirement (Kessler, 1991). There was no significant

Table 2: Chemical composition (%DM) of diets and *Cynodon nlemfuensis*

	A	B	C	<i>Cynodon nlemfuensis</i>
Crude protein	15.05	15.04	15.01	8.07
Ether extract	4.59	4.95	4.90	1.38
Nitrogen free extract	62.05	62.07	62.11	81.48
Cellulose	13.25	14.21	14.00	9.03
Hemicellulose	23.01	23.10	23.12	34.72
Lignin	46.53	47.30	47.40	72.24
Starch	0.20	0.31	0.43	0.42
Soluble pectin	0.17	0.26	0.38	0.23
Insoluble pectin	0.07	0.12	0.17	0.31
Cell wall constituents	0.54	0.53	0.53	1.45
Energy (MJ/kg)	9.75	9.88	9.80	10.05

Table 3: Dry matter intake, milk yield and composition of lactating WAD goats

Parameters	DIETS			SEM
	A	B	C	
Dry matter intake (g/d)	700.00 ^c	820.00 ^b	910.00 ^a	50.00
Dry matter intake (g/kgBW ^{0.75})	155.55 ^c	174.77 ^b	193.34 ^a	17.45
Milk yield (g/d)	185.30 ^c	301.20 ^b	340.05 ^a	9.05
Protein (%)	4.03	4.05	4.10	0.10
Fat (%)	6.25	6.20	6.41	0.35
Lactose (%)	5.99	6.09	6.12	0.15
Acid (%)	0.68	0.71	0.78	0.12
Total solids (%)	16.95	17.05	17.41	0.30

^{a, b, c}: Means on the same row with same superscripts are not significantly different ($P > 0.05$)
 SEM: Standard Error of Means

Table 4: Minerals (Ca, P, and Mg) in milk of lactating WAD goats (mg100ml⁻¹)

Mineral	Period	DIETS			SEM
		A	B	C	
Ca	Colostrum	138.20 ^e	145.65 ^b	152.63 ^a	7.45
	Early lactation	112.50 ^e	120.15 ^b	129.15 ^a	7.01
	Mid lactation	122.70 ^e	127.75 ^b	131.50 ^a	6.99
	Late lactation	127.75 ^e	133.75 ^b	135.25 ^a	7.02
	Mean (lactation)	120.98 ^e	127.20 ^b	131.97 ^a	7.05
P	Colostrum	107.20 ^a	111.65 ^b	113.45 ^c	9.30
	Early lactation	84.01 ^b	89.50 ^b	97.00 ^a	2.05
	Mid lactation	80.50 ^b	91.35 ^a	94.25 ^a	2.01
	Late lactation	89.00 ^b	88.50 ^b	91.00 ^b	2.03
	Mean (lactation)	84.50 ^b	89.78 ^b	94.08 ^a	2.01
Mg	Colostrum	27.67 ^c	43.30 ^b	56.45 ^a	9.25
	Early lactation	21.03 ^c	43.01 ^b	52.51 ^a	7.10
	Mid lactation	18.58 ^b	41.93 ^a	48.27 ^a	7.15
	Late lactation	17.13 ^c	38.61 ^b	42.07 ^a	8.03
	Mean (lactation)	18.90 ^b	41.19 ^a	47.61 ^a	7.05

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difference ($P > 0.05$) in mean milk Mg values obtained for goats on diets B and C during lactation, while the Mg value obtained for goats on diet A was significantly ($P < 0.05$) lower than the values for diets A and B, respectively.

Serum Ca, P, and Mg contents

The summary of circulating levels of Ca, P, and Mg in serum is presented in Table 5. Treatment effects on sera Ca, P, and Mg were significant ($P < 0.05$). It was generally observed that the obtained sera mineral values increased ($P < 0.05$) with increasing levels of dietary mineral

inclusions. Circulating sera Ca levels showed a trend of gradual decline from early lactation period to mid lactation and tend to increase thereafter till the close of lactation. The corresponding Mg level appeared to decline throughout the lactation period. Does on diet A (0.5% MS) consistently having significantly ($P < 0.05$) least mean (lactation) sera Ca, P, and Mg values of 9.75, 7.15, and 3.20 respectively. A linear relationship with a highly significant ($P < 0.01$) positive correlation ($r = 0.99$ and 0.97) existed between the daily sera Ca and P, values and corresponding values in milk of the

Table 2: Chemical composition (%DM) of diets and *Cynodon nlemfuensis*

	A	B	C	<i>Cynodon nlemfuensis</i>
Crude protein	15.05	15.04	15.01	8.07
Ether extract	4.59	4.95	4.90	1.38
Nitrogen free extract	62.05	62.07	62.11	81.48
Ash	13.25	14.21	14.00	9.03
ADF	23.01	23.10	23.12	34.72
NDF	46.53	47.30	47.40	72.24
Ca	0.20	0.31	0.43	0.42
P	0.17	0.26	0.35	0.23
Mg	0.07	0.12	0.17	0.31
K	0.54	0.53	0.53	1.45
Energy (MJ/kg)	9.75	9.88	9.80	10.05

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Milk yield (g/d)	185.30 ^c	301.20 ^b	340.05 ^a	9.05
Protein (%)	4.03	4.05	4.10	0.10
Fat (%)	6.25	6.20	6.41	0.35
Lactose (%)	5.99	6.09	6.12	0.15
Ash (%)	0.68	0.71	0.78	0.12
Total solids (%)	16.95	17.05	17.41	0.30

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Influence of mineral supplementation on goat milk

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Ca	Colostrum	138.20 ^c	145.65 ^b	152.63 ^a	7.45
	Early lactation	112.50 ^c	120.15 ^b	129.15 ^a	7.01
	Mid lactation	122.70 ^c	127.75 ^b	131.50 ^a	6.99
	Late lactation	127.75 ^c	133.75 ^b	135.25 ^a	7.02
	Mean (lactation)	120.98 ^c	127.20 ^b	131.97 ^a	7.05
P	Colostrum	107.20 ^a	111.65 ^b	113.45 ^c	9.30
	Early lactation	84.01 ^b	89.50 ^b	97.00 ^a	2.05
	Mid lactation	80.50 ^b	91.35 ^a	94.25 ^a	2.01
	Late lactation	89.00 ^b	88.50 ^b	91.00 ^a	2.03
	Mean (lactation)	84.50 ^b	89.78 ^b	94.08 ^a	2.01
Mg	Colostrum	27.67 ^c	43.30 ^b	56.45 ^a	9.25
	Early lactation	21.03 ^c	43.01 ^b	52.51 ^a	7.10
	Mid lactation	18.58 ^b	41.95 ^a	48.27 ^a	7.15
	Late lactation	17.13 ^c	38.61 ^b	42.07 ^a	8.03
	Mean (lactation)	18.90 ^b	41.19 ^a	47.61 ^a	7.05

^{a, b, c} Means along the same row with same superscripts are not significantly different ($P > 0.05$) SEM: Standard error of means

difference ($P > 0.05$) in mean milk Mg values obtained for goats on diets B and C during lactation, while the Mg value obtained for goats on diet A was significantly ($P < 0.05$) lower than the values for diets A and B, respectively.

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inclusions. Circulating sera Ca levels showed a trend of gradual decline from early lactation period to mid lactation and tend to increase thereafter till the close of lactation. The corresponding Mg level appeared to decline throughout the lactation period. Does on diet A (0.5% MS) consistently having significantly ($P < 0.05$) least mean (lactation) sera Ca, P, and Mg values of 9.75, 7.15, and 3.20 respectively. A linear relationship with a highly significant ($P < 0.01$) positive correlation ($r = 0.99$ and 0.97) existed between the daily sera Ca and P, values and corresponding values in milk of the

Table 5: Serum Calcium, Phosphorus and Magnesium (mg100ml⁻¹) of WAD goats during lactating phases.

Mineral	Period	DIETS			SEM
		A	B	C	
Ca	Colostrum	9.94 ^b	10.21 ^{ab}	10.53 ^a	0.15
	Early lactation	9.73	9.70	10.05	0.16
	Mid lactation	9.45	10.00	10.10	0.12
	Late lactation	10.08	10.05	10.13	0.10
	Mean (lactation)	9.75 ^b	9.92 ^{ab}	10.09 ^a	0.35
P	Colostrum	7.80 ^c	8.63 ^b	9.16 ^a	0.40
	Early lactation	6.43 ^b	7.10 ^a	7.23 ^a	0.35
	Mid lactation	6.55 ^b	6.85 ^b	7.20 ^a	0.26
	Late lactation	8.48 ^b	8.75 ^a	9.05 ^a	0.30
	Mean (lactation)	7.15 ^b	7.57 ^{ab}	7.83 ^a	0.51
Mg	Colostrum	3.98 ^c	4.78 ^b	6.10 ^a	0.60
	Early lactation	3.75 ^b	4.00 ^b	6.07 ^a	0.52
	Mid lactation	3.60 ^b	3.30 ^b	4.40 ^a	0.30
	Late lactation	2.25 ^b	3.25 ^b	3.15 ^a	0.41
	Mean (lactation)	3.20 ^b	3.52 ^b	4.54 ^a	0.31

^{a, b, c} Means on the same row with same superscript are not significantly different ($P > 0.05$)

SEM: Standard Error of Means.

experimental lactating goats. Such positive correlation ($r = 0.73$) however was significant ($P < 0.05$) for the serum and milk Mg values.

Discussion

Protein and energy contents of the diets conformed to the recommended (Devendra and Burns, 1983; NRC, 1981) ranges of 14-18% CP and 8.79 – 11.30 MJ/kg, ME respectively for lactating goats. Dietary Ca, P, Mg and K levels (0.20 - 0.43; 0.17 – 0.35; 0.07 - 0.17; and 0.53 – 0.54 %DM) respectively, were considered adequate since the experimental goats had sufficient feed intake and exhibited no symptoms

of ill health or nutritional disorders which could have indicated any form of toxicity. In addition, the obtained mineral levels except the Mg level in diet A (0.07%) which was lower than the minimum 0.12% were within the recommended (NRC, 1985) values for small ruminants of all classes. Animals, however, had sufficient intake from the basal diet of *Cynodon nlemfuensis*. The K levels of the three diets were similar due probably to the isonitrogenous and isocaloric nature of the diets. In addition, the diets were not supplemented with supplemental K salt consequently making its' control difficult. DM consumption of the lactating goats averaging 3% of their body weight was sufficient; and this fell

within the recommended range of 1.9 to 5% (Devendra and Mcleeroy, 1982; NRC, 1981). The significantly ($P < 0.05$) higher DMI values of goats on diets B (0.5% MS) and C (1.5% MS) suggest that increasing Ca, P and Mg levels enhanced palatability and acceptability of a given diet. This also had a positive influence on milk yield with these groups of animals recording higher ($P < 0.01$) values than diet A respectively. Generally, milk yield values obtained in the present study were low when compared with 2.65 kg and 3.28 kg day⁻¹ for Alpine and Saanen goats respectively (Sahlu *et al.*, 1993; Devendra and Burns, 1983). The low milk yield could be due to the fact that the WAD goats are not dairy types. In addition, the experiment was carried out under different environmental situations which could affect the findings.

Milking frequency (twice per day) and method (hand milking) used in the present study could also be responsible as these may not be as efficient as more frequent milking and the use of milking machine as practiced in the developed countries. However, it has been reported that thrice – daily milking increases the daily rate of milk secretion by up to 20% in cows (Pearson *et al.*, 1979) and 43% in goats (Henderson *et al.*, 1985). The milk yield pattern of the WAD goats was such that it got to the peak at about 5th week of lactation and this probably due to increased secretory activity per cell (Capuco *et al.*, 2002) and gradually declined shortly thereafter till the close of the 12 – week lactation period. Does on diet A (0.5% MS) with lowest milk yield value however were first to dry off at week 11 of lactation. This confirmed the report by Cooper *et al.* (1994) that lactation length is extremely

variable and thus, shorter for low yielders and longer for good dairy animals. Variations observed due to treatment effects on milk composition (protein, fat, lactose and ash) were not significant ($P > 0.05$). This could be attributed to the isonitrogenous and isoenergetic nature of the diets fed the goats.

In literature, information on goats' mineral utilization and requirements during lactation are very scanty and thus limit comparison. Though results obtained in this study are relatively low compared with what was reported elsewhere for temperate breeds, they are very relevant as they give useful information needed in estimating requirements for these indigenous WAD goats with a view to improving their performance during lactation. Milk Ca, P and Mg contents of goats on diets A, B and C during lactation, were lower than the corresponding contents in colostrums (Table 4). Similar trend has been reported for human milk (Kisza and Zbikowski, 1975) and cow milk (Miriani and Russo, 1976). Higher mineral content of colostrum confirms its nutritional quality as a complete diet for the neonates to survive the critical period of their lives. The significantly ($P < 0.05$) higher milk Ca and P values of does on diet C (1.5% MS) compared with does on diets A and B respectively, could be due to higher dietary level of supplementation. While the P content of mature milk decreased with advancing lactation, the Ca content (Table 4) decreased at the mid lactation (diet A) and spontaneously increased in late lactation. Higher milk Ca output in late lactation as observed in the present study could probably be due to physiological responses during lactation in which bone secretes minerals

particularly calcium in milk (Frandsen, 1981). Except for does on diet A (0.5% MS) which had relatively lower mean value (120.98 mg/100ml) probably due to low intake of Ca occasioned by non - supplementation of the diet, the obtained milk Ca values for does on diets B and C were in accordance with a range of 128.48 to 152.16 (mg/100ml) reported (Simons *et al.*, 1991) for native Greek goats.

Mg concentration in milk has been reported as a criterion for its requirement for lactation (McDowell, 1992). Does on diet A (0.5% MS) with milk Mg value of 18.90 (mg/100ml) is comparable to the value of (0.14 g/kg) reported by Brendehaug and Abrahamsem (1987) for European Saanen and Alpine goats. Corresponding animals on diets B (1% MS) and C (1.5% MS) had higher ($P < 0.05$) mean values than those on diet A respectively, which may be due to the dietary levels of Mg. It was also observed that milk Mg values tend to decline with advancing lactation. This observation agreed with report of Babayemi (1997).

It was generally observed that the obtained sera Ca and P values increased with increasing levels of dietary mineral inclusions and declined gradually from early lactation period to mid lactation and increased spontaneously thereafter till the close of lactation. Serum Mg values in contrast appeared to decline with advancing lactation. However, mean serum values of these minerals were within normal ranges Ca, 10 -12, P 4.5 -6 and Mg 1.8 -3.2 mg/100ml (McDowell, 1992), as adequate for goats, thus suggesting adequacy of the mineral contents of the diets with grass fed the lactating goats.

The Mg concentration in milk and serum also followed similar trend observed for Ca and P as it increased with increasing dietary Mg level. This further indicates that diets are the primary source of serum and milk minerals. Treatments had significant ($P < 0.05$) effects on the mineral contents of milk which may be due to effects of mineral contents of blood as minerals found in milk have been reported (Smith, 1959) to originate from blood. This is further proven by the significant ($P < 0.05$) positive correlations ($r = 0.99, 0.97$ and 0.73) that were observed between Ca, P, and Mg contents of milk and corresponding contents in blood, respectively.

Conclusion

The entire biochemical studies on Ca, P and Mg in sera of lactating WAD does coupled with concomitant secretions in milk reflected adequacy of nutrition of the test animals. Consequently, the present findings indicate that the dry matter consumption (910 g/day), milk yield (340.05 g/day) and composition of Ca, P and Mg (131.97, 94.08, and 47.61 mg/100ml) of the lactating does seemed to be best at dietary Ca, P, and Mg levels of 0.43, 0.35 and 0.17, respectively. This provides useful information to further nutritional studies on WAD goat with a view to estimating Ca, P, and Mg requirements for lactation.

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References

- AOAC.** 1990. Association of Official Analytical Chemists. Official methods of analyses, 15th ed. Washington, DC, pp. 376 – 384.
- Babayemi, O. J.** 1997. Magnesium and Copper requirements of West African Dwarf goats for pregnancy and lactation. PhD Thesis, Dept. of Animal Science, University of Ibadan, Ibadan, Nigeria.
- Brendehaug, J. and Abrahamsem, R. K.** 1987. Trace element in bulk collected milk. *Milchwissenschaft* 42, 289 -290.
- Capuco, A. V., Ellis, S. E., Hale, S. A., Long, E., Erdman, R. A., Zhao, X., and Paape, M. J.** 2002. Lactation Persistency: Insights from mammary cell proliferation studies. *J. Dairy Sci.* 85, suppl. 1.
- Chamberlain, A.** 1989. Milk production in the tropics. Longman Scientific and Technical, England. 242 pp.
- Cooper, R. A., Kirt, J. A., Lamwanja, L., and Banda, J.** 1994. Milk production from indigenous Malawi goats. Proceedings of the Third Biannual Conference of the African Small Ruminants Research Network. UICC, Kampala, Ugandan, pp 283 – 287.
- Devendra, C. and Burns, M.** 1983. Goat production in the tropics. Commonwealth Agricultural Bureaux Farnham Royal, U.K.
- Devendra, C. and Mcleroy, G. B.** 1982. Goat and sheep production in the tropics. Longman, London and New York, 271pp.
- Duncan, D. B.** 1955. Multiple Range and Multiple F. test. *Biometrics* 1, 11 -42.
- Frandsen, R. D.** (1981). Anatomy and physiology of farm animals. 3rd ed. Bailliere Tindall, London, p 204.
- Gomez, A. K. and Gomez, A. A.** 1984. Stastical Procedures for Agricultural Research. John Wiley and Sons Inc., pp359 – 371.
- Henderson, A. J., Blatchford, D. R., and Peaker, M.** 1985. The effects of long - term thrice daily milking on milk secretion in the goats: evidence for mammary growth. *Quarterly J. Experimental Physiology*, 70, 557 – 565.
- Kessler, J.** 1987. Effect of high dietary potassium content on Mg, K⁺ and Na⁺ metabolism in the lactating goats. In: Goat Nutrition, Morand -Fehr, P. (Ed.) European Association for Animal Production, Publication No 46, pp: 104 - 119.
- Kessler, J.** 1991. Mineral nutrition of goats. In: Goat Nutrition, Morand -Fehr, P. (Ed.) European Association for Animal Production, Publication No 46, pp: 104 - 119.
- Kisza, T. and Zbikowski, Z.** 1975. Composition of human colostrum and milk. *Pediat. Polska* 50: 333-340.
- McDowell, L. R.** 1992. Mineral in animal and human nutrition. Academy Press, Inc. Harcourt Brace Jovanovich (Publ) NY. 524pp.

- Miriani, P. and Russo, V. 1976.** Calcium and Phosphorus contents in cow milk of the Italian Friesian, Italian Brown, Reggio and Modena breeds. *Rvista de Zooteniae veterinarian* 1:23 - 46.
- NRC, 1981.** National Research Council. Nutrient requirements of goats. Angora, dairy and meat goat in temperate and tropical countries. No.15, National Academy of Science, Washington, DC., USA
- NRC, 1985.** National Research Council. Nutrient requirements of sheep. National Academy of Science, Washington, DC., USA.
- Pearson, R. E., Fulton, L. A., Thompson, P. D. and Smith, J. W. 1979.** Three times a day milking during the first half of lactation. *J. Dairy Sci.* 62: 1941 - 1950.
- Pfeffer, E. and Keunecke, R. 1986.** Untersuchungen uber die Gehalte an Protein, Fett undm Mineralstoffen im Korper wachsender Ziegen. *J. Animal Physiology and Animal Nutrition*, 54, 166 - 171.
- Sahlu, T., Fernandez, J. M., Jia, Z. H., Akinsoyinu, A. O., Hart, S. P. and The, T. H. 1993.** Effect of source and amount of protein on milk production in dairy goats. *J. Dairy Sci.* 76, 2701 - 2710.
- Sawaya, W. N., Khalil, J. K. and Al-shalhat, A. F. 1984.** Mineral and vitamin content of goat's milk. *J. of the American Dietetic Association* 84, 433 -435.
- SAS, Statistical Analysis System Institute. 1995.** SAS user's guide. SAS Institute, Cary, N.C.
- Simons, E. L., Vontsinas, P. and Pappas C. P. 1991.** Composition of milk of native Greek goats in the region of Metsovo. *Small Ruminant Research.* 4, 47 -60.
- Singh, H. and Moore, E. N. 1982.** Feeding and management of goats. In: Livestock and poultry production, Bundy, C. E., Diggins, R. Y. and V. W. Christensen Eds. 2nd ed. (Revised), Prentice - Hall of India Private Limited, pp 329 - 340.
- Smith, V. 1959.** Physiology of lactation. 5th ed. IOWA State University Press, IOWA, US, 215pp.
- Van Soest, P. J. and Robertson. J. B. 1985.** Analysis of forage and fibrous foods As 613 manual, Dept. of Animal Science, Cornell University, Ithaca, pp 105-106.
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