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Studies on Milk Mineral Composition of Lactating West African Dwarf Goats

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Abstract: A study was conducted to examine the efficacy of dietary mineral supplementation ($CaPO_4$ and $MgSO_4$. $7H_2O$) on the milk mineral (Ca, P, Mg and K) content of the West African dwarf, WAD, goats. Eighteen monoparous lactating WAD does were utilized for feeding trial in a 12-week lactation period in which the does were randomly assigned to one of the three dietary treatment groups (A, B, C) of six animals in a completely randomized design. The three isonitrogenous (15% CP) and isocaloric (2.34 Mcal ME) supplementary diets fed to a based diet of *Panicum maximum* grass contained graded levels (%) 0, 1 and 2 of Ca/P and Mg supplementations in diets A, B and C respectively. Results showed that treatment effects on dry matter intake, DMT (kg day^{-1}), body weight (Bw) gain (g day^{-1}) circulating levels (mg dL^{-1}) of Ca, P, Mg and K in serum and milk of WAD does were significant ($p<0.05$). Similar effect on milk yield was highly significant ($p<0.01$). The mean values (mg dL^{-1}) of circulating levels of CA, P, Mg and K in serum of WAD does on diets A, B and C were: Ca 9.75, 10.00 and 10.13, P 7.15, 7.57 and 7.79; Mg 3.20, 3.52 and 4.54 and K (mmolL^{-1}) 3.53, 3.83 and 3.77, respectively; while corresponding values (mgdl^{-1}) in milk were Ca 121.0, 127.0 and 132.0; P 84.5, 89.78 and 94.08; Mg 18.90, 41.82 and 47.61; and K 158.43, 165.03 and 160.58. The general trend was that increasing dietary mineral supplementation effected a concomitant increase in milk mineral (Ca, P, Mg and K) outputs. Significant positive correlations (r = 0.99, 0.97, 0.73 and 0.85) existed between serum and milk Ca, P, Mg and K contents respectively suggesting that blood is a secondary source of milk mineral secretion in lactating animals.

Key words: Goat, lactation, milk, mineral composition

INTRODUCTION

There is an increasing interest in goat milk production in tropical countries since it is difficult to meet the demand for cow milk by man. Goat milk has unique qualities over those of other animals. It is nearest to human milk in its contents of fat and protein[1] and serves a good dietary source of minerals which makes it a complete food for the neonates. Ripened goats cheese has a good image as a food for festive occasions while fresh goat milk is beginning to take a significant share of the animal product market.

However, the importance of mineral nutrition in livestock industry cannot be underscored as all forms of living matter require inorganic elements, or minerals for their normal life processes. All animal tissues and feeds contain inorganic or minerals elements in widely varying amounts and proportions[2].

Regrettably, however, despite the undeniable qualities of goats milk, the knowledge of its mineral contents still remain fragmentary in literature. Apart from some reports with exotic goats[3-5], the available data on the milk mineral composition of the indigenous WAD goats are very scanty in literature. Therefore, this informed the present study.

Since milk is high in calcium, Ca[6] and potassium, K identified as mineral elements present in highest concentration in milk[2], lactating goats should have a higher dietary requirements than non-lactating ones. Consequently, the knowledge of milk mineral composition particularly, the major ones, is a prerequisite in estimating the mineral nutritional needs of the lactating animals. For instance magnesium, Mg and potassium, K concentrations in milk have been reported[7] as criteria for their requirements for lactating goats.

Therefore, this study was designed to investigate the efficacy of dietary mineral supplementation ($CaPoO_4$ and $MgSO_4.H_2O$) on goat's milk production with a view to examining its contents of Ca, P, Mg and K, as part of a general study on goat mineral utilization

MATERIALS AND METHODS

Animal and management: Eighteen monoparous lactating WAD goats with average weight of 23.43 kg were utilized in the feeding trial which commenced eight day

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

Ingredient	A	B	C
Cassava flour	50.0	47.5	45.0
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
CaPo4	0.0	1.0	2.0
MgSo4.7H2o	0.0	1.0	2.0
Total	100.0	100.0	100.0

Dussa-a by product of fermented sorghum

postpartum. The kids were separated from their dams seventh day after parturition and subsequently bottle fed. The lactating does were transferred onto the metabolic cages for balance trials at weeks 2, 4, 6, 8, 10 and 12 of lactation which represented early lactation (2-4 weeks), mid lactation (5-8 weeks) and late lactation (9-12 weeks), respectively.

Experimental design: The lactating does were randomly allocated into one of the three (A, B and C) Ca/P and Mg supplemented diets (Table 1) fed to a basal diets of *Panicum maximum* grass in a complete randomized design. Animals were offered diets as 4% their Body weights in two split does at 7.00 and 1700 h daily. Daily feed intake and weekly body changes were monitored.

Collection of samples: Each does was placed in individual metabolic cages modified for separate collection of faces and urine[8]. Balance trial periods involved 7 –day cage adjustment period and 7-day of collection. Ten percent (10%) faeces and 20% urine were collected and bulked separately for analysis. Blood samples were withdrawn via jugular venipucture at each balance trial period. The blood coagulated, centrifuged with the serum harvested and store in a frozen cabinet at 20^0 C till required for analysis. Samples of colostrum were collected within the first seven days postpartum (pre-lactation days). Collection of milk samples lasted about 12 weeks of lactation from 8 days postpartum does were hand milked in the morning at 7.00 h and in the evening at 17.00. About 30% of daily milk collection was stored in clean plastic bottles with lid and kept together with the sample colostrums in a frozen cabinet. Ten percent (10%) of daily milk collection were bulked to give a sample for 2 weeks. Collected samples of feed offered, faeces, urine, blood and milk were analyzed for mineral and proximate composition as reported elsewhere[9].

Statistical analysis: Collected data were subjected to general linear model procedures of SAS[10]. Treatment means were separated with the method of Duncan's multiple range tests[11]. The simple linear correlations between serum (mg 100 mL^{-1}) Ca, P, Mg and K contents (X) with corresponding contents of milk (Y) were computed using the equation below.

$$r = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}}$$

Where r = correlation coefficient

RESULTS AND DISCUSSION

The proximate composition of the diets and grass is shown in Table 2. The isonitrogenous (15%CP) and isocaloric (2.35Mcal ME) formulated diets conformed with the recommended by NRC[6] range of (14-18% CP and (2.1-2.7 Mcal ME), respectively. The mineral inclusion were considered adequate since the experimental goats gained weight and exhibited no symptoms of nutritional disorders which could have indicted any form of toxicity. The Ca and P levels of (0.35-0.71) and (0.18-0.30), respectively were higher than values reported by Afolabi[12] and that of Mg levels by Babayemi[13]. However, the inclusion values obtained for Ca, P, Mg and K in this present study were within the recommended [14] values for sheep (small ruminant) of all classes.

The performance characteristics of does are presented In Table 3. The goats had sufficient dry matter intake, DMI with the average of 2.9% of their body weight which is within the recommended range of 1.9 to 3.8% of

Table 2: Proximate composition (g 100 gDm) of the diets fed to lactating WAD goats

Parameters	A	B	C	GRASS*
Crude fibre	4.41	5.05	5.03	34.02
Crude protein	15.05	15.04	15.01	8.99
Ether extract	4.59	4.95	4.90	1.25
Ash	13.25	14.21	14.00	9.33
Ca	0.35	0.60	0.71	0.40
P	0.18	0.23	0.30	0.20
Mg	0.11	0.16	0.18	0.30
K	0.32	0.69	0.51	1.58
Energy (Mcal/gDM)	2.33	2.36	2.34	2.75

**Panicum maximum*

Table 3: Performance characteristics of lactating WAD goats

Parameters	A	B	C	SEM
Initial weight (kg)	22.92	23.35	24.01	2.08
Final weight (kg)	25.32	26.00	26.91	2.16
Weight change (kg)	2.40	2.65	2.90	0.90
Daily weight gain (g)	28.99^a	31.54^b	34.52^b	2.53
Dry matter intake (kg day^{-1})	0.66^a	0.75^b	0.80^b	0.04
Milk yield (g day^{-1})	185.30^a	301.20^b	340.05^c	9.05

a, b, c: Means on the same row with same superscript are not significant different (p>0.05), A B C: See text, SEM: Standard error of the means

Table 4: Circulating levels of Calcium, Phosphorus, Magnesium (mg 100 mL^{-1}) Potassium (mmol L^{-1}) in serum of lactating WAD goats

Minerals	Period	A	B	C	SEM
Ca	Prelactation (days)	9.94[a]	10.21[ab]	10.53[b]	0.15
	Lactation (weeks)				
	Early lactation (2-4)	9.73	9.70	10.05	
	Mid lactation (6-8)	9.45	10.00	10.10	
	Late lactation (10-12)	10.08	10.05	10.13	
	Mean	9.75[a]	10.05[b]	10.35[b]	0.35
P	Prelactation				
	(0 -7 days)	7.80[a]	8.63[b]	9.16[c]	0.40
	Early lactation	6.43	7.10	7.23	
	Mid lactation	3.60	3.30	4.40	
	Late lactation	2.25	3.25	3.15	
	Mean	3.20[a]	3.52[a]	4.52[b]	0.31
K	Prelactation				
	(0-7 days)	4.30	4.80	4.28	0.08
	Early lactation	3.60	3.95	3.85	
	Mid lactation	3.60	3.80	3.80	
	Late lactation	3.40	3.75	3.65	
	Mean	3.53	3.85	3.77	0.07

a, b, c: Means on the same row with same superscript are not significant different ($p>0.05$), A B C: See text, SEM: Standard error of the means

Table 5: Minerals (Ca, P, Mg and K) in milk of lactating WAD goats (mg100 mL^{-1})

Minerals	Period	A	B	C	SEM
Ca	Prelactation (days)				
	0-7	138.20	145.65	152.63	7.45
	Lactation (weeks)				
	Early lactation (2-4)	192.50	120.15	129.15	
	Mid lactation (6-8)	122.70	127.75	131.50	
	Late lactation (10-12)	127.75	133.75	135.25	
	Mean	120.98[a]	127.20[b]	131.97[c]	7.05
P	Prelactation				
	0-7	107.20[a]	111.65[b]	113.45[c]	9.30
	Early lactation	84.01	89.50	97.00	
	Mid lactation	80.50	91.35	94.25	
	Late lactation	89.00	88.50	91.00	
	Mean	84.50[a]	89.78[a]	94.08[b]	2.01
Mg	Prelactation				
	(0-7 days)	27.67[a]	43.30[b]	56.45[c]	9.25
	Early lactation	21.03	43.01	52.51	
	Mid lactation	18.58	41.95	48.27	
	Late lactation	17.13	38.61	42.07	
	Mean	18.90	41.19	47.61	
K	Prelactation				
	(0-7 days)	178.45	186.78	179.95	8.09
	Early lactation	152.90	165.01	152.51	
	Mid lactation	155.00	160.33	161.87	
	Late lactation	167.13	169.72	167.35	
	Mean	158.43[ac]	165.03[b]	160.58[bc]	

a, b, c: Means along the same row with same superscripts are not significantly different ($p>0.05$), A, B, C: See text, SEM: Standard error of the means

the body weight of goats[6]. Goats on diets B and C had significantly different ($p<0.05$) mean DMI values than their corresponding goats on diets A. This suggested that increasing Ca, P, Mg and slightly declined K levels increased acceptability and indeed the DMI of feed. The mean values of DMI are presented above. The weight changes of the animals also followed similar trend with does on diet C which had highest DMI recorded highest daily weight gain (g) of 34.52 compared with does on diets A and B with 28.99 and 34.52 respectively. Treatment effects on weight changes were significant ($p<0.05$). the animals had adequate DMI which resulted into appreciable weight gain observed during this study.

The average milk yield (g day^{-1}) obtained for animals on diets A, B and C were reported above. The values were low when compared with 2.65 kg and 3.28 kg day^{-1} for Alpine and Saanen goats, respectively[15,16]. Effect of treatment a milk yield increased with increasing levels of Ca, P, Mg and slightly declined (0.53%) K in the diets with similar trend to that of DMI. The low milk yield obtained for WAD goats could be due to the fact that they are not dairy types unlike Alpine and Saanen. In addition, the experiments were carried out in different environmental situations which could affect the findings. The milking method (hand milking) could also be responsible as this may not be as efficient as milking machine used in the temperate. Variation was observed between milk evacuated from udder halves but such variation were not significant ($p>0.05$). The result of circulating levels of Ca, P, Mg and K in serum and milk are presented in Tables 4 and 5, respectively.

Treatment and period (weeks 2, 4, 6, 8, 10 and 12) effects on serum Ca, P, Mg and K were significant ($p<0.05$). It was generally observed that the obtained serum Ca, P, Mg and K 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 declined with advancing lactation. However, mean serum values of these minerals were with the normal ranges (mg 100 mL^{-1}), Ca, 10-12, P 4.5-6 and Mg 1.8-3.2 mg as adequate for goats, thus suggesting adequacy of the mineral contents of the diets fed the lactating goats. Though, serum K has been reported[17] to be a poor indicator of K depletion or K status in the animal or human body, it was determined in the present study to access any existing correlation with the corresponding content of K in milk of WAD goats.

However, because reliable evaluations of K deficiency based on tissue analyses are not available, dietary K concentration appears to be the best indicator of K status.[2]. Therefore, for the purpose of this study dietary K concentration which ranged from 0.32 to 0.69 and still within the recommended[6] range values of 0.50 to 0.80% except for diet A which contained 0.32% but had more supply from grass, thus suggested that the animal had sufficient K in their fed diets. Dietary supplementation of K was not done in the present study since common plants food or feeds have been reported[2,7,18] to generally contain plentiful supplies that can meet animals dietary requirements. This made its control in the diets (A, B and C) ineffective compared to supplemented minerals.

Besides, it's also to prevent complex interactions among the supplemented salts which may result to the formation of complex compounds that might inhibit palatability and acceptability of the diets. Indeed supplemented forms of K have been reported[2] to be unpalatable.

The milk concentration of (Ca, P, Mg and K) where characteristically similar for goats on diets A, B and C the concentration of these minerals were higher in colostrum (prelactation days) than the mature milk (Table 5). Similar trend has been reported for human milk[19] and cow milk[20]. The higher contents in colostrum confirmed its nutritional quality of as a complete diet for the neonates for them to survive the critical period of their lives. Treatment effects on milk Ca and P were significant ($p<0.05$). While the Ca content of mature milk increased with advancing lactation the P contents of milk (Table 5) increased with increasing dietary Ca and P levels. The obtained Ca content of milk (Table 5) for does on diets A, B and C were in accordance with a range of (mg dL^{-1}) 128.48 to 152.16[21] except for does on diet A that had relatively lower mean value.

The Mg and K concentrations in milk have been reported as criteria for their requirements for lactation goats[7]. Treatment effect on milk Mg was significant ($p<0.05$) the mean values of Mg in milk (mg 100 mL^{-1}) for goat on diets A, B and C (Table 5) were higher than the value of (0.14 Kg^{-1}) reported by Brendehang and Abrahamsem[22] for European Saanen and Alpine milk. Except for goats on diet A 18.90 (mg 100 L^{-1}) which had relatively close value to that of published value for European breeds the higher values obtained in this study may be due to the dietary levels of Mg. Treatment effect on milk K was also significant ($p<0.05$) the mean value of K in milk (mg 100 Lm^{-1}) of WAD goats were presented in Table 5. The values were lower than (2.1g Kg^{-1} milk) reported for Alpine goats[23,24]. The K values for the present study were probably normal for goats in the tropics owing to their smallish body size. The Mg and K concentration in milk and serum also followed similar trend reported for Ca and P as they increased with increasing dietary Mg and K levels. This further indicates that diets are the primary source of serum and milk mineral. Treatment has significant effect 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[25] to originate from blood contents. This is further proven by the highly significant ($p<0.05$) positive correlation ($r = 0.99$, 0.97 and 0.85) and a significant ($p<0.05$) positive correlation (0.73) observed between Ca, P, K and Mg contents of milk and corresponding contents in blood, respectively.

CONCLUSION

The entire biochemical studies on Ca, P Mg and K in serum of lactating does coupled with concomitant secretion in milk reflected adequacy of nutrition of the test animals. Thus, the results obtained for Ca, P, Mg and K value in milk of lactating WAD goats in this study are prerequisite and indeed imperative to further studies on goat mineral (Ca, P, Mg and K) requirements for lactation. The present finding also indicate that the dry matter intake DMI of the lactating does increased with the increasing dietary levels of Ca, P, Mg and slightly declined K. Therefore, where fortification of diet is necessary, dietary Ca, P, Mg and K levels should not be more than 0.71, 0.30, 0.18 and 0.53%, respectively for improved goat performance during lactation. This was evident by the elevated DMI, with concomitant increased milk yield and its contents of Ca, P, Mg and K obtained in the present findings.

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