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EFFECTS OF VARYING LEVELS OF DCAD WITH TWO LEVELS OF MG AND K ON ACID BASE STATUS, MG METABOLISM AND PRODUCTIVE PERFORMANCE OF BEETAL GOATS

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ABSTRACT

Thirty-six *Beetal* goats in early lactation were used in a 6-wk experiment with a 3 x 2 x 2 factorial arrangement of treatments. The objective was to reveal the effects of three levels of DCAD (-15, 2.5 and 20mEq/100g of feed DM) with two levels of K (1.35 and 2.0% of feed DM) and two levels of Mg (0.37 and 0.74%) in diets on productive performance. Increasing DCAD levels in diets significantly increased DMI, milk yield and milk fat percentage. Moreover, increasing K levels in diets increased milk yield of goats. However, increasing Mg levels in diets from 0.37% to 0.74% of feed DM negatively influenced the DMI intake, DM digestibility, milk yield and milk protein contents, as all the traits were reduced by increasing Mg levels. A linear increase in pH and HCO_3^- contents of blood and urine by increasing DCAD levels in diets evidenced a positive alteration in acid base status of the animals. However, K and Mg levels of diets showed no effect on same traits. Moreover, increasing K levels of diets reduced the Mg absorption. Similarly, higher Mg absorption, retention and balance were observed when added Mg was increased in diets. Overall, increasing DCAD levels in diets improved DMI and milk yield (3.5 and 11.1%, respectively), however, increasing Mg levels in diets showed negative effects on productive performance of *Beetal* goats.

Key words: Dietarycation anion difference (DCAD); dry matter intake (DMI); Bicarbonate (HCO_3^-); magnesium (Mg); potassium (K); nitrogen (N).

INTRODUCTION

Sodium (Na), K and Cl are the main electrolytes and are interlinked to maintain body fluid, osmotic balance, acid-base equilibrium, integrity, and pumping mechanism of cell membranes in livestock performance. Na makes up over 90% of the total body cations and Cl, two third of the acidic anions. Being the major intracellular cation (approximately 75 percent of total cation), K performs the same function that Na performs outside the cell (McDowell 1992).

As fixed ions, Na, K, and Cl remain un-metabolized in the system after absorption thus affects the electrical balance of the body fluids. However, to maintain acid base status of the body within desirable range, animal's body regulates the output of acidity in response to any change in input. Mongin (1980) revealed that net acid intake can be presented as the difference between cations and anions present in the diet. This difference is referred as DCAD. Several studies showed that Na, K and Cl in diet effects the acid base status of the animal's body resulting in altered productive performance (Sanchez *et al*. 1994). Research on lactating animals showed that DCAD can be used as a tool to check the acid base status of the animals within desirable range and ultimately to get the optimum milk production (Tucker *et al*. 1988). However, not much research is carried out in small ruminants especially in local breeds of Pakistan.

In Pakistan, small ruminants mostly raised by small land holders and they mostly rely on grazing for their animals, without any concentrate supplementation. Forages are usually high in K which inhibits Mg absorption in cows and sheep (Kemp *et al*. 1961; Newton *et al*. 1972) which is the second major intracellular cation after K and is an active constituent of numerous enzymes in animal's body. Moreover, grazing animals fed only on forages usually are more prone to grass tetany (McDowell 1992), one of the major problems associated with Mg deficiency.

Keeping all the above issues in view, the present study was planned to evaluate the influence of varying levels of DCAD with two levels of Mg and K in diets on acid base status, Mg metabolism and productive performance of *Beetal* goats.

MATERIALS AND METHODS

Experiment was conducted at Small Ruminants Training and Research Centre, Ravi Campus, UVAS and all the analytical work was done at the Department of Animal Nutrition, , UVAS.

Housing and Animals: Experiment was conducted from mid-June till end-July. Thirty six *Beetal* goats (45-55

kgs) in early lactation were grouped according to body weight and randomly assigned to twelve different experimental treatments under a 3 x 2 x 2 factorial arrangement. Goats were fed in individual feeding stalls for two weeks which was an adjustment period before conducting the actual experiment/trial. In first week of adjustment period, goats were fed on standard herd diet and data of feed intake, milk yield, milk composition, urine and plasma constituents were collected which were further used for covariate analysis of treatment period data. During second week of adjustment period, feed was changed from standard herd diet to treatment diets which were followed by four collection periods of 7 days each.

Diets and feeding schedule: Animals were fed on total mix ration (TMR). Twelve different experimental diets were offered (Table: 43) to different animal groups consisting of three levels of DCAD (-15, +2.5 and +20), (Na+K–Cl+SmEq/100g of DM; Tucker *et al*. 1992) by using two levels of Mg (0.37% and 0.74% of DM), and two levels of K (1.45% and 2.0% of DM). The diets were madeiso-nitrogenous and iso-caloric to meet the NRC requirements of sheep for protein and energy (NRC1985). Animals were fed twice daily at 0600 h and 1800 h *ad-libitum* and rations were fed to allow for approximately 10% refusal the next day.

Sampling schedule and procedure: Feed sampling was done weekly for each diet and pooled over the whole experimental period for each group. Daily feed refusals were weighed and DMI was calculated. Total collection of faeces for individual animal was done by using specially designed drums, followed by weighing. Feed and faeces samples were dried in hot air oven at 55 °C and stored at -40 ˚C until further analysis. Blood samples (12ml) were taken from the jugular vein in two separate heparin coated vacuum tubes of 6ml each (Becton Dickinson Vacutainer Systems; Franklin Lakes. NJ). Blood pH was immediately analysed from one tube by using blood pH analyser while plasma, separated from second tube, was transferred to plastic scintillation vials and frozen at -40 ˚C for future analysis. For total collection, urine was collected in small special metal buckets fitted with plastic pipe. The metal buckets surround the vulva and plastic pipe ended in a collection container. On each collection period, midstream urine was collected followed by immediate urine pH measurement. Moreover, 30ml urine sample was acidified with 50% H_2SO_4 and stored in plastic container at -40 ˚C for further analysis. Milking was done twice daily and milk yield was determined at each milking using calibrated weigh jars. A daily composite of milk from the 0600 and 2000 h milking was sampled and stored at -40 ˚C for further analysis.

Analytical methods and calculations: Feed and faeces were measured for DM (method 930.15; AOAC 1990) and crude protein (CP; Kjeldhal method; 955.04; AOAC 1990). The analysis of minerals (Na, K, Mg and Calcium; Ca) was carried out by using Flame Atomic Absorption Spectrophotometer (FAAS; Perkin-Elmer, AA400) for feed, faeces after wet digestion and blood plasma and urine by direct aspiration without any prior treatment. Milk Mg contents were also analysed by FAAS after fat removal by trichloricacetic acid (TCA) treatment. The Cl was extracted with the help of acetic acid and nitric acidcombinationfrom feeds and determined along with P (wet digested sample) by Immune Coupled Plasma Atomic Emission Spectroscopy (ICP-AES; Optima 7000 DV; PerkinElmer Inc, MA, USA). However, P, Cl, urea, creatinine, glucose and HCO_3^- in blood plasma and P, Cl and creatinine in urine samples were analysed spectrophotometerically by using commercially available kits (Randox Laboratories Ltd., Antrim, UK; BioSupply, UK). HCO_3^-concentration in urine samples were analysed by titration with 0.01N H_2SO_4 (AOAC 1990) and sulfur (S) concentrations in feed samples were estimated by gravimetric analysis with $BaCl_2$ (AOAC, 1995). Milk composition was determined by infrared analysis using milk analyser (Milkoscan, Foss Electric, Hillerød, Denmark). Mg balances were determined by using equations as described by NRC (2001). Urine cation anion balance (CAB; Na+K-ClmEq/L) was calculated as described by West *et al.(*1992).

Statistical Analysis: Results were analysed by JMP using the three way ANOVA (3 levels of DCAD x 2 levels of K x 2 levels of Mg).

RESULTS AND DISCUSSION

DMI and DM digestibility: Results of present study indicated that increasing the DCAD levels of the diets linearly ($P<0.05$) increased the DMI of the animals (Table. 2). However, same treatment showed no effect on DM digestibility. Moreover, increasing Mg levels in diets significantly ($P<0.01$) reduced the DMI and DM digestibility of experimental animals (Table. 2). However, K levels of the diets showed no effect on same traits. A linear increase in DMI was previously observed with increasing the DCAD level of the diet by other scientist (Tucker *et al*. 1988; West *et al*. 1992; Hu *et al*. 2007). A recent meta-analysis also indicated a positive correlation between DMI and DCAD levels of the diet and revealed a linear increase in DMI when diets turned cationic from anionic ones (Hu and Murphy 2004). This increase in DMI might be due to improved acid-base status of the animals as evidenced by alterations of blood and urine pH. Though, another possible justification could be the improved rumen environment as alkaline environment is better for rumen micro floral activity (Tucker *et al*. 1988). Moreover, diets with high anionic salts are also linked with poor DMI due to un-palatability

of diet after adding such anionic salts (Goff *et al*. 1991; Spanghero 2004) especially $CaCl_2$ (Escobosa *et al*. 1984),.

In the present study, increasing Mg level in diet showed reduction in DMI. Thomas and Emery (1969) reported reduced DMI (12-16%) in goats fed on diets containing Mg content of 0.33 to 0.72%, respectively and Mg depressed DMI. NRC (1980) reported 0.5% Mg as the maximum tolerable level for sheep and a major decrease in DM digestibility is reported above 0.6% Mg in the diet (Chester-Jones *et al*. 1989). We can assume that the 0.75% Mg in the present study was above the desirable level of dietary Mg for *Beetal* goats. However, findings of Erdman *et al*. (1980); Teh *et al*. (1985) were contradictory; they observed no impact of Mg supplementation on DMI. Some researchers also reported that high Mg in diet leads to anorexia (Gentry *et al*. 1978; Quillian *et al*. 1980). In current study, DCAD and K levels showed no effects on DM digestibility. Previous research showed a mix response of increasing alkalinity of diet on DM digestibility, as some researchers reported no effect on said parameter (Delaquis and Block 1995; Tucker *et al*. 1991a). However, other researchers showed a positive effect of adding NaHCO3 in the diet on DM digestibility (Rogers *et al*. 1985; Stokes *et al*. 1986). Though, this positive effect of NaHCO3 on DM digestibility showed different response when added with different type of feeds (Canale and Stokes 1988). Results of current study showed that increasing the Mg level from 0.37% to 0.74% in diet decreased the DM digestibility significantly.

Milk yield and composition: Analysis of milk yield and composition revealed significant differences owing to the varying DCAD, Mg and K levels. The increase in DCAD levels from -15 to 20mEq/100g of DM linearly increased ($P<0.01$) the milk production (Table 2). Moreover, a significantly ($P<0.01$) higher milk fat % was observed in the animal groups fed on DCAD levels of 20mEq/100g of DM as compared to the animals fed on DCAD level of -15 mEq/100g of DM. Furthermore, higher K levels of the diets significantly ($P<0.01$) increased the milk yield but reduced the milk fat content in the same time (Table. 2). However, changing the DCAD and K levels of diets showed no effect on milk protein, lactose and SNF contents. Results further revealed that higher Mg levels of the experimental diets significantly ($P<0.01$) reduced the milk yield and protein content. (Table. 3). However, milk fat, lactose and SNF contents were not affected by varying Mg levels in the diets. The results of present study are in agreement with the findings of other researchers (Tucker *et al*. 1988, West *et al*. 1991; Delaquis and Block 1995; Shahzad *et al*. 2008). However, Joyce *et al*. (1997) reported no effect of DCAD on milk yield. Similarly, Roche *et al*. (2003) observed a decrease in milk production from 25.4 to 23.2L/d by increasing DCAD level from 21 to 127mEq/100g of DM which might be due to different levels of DCAD used in their research. Hu and Murphy (2004) suggested an optimum level of DCAD (34-40mEq/100g of DM) for optimal milk production in dairy cows after conducting a meta-analysis.

In early lactation, usually animals are offered high grain diets, which tend to create acidic condition in the body. Moreover, animals in early lactation are more prone to acidic condition due to high metabolic activity. Feeding high DCAD diets might improve the acid base balance of animals by its alkaline nature, which improves DMI and ultimately milk production of animals. Results of present study further revealed that increasing K level in diets increased the milk yield. The effect of K levels in diets are also season dependent. An increased milk yield was observed in summer season by increasing dietary K levels (Schneider *et al*. 1984, 1986) but no effects were observed during winter season (O'Connor *et al*. 1988). These findings are in agreement with the results of this study conducted in summer season, variations in findings might be due to different weather conditions during research.

An increased milk production was observed by increasing dietary Mg from 0.26 to 0.48%, however it decreased when Mg level (0.60%) was further increased (O'Connor *et al*. 1988). However, no effect of Mg supplementation on milk production was reported by other studies (Thomas *et al*. 1984). This might be due to the use of different Mg concentrations in diets. Milk fat percentage was also significantly improved by increasing DCAD levels of diets during this study and supported by the previous studies (West *et al*. 1992; Roche *et al*. 2005) which stated that by increasing the DCAD levels of diets in lactating dairy cows increased milk fat percentage. It assumed that high DCAD diets might change rumen fermentation configuration from propionate to butyrate because of its alkaline nature (Klover and de Veth 2002). Increasing K level in diets reduced the milk fat percentage in current study. Furthermore, increasing Mg level in diets decreased the milk protein contents. These results are in agreement with those reported by other researchers (Thomas and Emery 1969, O'Connor *et al*. 1988). However, Erdman *et al*. (1982) reported no effects of Mg levels on milk protein percentage.

Blood analysis: Results of present study revealed that blood pH and concentrations of HCO_3^- linearly increased by increasing the DCAD levels of experimental diets and maximum values were observed at DCAD level of 20.0mEq/100g of DM (Table 3). However, none of the experimental treatments affected the urea, creatinine and glucose concentrations of blood plasma. Similar results are reported earlier – DCAD usually influence pH and $HCO_3^-$of blood as is indicated from the studies of Jackson *et al*. 1992; Roche *et al*. 2005; Charbonneau *et*

al. 2006; Hu *et al*. 2007; Li *et al*. 2008. Fredeen *et al*. (1988) also reported an elevated blood pH and $HCO_3^-$by increasing the DCAD level of the diet in lactating goats. Cl ion absorbed into the blood by exchange of Na ion and when Cl ions concentration is higher than Na ion, then HCO_3^-defecate from blood to compensate a Cl ion and to maintain the blood pH in desirable range. Similarly, Na ion concentration increases than Cl concentration, and then H+ ions compensate the Na ion (Block, 1994). In present study, a linear decrease in HCO_3^- concentration and blood pH with increasing Cl contents of diet is in agreement of said mechanism.

The DCAD levels of the diets significantly affected the plasma Na, Cl and P concentrations. Plasma Na concentrations increased with increasing the DCAD levels, however, maximum concentrationswere observed in DCAD levels of 2.5 mEq/100g of DM (Table. 3). Moreover, a linear decrease in plasma Cl concentrationsand a linear increase in plasma P concentrations were observed by increasing the DCAD levels from -15 to 20 mEq/100g DM of the experimental diets.However, plasma K, Ca and Mg concentrations were not affected by DCAD alterations in diets. Fredeen *et al*. (1988) reported an increased plasma Na concentration in goats with increasing DCAD level of the diet. However, these results are in contradiction with previous studies which reported no change in plasma Na concentrations (Tucker *et al*. 1988; West *et al*. 1992; Hu and Murphy 2004). Decreased plasma Cl contents with higher DCAD levels in present study are in agreement with the results of previous studies (Fredeen *et al*. 1988; Tucker *et al*. 1991b). Moreover, Roche *et al*. (2005) reported an elevated plasma P in response to higher DCAD levels of the diets.Na and K excretion through urine is coupled with the excretion of Cl and in present study plasma K concentration was not changed even with high intake of K, moreover, though plasma Na was changed with higher Na intake but still that changes were not much prominent as compared to plasma Cl concentrations. The higher K and Na concentration entered in blood, were excreted with Cl which showed a clear decrease in Cl contents of plasma with increase in dietary K and Na contents. Increasing the K levels of the diets from 1.35 to 2.0% significantly ($P< 0.01$) increased the plasma Na concentrations, however, the same dietary alteration significantly decreased ($P< 0.01$) the plasma Ca concentrations (Table. 3). Furthermore, increasing the dietary Mg levels significantly increased the Mg and Na concentrations in blood plasma. O'Connor *et al*. (1988) observed an increased plasma Mg concentrations from 2.52 to 2.68mg/dL when increased Mg contents of diet from 0.26 to 0.6%. Other studies also reported the same results (Teh *et al*. 1985;Thomas *et al*. 1984).

Mg metabolism: Mg metabolism (Table 4) influenced ($P<0.01$) by various levels of DCAD, Mg and K in diet. Increasing the K levels of the diets from 1.35 to 2.0% significantly ($P<0.01$) reduced the Mg absorption.Furthermore, higher K levels significantly ($P<0.01$)increased the Mg excretion through faeces. However, reduced urinary excretion of Mg was observed at 2.0% K level when compared with the animals fed 1.35% K in diets.However, Mg intake, retention, milk secretions and overall balance were not affected by manipulations of dietary K levels.Greene *et al*. (1983) observed the increased Mg excretion in faeces and decreased Mg absorption when K levels of diets increased from 0.06 to 4.8% of diet. Moreover, he observed a lower Mg excretion in urine by increasing K levels in diets, however, results were not statistically significant. Similarly, Field and Suttle (1979) reported that increasing K levels in diets decreased the faecal Mg contents but increased the Mg excretion in urine. Other researchers also reported a decrease in Mg absorption by increasing added K in diets (Kemp *et al*. 1961; Newton *et al*. 1972).

Increasing the Mg levels in diets significantly increased ($P<0.01$) its intake, absorption, excretion through urine and faeces, retention and overall balance in animals' body (Table. 4). However, Mg secretions through milk were not affected by altering Mg levels in experimental diets. DCAD levels of the diets significantly ($P<0.01$) affected the Mg absorption and its excretion through urine but Mg retention and overall balance remained intact. Maximum Mg absorption and urinary excretions were observed with the DCAD level of 2.5mEq/100g of feed DM. Results of present study coincide with other scientists (Rook and Storry 1962; Dutton and Fontenot 1967) who observed the increased absorption, retention and excretion via urine and faeces with increased Mg in the diets of sheep.

Urine analysis: The urine pH and HCO_3^- concentrations linearly ($P<0.01$) increased by increasing the DCAD levels of experimental diets (Table. 3). However, Mg and K levels of the diets did not affect any of the said parameter.Linear increase observed in urine pH and HCO_3^- contents of urine, representing an alteration in acid base status of the animals. Several researchers reported the drop in pH by decreasing DCAD level in goats (Stratton-Phelps and House 2004), feed lot cattle (Manna *et al*. 1999) and dairy cows (West *et al*. 1992; Pehrson *et al*. 1999; Hu *et al*. 2007). Drop in urinary pH is directly reflects acidic nature of the diet. Borucki Castro *et al*. (2004) reported increased urine HCO_3^- content by increasing the DCAD level in the diets. Higher urinary HCO_3^-levels were in response to homeostasis mechanism of body tried to keep the body in desirable acid base status when alkaline diets were exposed to the animals (Halperin and Goldstein 1994). The urinary CAB

(Na+K-ClmEq/L) was linearly increased by increasing DCAD level (Table. 3). Findings of present study are in

concur with West *et al*. (1992) and Wildman *et al*. (2007) who reported a linear increase in urinary CAD level by increasing the DCAD levels. A strong correlation between DCAD and urinary CAD was obvious, as Na, K, and Cl mainly excrete via urine and any change in their dietary intake can directly influence their excretions in urine.

Urine analysis further indicated that DCAD levels significantly affect (P<0.01) all minerals/creatinine ratios except P. However, changing Mg Levels in the feed significantly (P<0.01) affect the Na/creatinine (Na/Cr) and Mg/creatinine (Mg/Cr) ratios whereas K levels had significant (P<0.01) effects on K/creatinine (K/Cr), Cl/creatinine (Cl/Cr) and Mg/Cr ratios. Changing the DCAD levels showed curvilinear response in Na/Cr, K/Cr, and Mg/Cr, however the same treatment linearly changed (P<0.01) the Cl/Cr and Ca/creatinine (Ca/Cr) ratios in urine. Cl/Cr ratio decreased by increasing (P<0.01) the DCAD level in diet from -15 to 2.5 and 20mEq/100g of DM, respectively but increasing the DCAD level in same manner decreased (P<0.01) the Ca/Cr ratios.Furthermore, increasing the added Mg in diet from 0.37 to 0.74% significantly decreased (P<0.01) the Na/Cr ratios but increased (P<0.01) the Mg/Cr ratios (Table. 3). However, no effects of added Mg were observed in K, Cl, Ca and P excretions through urine. Results of the present study further indicated that increasing the added K in the diet from 1.35% to 2.00% significantly increased (P<0.01) the K/Cr and Cl/Cr ratios. However, Mg/Cr ratio decreased (P<0.01) by increasing the K of the diets.Moreover, increased K levels in diets showed no effects on Na, ca and P excretions. West *et al*. (1992) reported a linear decrease in Ca/Cr and Cl/Cr ratios in urine by increasing DCAD levels and significant effects of same treatment on Na/Cr and K/Cr ratios in urine of dairy cows. Similarly, increasing DCAD linearly reduced the Ca/Cr and Cl/Cr ratios in urine, however, Na/Cr ratio increased linearly by increasing the DCAD levels of feeds offered to dairy cows (Roche *et al*. 2005). Decreased Cl excretion in urine was the body mechanism to counter the acid condition of body caused by low DCAD diets. Similarly, decreased urinary excretions of Ca through urine evidenced that decreasing the DCAD level increased the Ca absorption. Lowering the urinary excretion of Ca by increasing the DCAD level was might be due to increased reabsorption of Ca in distal tubules. Ram *et al*. (1998) reported increased Mg excretion in urine by increasing Mg contents of diet. Similarly, increased Mg excretion in urine was observed when Mg levels of diets increased from 0.1 to 0.2% of the diet fed to whether lambs (Greene *et al*. 1983). Increased urinary excretion of Mg was might be due to increased Mg absorption in present study. Results of present study further indicated that increased K levels in diets significantly increased K/Cr ratio but decreased Mg/Cr ratio in urine. Increased urinary excretion of K might be due to function of increased K absorption.

Table1. Ingredient and nutrient composition of diets (% of DM)

	DCAD + 20				DCAD + 2.5				DCAD -15			
*	LK		HK		LK		HK		LK		HK	
**	HM	LM	HM	LM	HM	LM	HM	LM	HM	LM	HM	LM
Ingredients (%)												
Corn	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
Wheat straw	30.63	31.29	29.31	29.97	30.09	31.36	28.85	30.08	29.07	30.25	27.85	29.02
Canola meal	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21
Sunflower meal	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Corn gluten 30%	20	20	20	20	20	20	20	20	20	20	20	20
Rice polishing	20	20	20	20	20	20	20	20	20	20	20	20
Sugarcane molasses	10	10	10	10	10	10	10	10	10	10	10	10
Mineral and vitamin premix	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
$CaCO_3$	0.614	0.614	0.614	0.614	-	-	-	-	-	-	-	-
$CaCl_2$	-	-	-	-	0.670	0.670	0.670	0.670	0.670	0.670	0.670	0.670
$NaHCO_3$	0.668	0.668	0.726	0.726	0.693	0.205	0.693	0.260	-	-		-
NaCl	-	-	-	-	-	0.335	-	0.297	0.577	0.577	0.577	0.577
K_2CO_3	-	-	-	-	-	-	-	-	-	-		-
KCl	-	-	1.26	1.26	-	-	1.26	1.26	-	-	1.26	1.26
MgO	0.658	-	0.658	-	0.535	-	0.580	-	0.227	-	0.237	-
$MgCl_2$	-	-	-	-	0.582	-	0.516	-	2.026	-	1.978	-
NH_4Cl	-	-	-	-	-	-	-	-	-	1.075	-	1.040
Mineral Composition (%)												
Na	0.303	0.306	0.321	0.319	0.311	0.310	0.310	0.313	0.350	0.351	0.350	0.350
K	1.344	1.340	2.071	2.052	1.348	1.344	1.971	2.002	1.352	1.355	2.043	2.102
Cl	0.475	0.477	1.072	1.073	1.108	1.103	1.681	1.679	1.960	1.967	2.541	2.539
Ca	0.502	0.507	0.500	0.510	0.506	0.507	0.506	0.502	0.501	0.500	0.510	0.503
P	0.614	0.614	0.618	0.617	0.616	0.614	0.615	0.619	0.611	0.614	0.613	0.611
Mg	0.744	0.375	0.749	0.371	0.742	0.377	0.749	0.372	0.743	0.371	0.747	0.372
S	0.234	0.233	0.237	0.234	0.236	0.237	0.234	0.236	0.239	0.238	0.238	0.236
***DCAD**	+19.6	+19.5	+21.9	+21.3	+2.00	+2.00	+1.91	+2.04	-20.3	-20.3	-18.9	-18.3

* LK= low K (1.35%), HK = High K (2.0%); ** LM = low Mg (0.37%), HM = (0.74%) ***DCAD = (Na + K –Cl –S mEq/100g of feed DM)

Table 2. Effect of varying levels of DCAD, K and Mg on DMI, DM digestibility, milk yield and milk composition

Variable	[1]DCAD			Mg		K		Effect (P)		
	-15	2.5	20	0.74%	0.37%	2.0%	1.35%	DCAD	Mg	K
DMI, g/d	1229.2±46.00	1256.3±52.52	1272.8±64.73	1220.8±17.37	1284.7±16.90	1250.3±8.83	1255.3±23.44	<0.05	<0.01	[2]NS
DM Digestibility, %	61.59±2.11	63.19±3.40	61.78±2.22	60.71±1.02	63.66±1.19	62.43±1.24	61.94±1.14	NS	<0.01	NS
Milk										
Yield, ml	549±27	563±20	609±19	551±11	596±9	583±8	565±11	<0.01	<0.01	<0.01
Fat, %	4.14±0.20	4.06±0.17	4.38±0.23	4.23±0.09	4.16±0.05	3.87±0.04	4.51±0.07	<0.01	NS	<0.01
Protein, %	3.51±0.105	3.51±0.110	3.48±0.132	3.39±0.057	3.61±0.050	3.49±0.064	3.50±0.040	NS	<0.01	NS
Lactose, %	4.04±0.203	3.90±0.162	3.97±0.178	3.97±0.037	3.96±0.088	3.94±0.033	3.99±0.089	NS	NS	NS
SNF, %	7.87±0.340	7.76±0.327	8.04±0.286	8.06±0.052	7.72±0.086	7.88±0.077	7.90±0.118	NS	NS	NS

[1]DCAD= (Na+K-Cl-S)mEq/100g of DM [2]NS = P > 0.05

Table 3. Effect of varying levels of DCAD, K and Mg on blood and urine pH and constituents

Variable	[1]DCAD			Mg		K		Effect (P)		
	-15	2.5	20	0.74%	0.37%	2.0%	1.35%	DCAD	Mg	K
Blood										
pH	7.38±0.237	7.39±0.281	7.42±0.243	7.41±0.052	7.39±0.107	7.40±0.049	7.40±0.125	<0.05	[2]NS	NS
HCO_3^-, mM/L	24.43±1.041	25.41±0.900	27.84±1.174	26.24±0.302	25.55±0.313	26.61±0.247	25.18±0.328	<0.05	NS	NS
Urea, mg/dL	41.78±1.984	47.10±2.016	43.05±1.369	42.53±0.649	45.42±0.516	44.67±0.641	43.28±0.504	NS	NS	NS
Creatinine, mg/dL	0.60±0.021	0.58±0.018	0.58±0.024	0.59±0.004	0.59±0.006	0.58±0.004	0.59±0.005	NS	NS	NS
Glucose, mg/dL	51.75±2.561	52.33±1.591	49.70±1.726	51.62±0.343	50.90±1.128	52.05±0.892	50.47±0.797	NS	NS	NS
Na, mg/dL	294.78±10.301	301.40±11.180	296.08±11.185	300.43±4.448	294.40±5.170	306.05±4.881	288.78±5.110	<0.01	<0.05	<0.01
K, mg/dL	18.04±0.857	18.15±0.747	18.38±0.831	18.35±0.393	18.03±0.377	18.33±0.369	18.06±0.468	NS	NS	NS
Cl, mg/dL	380.43±9.625	368.95±16.233	360.75±13.954	376.17±4.388	363.92±4.796	373.53±4.899	366.55±4.489	<0.01	NS	NS
Ca, mg/dL	8.04±0.284	7.96±0.296	7.86±0.352	8.00±0.141	7.91±0.074	7.82±0.135	8.09±0.078	NS	NS	<0.01
Mg, mg/dL	2.24±0.076	2.30±0.107	2.26±0.103	2.35±0.046	2.18±0.035	2.26±0.040	2.28±0.042	NS	<0.01	NS
P, mg/dL	6.07±0.185	6.16±0.221	6.32±0.328	6.12±0.161	6.24±0.033	6.29±0.143	6.07±0.094	<0.01	NS	NS
Urine										
pH	7.05±0.277	7.81±0.298	8.13±0.296	7.78±0.078	7.55±0.067	7.64±0.048	7.69±0.079	<0.01	NS	NS
HCO_3^-, mM/L	65.13±2.251	121.90±4.277	232.70±6.467	139.38±2.925	140.43±1.941	137.25±2.305	142.57±2.629	<0.01	NS	NS
[3]CAB	-17.05±0.667	44.50±2.410	154.95±5.913	58.07±2.777	63.53±2.280	61.85±2.994	59.75±1.980	<0.01	NS	NS
Na:creatinine, mg:mg	2.82±0.109	1.81±0.064	2.79±0.125	2.32±0.030	2.63±0.070	2.44±0.028	2.50±0.061	<0.01	<0.01	NS
K:creatinine, mg:mg	10.49±0.411	6.89±0.221	9.04±0.300	8.41±0.122	9.21±0.107	10.57±0.086	7.05±0.153	<0.01	NS	<0.01
Cl:creatinine, mg:mg	13.44±0.512	6.58±0.276	5.40±0.174	8.00±0.168	8.95±0.198	10.03±0.172	6.92±0.162	<0.01	NS	<0.01
Ca:creatinine, mg:mg	0.13±0.005	0.06±0.002	0.03±0.001	0.07±0.003	0.08±0.002	0.07±0.002	0.08±0.003	<0.01	NS	NS
Mg:creatinine, mg:mg	1.19±0.045	0.82±0.035	1.00±0.038	1.24±0.016	0.77±0.008	0.95±0.017	1.06±0.020	<0.01	<0.01	<0.01
P:creatinine, mg:mg	0.04±0.002	0.03±0.001	0.03±0.001	0.03±0.001	0.03±0.001	0.03±0.001	0.03±0.001	NS	NS	NS

[1]DCAD= (Na+K-Cl-S)mEq/100g of DM
[2]NS = P > 0.05
[3]CAB = (Na+K-Cl) mEq/L

Table 4: Effect of varying levels of DCAD, K and Mg on Mg metabolism

Variable	[1]DCAD			Mg		K		Effect (P)		
	-15	2.5	20	0.74%	0.37%	2.0%	1.35%	DCAD	Mg	K
Intake, g/d	4.73±0.242	4.80±0.271	4.91±0.253	6.28±0.089	3.34±0.095	4.84±0.103	4.79±0.100	[2]NS	<0.01	NS
Faeces excretion, g/d	2.50±0.089	2.40±0.112	2.54±0.100	3.22±0.045	1.73±0.013	2.57±0.062	2.39±0.054	NS	<0.01	<0.01
Absorption, g/d	2.23±0.074	2.40±0.099	2.38±0.067	3.07±0.037	1.61±0.035	2.28±0.045	2.40±0.032	<0.01	<0.01	<0.01
Urine excretion, g/d	0.82±0.025	0.90±0.040	0.87±0.025	1.10±0.021	0.63±0.007	0.83±0.012	0.90±0.024	<0.01	<0.01	<0.01
Retention, g/d	1.42±0.050	1.50±0.055	1.51±0.059	1.96±0.018	0.98±0.009	1.45±0.020	1.50±0.028	NS	<0.01	NS
Milk secretion, g/d	0.082±0.030	0.078±0.003	0.076±0.003	0.076±0.001	0.081±0.001	0.081±0.001	0.076±0.001	NS	NS	NS
Balance, g/d	1.34±0.042	1.42±0.051	1.43±0.053	1.89±0.018	0.90±0.011	1.37±0.021	1.42±0.024	NS	<0.01	NS

[1]DCAD= (Na+K-Cl-S)mEq/100g of DM [2]NS = P > 0.05

Conclusion: In conclusion, present study revealed the positive effects of higher DCAD on DMI, milk yield, and milk fat percentage in *Beetal* goats. Furthermore, it protracted our understanding about different levels of Mg and K in diets of *Beetal* goats, as increased Mg level from 0.37% to 0.74% imposed negative effects on production performance of experimental animals. Moreover, increasing K levels in diets showed negative effects on Mg absorption and overall metabolism.

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