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**Madhu Suman**
Assistant Professor, ILFC, DGCN, COVAS Palampur, Himachal Pradesh, India

**Bhupendra T *Phondba***
Dairy Cattle Nutrition Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

**Preeti**
Dairy Cattle Nutrition Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

**Shivani Katoch**
Dairy Cattle Nutrition Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

**Harjit Kaur**
Former Principal Scientist, Dairy Cattle Nutrition Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

**Correspondence**
**Madhu Suman**
Assistant Professor, ILFC, DGCN, COVAS Palampur, Himachal Pradesh, India

# Effect of positive dietary cation anions difference based diet on feed intake and acid base status in crossbred calves in winter months

**Madhu Suman, Bhupendra T Phondba, Preeti, Shivani Katoch and Harjit Kaur**

**Abstract**
Present investigation has been focussed to study the effect of positive dietary cation anion difference (DCAD) based diet on nutrient intake and acid-base status of crossbred calves in winter months (December 10, 2011 - April 8, 2012). The calves were blocked into three equal groups on the basis of average body weight. The calves either received a basal diet (control) or +150 /+250 mEq/ Kg dry matter (DM) DCAD diets ($W_1$, $W_2$). The overall mean DMI in $W_2$ was significantly higher ($P<0.05$) as compared to $W_1$ and control groups. Na and K intakes were significantly more ($P<0.01$) in treatment groups as compared to control group. K balance was more $P<0.01$) in $W_2$ group as compared to control. Positive DCAD diets of +250 and +350 mEq/kg DM improved the nutrient intake and acid-base status so helpful in ameliorating the climatic stress.

**Keywords:** Thermal stress, dietary cation anion difference, crossbred calves, dry matter intake

## 1. Introduction

Climatic stress has strong impact on growth, productive and reproductive processes of the animals. Stress occurs when an animal experiences changes in the environment that stimulate body responses aimed at re-establishing homeostatic conditions [1]. Thermal stress increases demand for net energy for maintenance so there are reduction in energy for tissue growth and production [2, 3]. Cold stress (below the thermoneutral zone) increase maintenance requirement of livestock [4]. At ambient temperature below the lower limit of the thermoneutral zone, animals convert more energy to heat and digest the feed less efficiently [5]. In cold stress the feed intake is increased to compensate for heat loss, this response is directly related to the activity of the thyroid gland, which is elevated due to increased rumino-reticulum motility and higher rate of passage of digesta [4, 6]. To optimize the productive as well as reproductive performance in thermal stress, a diet containing various nutrients in balance quantity is necessary [7]. Dietary minerals plays very important role in various biological functions in the body. The difference between certain cations ($Na^+$, $K^+$) and anions ($Cl^-$, $S^-$) referred as a dietary cation anion difference (DCAD) which may be of more significance for animal productivity than their individual effects [8, 9]. Therefore, the present study was planned to determine the effect of different levels of DCAD based diets on feed intake and acid base status of crossbred calves in winter months.

## 2. Materials and Methods

### 2.1 Animals, experimental design and treatments

The present study was conducted at the Dairy Cattle Nutrition Division, National Dairy Research Institute, Karnal, Haryana 132 001. During the winter season, 18 female crossbred Karan Fries calves (5 to 9 months old) were selected from the institute’s herd and divided into 3 groups having 6 calves in each group, on body weight and age basis as control, $W_1$ and $W_2$. The experiment was continued for 120 days from December 10, 2011 - April 8, 2012. The crossbred calves of the three different groups were offered the same basal diet, but the animals in $W_1$ and $W_2$ groups were offered +150 and +250 mEq/ kg DM DCAD diet by addition of cationic salts ($NaHCO_3$ and $K_2CO_3$) in the basal diet. Experimental animals were fed as per NRC [5] standard and requirements of animal were fulfilled by feeding concentrate mixture, wheat straw and Maize/ berseem fodder.

The concentrate mixture was offered in the morning whereas, the chaffed green fodder was offered at 11:00 am. The dietary treatments were continued for 120 days. Concentrate mixture (CP 19.81% and TDN 70%) contained maize 33%, groundnut cake (oiled) 21%, mustard cake (oiled) 12%, wheat bran 20%, deoiled rice bran 11%, mineral mixture 2% and common salt 1%. Composition of roughage and concentrate mixture was estimated by drawing weekly samples. The feeds offered to the animals and residue left were recorded daily to find out the total DM intake of the animals. Animal experimentation was performed in compliance with regulations set by the cattle yard, NDRI and approved by the Institutional Animals Ethics committee. The animals were washed and brushed daily to remove dust and faeces adhered to the skin. Fresh drinking water was provided twice a day.

### 2.2 Chemical and mineral analysis of feed sample

The roughage and concentrate were grounded individually, labeled and analyzed for proximate composition as per AOAC [10] and cell wall constituents as per Goering and Van Soest [11]. Concentration of Na, K and Ca in feed, urine and faecal sample were analysed by atomic absorption spectrophotometer. Cl content of the samples was determined by the method of Chapman and Pratt [12]. S content in the samples was estimated by turbidimetric method [13] and P by Photometric method [10].

### 2.3 Statistical Analysis

The data obtained from both the experiments was analyzed by two way ANOVA as described in Snedecor and Cochran [14]. The test of significance among the different treatments was also analyzed [15].

## 3. Result and Discussion

### 3.1 Chemical composition of the experimental diet

Chemical and mineral composition of feedstuffs offered to the calves during the experimental period of 120 days is presented in Table 1.

**Table 1:** Chemical and minerals composition of feed ingredients DM basis (%)

| Feed/ fodder | CP | NDF | ADF | EE | Ash | Na | K | Cl | S | Ca | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Concentrate mixture | 21.23 | 34.17 | 21.83 | 4.72 | 5.04 | 0.99 | 1.30 | 1.33 | 0.47 | 1.16 | 0.71 |
| Maize fodder | 8.93 | 54.38 | 23.47 | 1.62 | 7.85 | 0.17 | 2.00 | 1.66 | 0.45 | 0.97 | 0.38 |
| Berseem fodder | 17.21 | 55.62 | 21.84 | 1.46 | 7.18 | 1.08 | 3.24 | 0.40 | 0.30 | 1.67 | 0.40 |

### 3.2 Environmental variables

The maximum and minimum temperature ($^0$C) during morning time ranged from 16.5-33.5 and 4.4-15.6, respectively throughout the experimental period (December - April). During afternoon, the corresponding temperature ranged from 19.5-34.1 and 5.8-18.16$^0$C (Table 2) which were higher than the morning temperature. The relative humidity in morning and afternoon ranged from 81-98% and 30-60%, respectively. The THI throughout the experimental period varied from 49.1-67.3 and 61.1-81.8 during morning and afternoon, respectively. Except in the last fortnight (VII and VIII) afternoon value for THI (72 and 81.8), all other values during the whole experiment were below 72, indicating cold stress to the animals [16].

**Table 2:** Environmental variables during the experimental period

| Fortnight | Max. Temp ($^0$C) | | Min. Temp ($^0$C) | | Relative Humidity (%) | | THI | |
|---|---|---|---|---|---|---|---|---|
| | M | A | M | A | M | A | M | A |
| 0 (Nov. 26,- Dec. 9,2011) | 26.1 | 26.4 | 12.1 | 15.8 | 94.0 | 43.0 | 59.0 | 71.6 |
| I (Dec. 10,- Dec. 24,2011) | 19.4 | 22.8 | 4.4 | 5.8 | 97.0 | 48.0 | 49.1 | 64.1 |
| II (Dec. 25,2011- Jan. 8,2012) | 18.4 | 21.7 | 6.9 | 8.3 | 98.0 | 60.0 | 54.6 | 62.3 |
| III (Jan. 9 – Jan. 23,2012) | 16.5 | 19.5 | 5.6 | 7.6 | 93.0 | 59.0 | 50.1 | 61.1 |
| IV (Jan.24 - Feb. 7,2012) | 19.1 | 21.6 | 6.0 | 7.4 | 88.0 | 49.0 | 51.7 | 64.1 |
| V (Feb. 8 – Feb. 22,2012) | 20.7 | 21.8 | 6.6 | 6.9 | 83.0 | 43.0 | 51.4 | 65.8 |
| VI (Feb. 23- March 8,2012) | 24.3 | 26.9 | 8.6 | 10.1 | 85.0 | 40.0 | 56.7 | 68.9 |
| VII (March 9- March 23,2012) | 26.3 | 27.4 | 10.9 | 12.9 | 82.0 | 36.0 | 58.3 | 72.0 |
| VIII (March 24- April 8,2012) | 33.5 | 34.1 | 15.6 | 18.1 | 81.0 | 30.0 | 67.3 | 81.8 |

M= observations recorded at 7:30 am, A= observations recorded at 2:30 pm

### 3.3 Dry matter intake

In the beginning of the experiment, DMI averaged 3.87, 3.85 and 3.96 kg/ d which increased progressively to 5.35, 5.40 and 5.83 kg/ d at the end of 120 days of experimental feeding in control, $W_1$ and $W_2$ group, respectively (Table 3). An increase in the dry matter intake of the calves with increase in body weight is evident from various earlier studies [17, 18]. The overall mean DMI in $W_2$ was significantly higher ($P$<0.05) as compared to $W_1$ and control groups. Likewise, an optimum range of +15 to +20 mEq/100 g of DM has been indicated to positively affect DMI in dairy cows [19, 8, 20]. An increase in nutrient intake with positive DCAD diet has also been reported [21]. The increase in DM intake in calves of $W_2$ group fed high DCAD diets might be due to increased rumen pH that makes the ruminal environment alkaline, which is a pre-requisite for optimum ruminal microbial activity [22, 7, 23]. The influence of DCAD on DMI has a direct effect on the supply of nutrients for maintenance, growth, gestation, and lactation.

**Table 3:** Effect of positive DCAD diets on DM intake (kg/d) in crossbred calves

| Fortnight | DMI (kg/d) | | | |
|---|---|---|---|---|
| | **Control** | **$W_1$** | **$W_2$** | **SEM** |
| 0 | 3.87 | 3.85 | 3.96 | 0.08 |
| I | 3.88 | 4.05 | 4.36 | 0.08 |
| II | 3.97 | 4.06 | 4.48 | 0.08 |
| III | 3.91 | 4.11 | 4.61 | 0.12 |
| IV | 4.10 | 4.31 | 4.74 | 0.11 |
| V | 4.30 | 4.56 | 4.97 | 0.09 |
| VI | 5.06 | 5.12 | 5.53 | 0.11 |
| VII | 5.36 | 5.37 | 5.75 | 0.07 |
| VIII | 5.35 | 5.40 | 5.83 | 0.09 |
| Mean | $4.42^a$ | $4.54^{ab}$ | $4.92^b$ | 0.05 |

### 3.4 Sodium and Potassium balance

Sodium intake (g/d) was 29.08, 33.94 and 38.60 in three respective groups, showing that Na intake was significantly higher ($P$<0.01) in treatment groups $W_1$ and $W_2$ as compared to control (Table 4). Faecal and urinary excretion of Na (g/d) also increased with increase in the level of Na in the diet, which was 4.07, 5.71, 7.56 and 18.88, 20.71, 21.25 in control, $W_1$ and $W_2$ groups, respectively. Faecal excretion (g/d) of Na was significantly more ($P$<0.01) in $W_2$ group as compared to control, whereas the urinary excretion of Na did not vary statistically ($p$>0.05) among groups. Na balance (g/d) was statistically similar ($P$>0.05) among groups. Percent Sodium retention was 20.93, 21.69 and 25.20 in control, $W_1$ and W2, groups, respectively, however there was no variation ($P$>0.05) observed among different groups.

**Table 4:** Effect of positive DCAD diet on sodium and potassium balances in crossbred calves

| | Parameter | Control | $W_1$ | $W_2$ | SEM | Sig. |
|---|---|---|---|---|---|---|
| Na | Na Intake (g/d) | $29.08^A$ | $33.94^B$ | $38.60^B$ | 0.10 | $P$<0.01 |
| | Faecal Na outgo (g/d) | $4.07^A$ | $5.71^{AB}$ | $7.56^B$ | 0.38 | $P$<0.01 |
| | Urinary Na outgo (g/d) | 18.88 | 20.71 | 21.25 | 0.78 | NS |
| | Na balance (g/d) | 6.13 | 7.52 | 9.80 | 0.85 | NS |
| | Na retention (%) | 20.93 | 21.69 | 25.20 | 2.16 | NS |
| K | K Intake (g/d) | $121.59^A$ | $136.44^B$ | $144.23^B$ | 2.68 | $P$<0.01 |
| | Faecal K outgo (g/d) | 30.02 | 30.41 | 30.73 | 0.76 | NS |
| | Urinary K outgo (g/d) | $31.89^A$ | $33.81^{AB}$ | $35.55^B$ | 0.56 | $P$<0.01 |
| | K balance (g/d) | $59.68^A$ | $72.22^B$ | $77.95^B$ | 2.24 | $P$<0.01 |
| | K retention (%) | 48.90 | 52.89 | 53.89 | 0.82 | NS |

Means having different superscripts within a row differ significantly. NS: Non-significant

Potassium intake (g/d) averaged 121.59, 136.44 and 144.23 in control, $W_1$ and $W_2$ groups, respectively. The K intake was significantly higher ($P$<0.01) in $W_1$ and $W_2$ groups as compared to control. Faecal and urinary excretion of K was 30.02, 30.41, 30.73 and 31.89, 33.81, 35.55 g/d in control, $W_1$ and $W_2$ groups, respectively. Urinary excretion was significantly more ($P$<0.01) in $W_2$ group as compared to control. K balance was significantly higher *(P*<0.05) in $W_1$ and $W_2$ (72.22 and 77.95 g/d) groups as compared to control (56.68 g/d) group of calves. The overall potassium retention (%) was 48.90, 52.89 and 53.89 in three respective groups and did not vary significantly ($P$>0.05) among groups. These finding are in line with [24] who observed that urinary and faecal mineral composition was closely associated with dietary mineral composition. Similarly it has been reported that buffaloes fed on high cationic diet had higher intake, excretion and retention of Na and K ions [6]. The intake as well as excretion of Na and K was increased in the treatment groups as the treatment diets contained higher Na and K concentrations and indicated that dietary mineral content influences absorption, excretion as well as retention of minerals [24, 23].

### 3.5 Chloride and Sulphur balances

The Cl and S intake and excretion were also not affected ($P$>0.05) by the different level of positive DCAD diet (Table 5). Cl and S balance (g/d) and retention (%) was also similar ($P$>0.05) in all the three groups. Similarly Tucker *et al*. (1992) reported that dietary supplementation with 2% Na bicarbonate had no effect on urinary Cl concentration. Increased urinary Cl concentration in cows fed low DCAD might be attributed to increased Cl content of the diet [26, 27]. Shahzad [6] also observed that at low DCAD diet, there was more intake of Cl (244.22 g/ d), so more excretion of it (92.15 g/d) as compared to high DCAD diet where lesser intake (75.33 g/d) and less excretion of Cl (25.123 g/ d) were observed. Since the diets in the present study were of high DCAD value and contained similar concentration of Cl and S in all the three respective groups, so, that might be the reason for no difference in the metabolism of these two minerals in different groups.

**Table 5:** Effect of positive DCAD diet on chloride and sulphur balances in crossbred calves

| | Parameter | Control | $W_1$ | $W_2$ | SEM | Sig. |
|---|---|---|---|---|---|---|
| **Cl** | Cl Intake (g/d) | 103.31 | 103.59 | 104.03 | 1.05 | NS |
| | Faecal Cl outgo (g/d) | 51.04 | 52.31 | 52.86 | 1.41 | NS |
| | Urinary Cl outgo (g/d) | 22.68 | 22.62 | 22.79 | 0.38 | NS |
| | Cl balance (g/d) | 29.59 | 28.66 | 28.38 | 1.82 | NS |
| | Cl retention (%) | 28.38 | 27.46 | 26.97 | 1.61 | NS |
| **S** | S Intake (g/d) | 25.73 | 25.95 | 26.07 | 0.28 | NS |
| | Faecal S outgo (g/d) | 8.33 | 8.22 | 8.20 | 0.20 | NS |
| | Urinary S outgo (g/d) | 3.45 | 3.93 | 4.22 | 0.09 | NS |
| | S balance (g/d) | 13.95 | 13.80 | 13.64 | 0.32 | NS |
| | S retention (%) | 54.01 | 53.15 | 52.05 | 0.92 | NS |

NS: Non-significant

### 3.6 Calcium and Phosphorus balances
The intake and excretion (faecal and urinary) of Ca and P was not affected by the treatment (Table 6). The Ca and P balance (g/d) and retention (%) was also statistically similar (*P*>0.05) among groups. Similarly, It has been reported that Ca and P intake and retention was not affected by the positive DCAD diet [28, 29]. It has been reported that absorption and excretions of Ca more affected by negative DCAD diet as compared to positive DCAD diet [30, 6, 31], because negative DCAD diet cause metabolic acidosis which ultimately affects parathyroid hormones [32, 33] but in the present study positive DCAD diet used so that might be the reason for no effect on Ca and P metabolism in the treatment group.

**Table 6:** Effect of positive DCAD diet on calcium and phosphorus balances in crossbred calves

| | Parameter | Control | $W_1$ | $W_2$ | SEM | Sig. |
|---|---|---|---|---|---|---|
| **Ca** | Ca Intake (g/d) | 44.61 | 44.93 | 45.11 | 0.41 | NS |
| | Faecal Ca outgo (g/d) | 27.56 | 28.59 | 28.62 | 1.79 | NS |
| | Urinary Ca outgo (g/d) | 1.06 | 1.19 | 1.23 | 0.05 | NS |
| | Ca balance (g/d) | 15.98 | 15.14 | 15.25 | 1.88 | NS |
| | Ca retention (%) | 35.47 | 33.62 | 33.52 | 4.14 | NS |
| **P** | P Intake (g/d) | 28.81 | 28.86 | 28.89 | 0.06 | NS |
| | Faecal P outgo (g/d) | 24.90 | 24.06 | 23.73 | 0.71 | NS |
| | Urinary P outgo (g/d) | 0.29 | 0.30 | 0.23 | 0.01 | NS |
| | P balance (g/d) | 3.60 | 4.48 | 4.92 | 0.71 | NS |
| | P retention (%) | 12.48 | 15.65 | 16.98 | 2.47 | NS |

NS: Non-significant

## 4. Conclusion
From the present study it can be concluded that, feeding positive DCAD diet (+250 mEq/kg DM) can used as a effective tool to enhance the nutrient intake, Na and K balances, so positive dietary cation anion difference based diet can be used as a strategy to ameliorate the effect of climatic stress.

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