*Indian J. Anim. Nutr.* 2025. 42 (1): 87-93
doi: 10.56093/IJAN.v42i1.13
Indian Journal of Animal Nutrition



# Effect of Varying Levels of Dietary Cation-Anion difference (DCAD) on Nutrient Digestibility and Rumen Fermentation in Deccani Lambs

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## ABSTRACT

Experiment was conducted to study different levels of dietary cation-anion differences (DCAD) on nutrient digestibilities and rumen fermentation pattern of Deccani lambs. Eighteen Deccani lambs (27.58±1.99 kg/body weight) were selected and randomly allotted to 3 groups, containing 6 animals in each.A sorghum stover based complete ration (50R:50C) was prepared as a basal diet.Three experimental rations viz., DCAD-160, DCAD-220 and DCAD-280 were prepared by adding sodium bicarbonate at 0.0, 0.477 and 0.955 % to the basal diet to achieve a DCAD level of 160, 220 and 280mEq/kg DM, respectively. Feeding on varying levels of DCAD had similar effects on digestibility of crude protein, ether extract, crude fibre and acid detergent fibre. However, the digestibility of DM, OM, NFE, NDF, hemicellulose and cellulose were lowered ($P<0.05$) significantly at +280 DCAD level while they were comparable inother two groups. Similarly, the TDN in DCAD-280 ration was significantly ($P<0.01$) lower than DCAD-160 or DCAD-220 rations. The rumen pH and total volatile fatty acids concentrations were comparable among the three experimental rations while, ruminal ammonia nitrogen concentration decreased significantly ($P<0.01$) in DCAD-280 ration. Thus, it can be concluded that, the sorghum stover based complete rations containing DCAD level of +220 shall be better for optimum digestibility and rumen fermentation in Deccani lambs.

**KEYWORDS:** DCAD, Deccani lamb, Digestibility, Fermentation, Nutrients

Article received: 05 November 2024; Article accepted: 28 March 2025

## INTRODUCTION

Deccani sheep is a dual purpose breed. It is highly climate resilient and is best adapted to the semi-arid tracts of Telangana state. It has a great potential for mutton production under intensive system of management. Now a days, the rearing method of sheep, changing from extensive to intensive and semi intensive systems of rearing in Telangana. It could be due to several reasons such as increased population, urbanization and pressure on land for food crops, industrial and infrastructural projects etc. In the intensive system of rearing feeding management particularly, minerals have great importance as animals have no access to soil unlike in extensive system.

Minerals involve directly or indirectly in all biological processes of an animal. The minerals are either in the form of anions or cations and the balance between cations and anions is necessary for optimum growth and production of animals. Dietary cation-anion difference (DCAD) refers to the numerical difference between major cations (sodium and potassium) and major anions (chloride and sulphate), thus it is defined as milli-equivalents of $(Na^+ + K^+) - (Cl^- + S^{2-})$ per 100g of dry matter or per kg of dry matter (Block, 1994). The DCAD values in the diet may be positive or negative. The DCAD is said to be positive if the concentration of dietary cations is more relative to the concentration of dietary anions and vice versa.

Positive DCAD indicates the generation of more blood buffers, accumulation of less hydrogen ions and higher pH, which further affects dry matter intake (DMI), nutrient utilization and growth in animals(Wildman et al., 2007). Positive DCAD diets in ruminants cause an increase in nutrient intake due to favourable rumen dynamics and blood biochemistry (Wildman et al., 2007). Crossbred calves fed with positive DCAD diets of +250 and +350mEq/kg DM during winter and summer seasons improved the nutrient intake, growth of performance, immunity and ameliorated climatic stress (Suman et al., 2018a; Suman et al., 2018b; Suman et al., 2019).Decrease in blood pH (negative DCAD) affects insulin (Robertson, 1987) and growth hormone secretion (Challa et al., 1993) which ultimately decreases feed intake and growth rate of growing lambs. Positive DCAD diet causes slight metabolic alkalosis of cellular environment which reduces the extent of cellular acidity produced by $CO_2$ and thus allow the cell to work to its maximum capacity and improve the growth of animals (Block, 1994). However, the scientific information pertaining to the effect of the DCAD on performance of sheep is limited in India. Therefore, the present experiment was planned to investigate the effect of different levels of DCAD on digestibility of nutrients and rumen fermentation pattern in Deccani lambs.

## MATERIALS AND METHODS

The studywas undertaken to evaluate the effect of varying levels of positive DCAD arrived by adding sodium bicarbonate in a sorghum stover based complete rations. The experiment was conducted at Department of Animal Nutrition, College of Veterinary Science, P.V.Narsimha Rao Telangana Veterinary University, Rajendranagar, Hyderabad.

### Experimental Rations

Sorghum stover based three iso-nitrogenous complete rations with 50:50 ratio of roughage and concentrate was prepared as per ICAR (2013) standards (Table 1). The DCAD levels of experimental rations viz., +160, +220 and +280 mEq/kg, respectively were maintained by adjusting sodium bicarbonate level. The roughage and concentrate ingredients were first proportioned and batched to 100 kg as per the formula. Later they were ground separately in a hammer mill and mixed in ribbon type horizontal mixer for 20 minutes. The mineral mixture, dicalcium phosphate and sodium bicarbonate were mixed thoroughly in premixer and then, directly added into the mixer.

The DCAD values of the three experimental feeds were arrived by taking into consideration the $Na^+$, $K^+$, $Cl^-$ and $S^{2-}$ ions concentration (%) of all the concentrate ingredients individually. Later the DCAD of the whole ration was calculated using the formula DCAD = $\{[(Na\% / 0.0023) + (K\% / 0.0039)] - [(Cl\% / 0.00355) + ((S\% / 0.0016)\times0.6)]\}$ mEq/kg DM (Table 2). Here, DCAD was calculated using the basic formula DCAD = $\{[Na^+ + K^+] - [Cl^- + (S^{2-}\times0.6)]\}$ (Goff et al., 2004), where the absorption coefficient of sulphur was also considered.

Table 1 Ingredient composition (%) of experimental rations

| Ingredient % | DCAD-160 | DCAD-220 | DCAD-280 |
|---|---|---|---|
| Sorghum stover | 50.0 | 50.0 | 50.0 |
| Maize | 22.0 | 22.0 | 22.0 |
| Cotton seed cake | 2.5 | 2.5 | 2.5 |
| Soybean meal | 15.0 | 15.0 | 15.0 |
| Deoiled rice bran | 5.60 | 5.37 | 5.15 |
| Red gram chunni | 2.25 | 2.00 | 1.75 |
| Urea | 0.5 | 0.5 | 0.5 |
| Dicalcium phosphate | 0.5 | 0.5 | 0.5 |
| Limestone | 1.2 | 1.2 | 1.2 |
| Mineral and vitamin mixture | 0.2 | 0.2 | 0.2 |
| Salt | 0.25 | 0.25 | 0.25 |
| Sodium bicarbonate | 0.000 | 0.477 | 0.955 |

Table 2. Mineral composition (% DMB) of experimental rations

| Mineral (%) | DCAD-160 | DCAD-220 | DCAD-280 |
|---|---|---|---|
| Sodium (Na+) | 0.28 | 0.42 | 0.56 |
| Potassium (K+) | 0.56 | 0.56 | 0.55 |
| Chloride (Cl-) | 0.20 | 0.20 | 0.20 |
| Sulphur (S2-) | 0.12 | 0.12 | 0.12 |
| DCAD (mEq/kg DM)* | +163.99 | +224.86 | +283.17 |

**Experimental animals**

Eighteen growing Deccani lambs of about 6-7 months age and of uniform body weight (23.86±1.70 kg) were selected and divided randomly into 3 groups viz., DCAD-160, DCAD-220 and DCAD-280, containing 6 animals in each by following completely randomized design.All the experimental lambs were housed in a well ventilated pens having individual feeding and watering. Lambs were fed with their respective experimental rations *ad libitum* twice daily.Body weights of animals were recorded at before and after completion of experiment.

**Digestion trial**

A standard digestion trial was conducted with twenty-one day preliminary period and six days collection period by adopting acid insoluble ash based indicator method (Sharma et al., 1983). The digestibility of nutrients in experimental diets was assessed by analyzing various chemical constituents in the feed and faeces (AOAC, 2012). Cell wall constituents of feeds and faecal samples were determined as per the method described by Van Soest et al. (1991).

**Rumen Fermentation**

The rumen liquor samples were collected by using stomach tube at 30 min, 2 h and 6 h post feeding for 2 consecutive days. The pH was determined immediately after collection using digital pH meter. Ammonia nitrogen was estimated as perMakkar and Becker, (1996) method. About 50 ml of strained RL was collected in separate containers from each sample and 0.5 ml of saturated mercury chloride was added and preserved at -20 C for estimation of total volatile fatty acids (TVFA) (Barnett and Reid, 1957).

**Statistical Analysis**

The data was analyzed using the general linear model of the Statistical Package for Social Sciences (version 15), and the means were compared using Duncan's multiple range test (Duncan, 1955). A statistical analysis of the data was carried out by using analysis of variance (Snedecor and Cochran, 1989).

## RESULTS AND DISCUSSION

The proximate and fiber constituentscomposition (% DMB) of experimental rations was presented in Table 3.

Table 3. Chemical composition (% DM basis) of experimental rations containing different levels of DCAD

| Constituents (%) | DCAD-160 | DCAD-220 | DCAD-280 |
|---|---|---|---|
| Proximate constituents | | | |
| Dry matter | 88.1 | 88.9 | 88.1 |
| Organic matter | 91.5 | 90.5 | 88.2 |
| Crude protein | 15.8 | 15.5 | 15.7 |
| Ether extract | 2.94 | 2.95 | 2.98 |
| Crude fibre | 22.3 | 22.7 | 22.04 |
| Nitrogen free extract | 50.4 | 49.3 | 47.4 |
| Total ash | 8.51 | 9.45 | 11.7 |
| Acid insoluble ash | 3.76 | 3.81 | 4.67 |
| Calcium | 0.97 | 0.97 | 0.95 |
| Phosphorus | 0.49 | 0.49 | 0.48 |
| Cell wall constituents | | | |
| Neutral detergent fibre | 48.4 | 48.5 | 48.1 |
| Acid detergent fibre | 27.7 | 29.3 | 27.5 |
| Hemicellulose | 20.6 | 19.2 | 20.5 |
| Cellulose | 20.8 | 21.5 | 21.5 |
| Lignin | 4.14 | 4.17 | 3.22 |

**Nutrient Digestibility**

Digestibility coefficients of dry matter (DM), organic matter (OM) and nitrogen free extract (NFE) were significantly higher ($P<0.05$) for DCAD-160 and DCAD-220 rations in comparison to DCAD-280 ration(Table 4). However, the digestibility coefficients of crude protein (CP), ether extract (EE) and crude fibre (CF) was comparable among the three experimental rations. In line with our findings,digestibility coefficients of proximate constituents remained unaffected by the feeding varying levels of DCAD in the rations of calves (Suman et al., 2018a), cows (Martins et al., 2016), Goats (Farooq et al., 2014) and lambs (Sarwar et al., 2007).

Among the cell wall constituents neutral detergent fibre (NDF), hemicellulose and cellulose digestibilities were significantly improved ($P<0.01$) in lambs fed DCAD-160 ration in comparison to DCAD-220 and DCAD-280 rations.In agreement with the present findings, Kawas et al. (2007) observed significant ($P<0.05$) decrease in NDF digestibility in 0.5 percent sodium bicarbonate supplemented lambs.However, in contrast to present study findings, the NDF digestibility linearly increased as DCAD level increases (+98 to +290 mEq/kg) and reported that positive effect of DCAD on NDF digestibility may be associated with a higher ruminal pH and consequently, a higher cellulolytic activity (Martins et al., 2016).

TDN (%) in DCAD-280 ration was significantly ($P<0.01$) lower than DCAD-160 and DCAD-220 rations.The per centdigestible CP (DCP) in the three experimental rations and daily intakes of CP, TDN, DM, digestible energy (DE) and metabolizable energy (ME) were not differ significantly among three experimental rations. The intake of CP (g/d), TDN (g/d), DMI (g/d), DE (Mcal/d) and ME (Mcal/d) in three experimental rations ranges 142 to 152, 528 to 552, 900 to 960, 2.33 to 2.43 and 1.91 to 1.99, respectively.According to ICAR (2013) recommendations, the CP, TDN, DM and ME requirements of growing lambs weighing 30 kg with a ADG of 75 g were 122 g/d, 543 g/d, 980 g/d and 1.96 Mcal/d, respectively.

Table 4. Effect of feeding different experimental rations containing varying levels of DCAD on nutrient digestibility (%) in Deccani lambs

| Nutrient | DCAD-160 | DCAD-220 | DCAD-280 | SEM | P value |
|---|---|---|---|---|---|
| Proximate constituents | | | | | |
| Dry matter | 59.1 $^{a}$±0.34 | 58.6 $^{a}$ ±0.84 | 55.9 $^{b}$ ±1.14 | 0.567 | 0.040 |
| Organic matter | 62.2 $^{a}$ ±0.37 | 61.9 $^{ab}$±0.90 | 58.7 $^{b}$±1.18 | 0.602 | 0.033 |
| Crude protein | 75.8±0.56 | 73.7±0.88 | 74.2±0.87 | 0.474 | 0.189 |
| Ether extract | 74.7±0.60 | 77.4±1.17 | 77.1±1.42 | 0.676 | 0.197 |
| Crude fibre | 54.5±0.76 | 52.7±2.38 | 52.6±1.88 | 1.002 | 0.710 |
| Nitrogen free extract * | 60.7 $^{a}$ ±0.61 | 59.9 $^{a}$ ±1.12 | 55.2 $^{b}$±1.24 | 0.810 | 0.004 |
| Cell wall constituents | | | | | |
| Neutral detergent fibre | 49.5$^{a}$±0.83 | 45.05 $^{b}$±1.28 | 43.1 $^{b}$±0.81 | 0.845 | 0.001 |
| Acid detergent fibre | 35.6±0.93 | 34.9±1.43 | 31.5±1.64 | 0.855 | 0.113 |
| Hemicellulose * | 68.2$^{a}$±1.34 | 60.4 $^{b}$±1.65 | 58.6±2.84$^{b}$ | 1.506 | 0.011 |
| Cellulose * | 51.3 $^{a}$±0.84 | 47.5 $^{b}$±1.24 | 45.05 $^{b}$±1.48 | 0.912 | 0.008 |

$^{ab}$ means with different superscripts within a row differ significantly (P<0.05, *P<0.01)

**Rumen fermentation**

The rumen pH values and TVFA concentrations were comparable among the three experimental rations while, ruminal ammonia nitrogen concentration decreased significantly (P<0.01) in DCAD-280 ration(Table5).The highest (P<0.01) ammonia nitrogen concentration was recorded in DCAD-160 and DCAD-220 and while lowest (P<0.01) was recorded in DCAD-280 rations. The pH values obtained in the present experiment were in consistent with the results reported by Baset et al. (2014) and Kawas et al. (2007) in which the ruminal pH values were also not influenced by DCAD (sodium bicarbonate level) in the ration of lambs.

The concentrations of TVFA not affected significantly neither among DCAD levels nor among time intervals of rumen liquor collection. These results were in accordance with the results reported by Ross et al. (1994), Baset et al. (2014), Hadjipanayiotou et al. (1988), Kawas et al. (2007), Apperbossard et al. (2010) and Gonazalez et al. (2008), who have noticed no effect of DCAD or sodium bicarbonate inclusion on the ruminal TVFA concentration. In contrary to the above findings, Santra et al. (2003) appreciated a significant (P<0.01) increase in TVFA concentration with increasing levels of sodium bicarbonate (0, 0.75, 1.50 and 2.25 per cent). The reason for unaltered TVFA concentration with the change in DCAD level in the present investigation might be due to the increased buffering capacity of sodium bicarbonate in the ration.

Table 5. Effect of feeding different experimental rations containing varying levels of DCAD on rumen fermentation in Deccani lambs

| Parameter | DCAD-160 | DCAD-220 | DCAD-280 | SEM | P Value |
|---|---|---|---|---|---|
| pH | 6.21±0.04 | 6.19±0.03 | 6.18±0.04 | 0.396 | 0.785 |
| Ammonia nitrogen (mg/100 ml) | 25.96$^{a}$±1.61 | 25.99$^{a}$±1.24 | 6.50$^{b}$±1.05 | 1.300 | 0.001 |
| Total volatile fatty acids (mmol/100ml) | 8.45±0.22 | 8.36±0.20 | 7.96±0.17 | 0.201 | 0.861 |

$^{abc}$ means with different superscript within a row differ significantly (P≤0.01).

Decrease of ammonia concentration with increase in DCAD level in the present experiment could be due to increased rumen dilution rate (Russel and Chow, 1993) which further decreases the rumen retention time. The results were in consistent with the results of Santra et al. (2003) who reported a decrease ($P<0.01$) in ammonia nitrogen concentration due to the addition of sodium bicarbonate in the rations of lambs.

## CONCLUSIONS

Feeding of Deccani lambs with higher DCAD (+280) diets significantly lowered the nutrient digestibility of dry matter, organic matter, nitrogen free extract, neutral detergent fibre, hemicellulose and cellulose and percent TDN, while they were not affected with lower DCAD levels (+160 and +220). Thus, it is concluded that the sorghum stover based complete rations containing DCAD level upto +220 shall be optimum for better digestibility and rumen fermentation in Deccani lambs.

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