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# Role of Cationic and Anionic Feeding in Farm Animals

**Aamir Iqbal*, Abdul Qudoos, I.Sadi Çetingül, Syed Rizwan Ali Shah, Ismail Bayram**
Department of Animal Nutrition and Nutritional Diseases, Faculty of Veterinary Medicine, Afyon Kocatepe University, Afyonkarahisar, Turkey.

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*** Corresponding Author**
e-mail:
aamir_vet @ yahoo.com

**ABSTRACT**

In animal diets, the cations and anions are supplemented in their respective and required proportions. This cationic and anionic feeding is of great importance in maintaining the equilibrium between acids and bases of animal body and, also, the osmotic pressure of body fluids. This maintenance is defined by three important factors; required and relevant balance of ions in diet, acid production and renal function. This review article elaborates the role and significance of cations and anions in animal nutrition particularly in preventing a very important disease of milk fever in dairy cows just after parturition. The cations and anions play very significant and crucial role in equating the acid base equilibrium as well as osmotic pressure in the body. There have been a lot of researches conducted on the topic of pathogenesis of milk fever in cows. To conclude, K ion is the most important to predispose the cows for milk fever. One way to counter the effects of K ions is to increase the anionic concentration of diet but it has also some detrimental effects. This can be done by balancing dietary cationic anionic difference.

## Introduction

The term cationic and anionic feeding or dietary cation-anion difference (DCAD) means two kinds of cation [potassium {K} and sodium {Na}] and two kinds of anion [chlorine {Cl} and sulfur {S}]. This phenomenon can also be defined as sum of total cations (Na and K) is subtracted from the sum of total anion (Cl and S) and divided by 100 g of DM. Milliequivalents (mEq) is the unit which determines the balance between the concentration of cation and anion of diet. Mathematically it is narrated as below (Dishington, 1975).

$(Na + K) – (Cl + S)/100\ g\ DM$

For example, from the above mentioned equation;

$(65.25 + 281.6) – (56.4 + 124.8) = mEq/kg$

$(346.85) – (181.2) = +165.65\ mEq/kg$

### *Guidelines*

- If the answer of calculation is + 200 mEq/kg DM or more then lower the K forage in diets of dry cow. Sometimes anionic salts are added in diets to reduce feed intake but this can be problematic because it can cause milk fever, metritis, ketosis and displaced abomasums.
- In transition period of cow, the DCAD should be – 100 mEq/kg and – 200 mEq/kg of DM just to counter the risk of milk fever and low blood Ca level.

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- Consecutively examine the urine of cow while using the anionic products because urine pH is an effective indication of the affectivity of anionic products. For Holstein, the urine pH should be 6.0 – 6.5 and, for Jerseys, the urine pH should be 5.5 – 6.0.
- To make ration more palatable, the anionic products should be slowly introduced in the diets of dairy cows. (Stewart, 1983)

To understand this phenomenon first of all we need to be familiar with the chemistry of anion and cation. For dietary point of view, important cations are sodium, calcium, magnesium, potassium while important anions are sulfur, phosphorus and chloride. The cations or anions, bearing positive and negative charges respectively, are the types dietary electrolytes added in feed. These ultimately influence the acid-base balance and calcium metabolism (Stewart, 1983).

The term “electrolytes” is commonly used in animal nutrition and primarily refers to the negative (Cl-) and positive ions (Na+, K+). These monovalent ions play their important role in tissue protein synthesis, maintaining the balance of homeostasis, electric potential across the plasma membranes, osmotic pressure, enzymatic reactions and acid base balance. In laying hen farming the birds undergo stress particularly when they are in cages and acid base balance is affected which leads to metabolic alkalosis (when cations are increased) and acidosis (when anions are increased). Although this electrolytic requirements can be fulfilled by supplementing organic ingredients and salts but the balanced cationic and anionic diet not only fulfills the electrolytic demand but also ensures optimum growth (Borges et al., 2003).

Dietary cation anion difference (DCAD) is a way to reckon the status of acid and base in the diets containing different levels of cations and anions. The diets given to cows before parturition containing low levels of cations and higher levels of anions sensitizes the parathyroid hormones which ultimately leads to low incidence of hypocalcaemia the mineral salts and acids are added to the diets just to tilt the acid base concentration of cows to acidosis and if the anions are added the the metabolic position can be achieved quickly (Goff, 1998).

Feeding anions more than 250 mEq/kg of feed will result in alkalosis or acidosis and other health related problems in dairy animals. The concentration of $HCO_3$- ions and blood pH is increased if the Na ions, without (Cl-), are supplemented and similarly the concentration of $HCO_3^-$ and pH is decreased if the $Cl^-$ ions, without Na, are given to the animals with feed. The electrolyte balance is changed from 17.4 to 12.1 mEq/kg of feed if soybean is replaced with fish meal in feed (Moncin, 1981).

In a study conducted by (Whiting et al., 1991), it was reported that in the stressful condition, a different response was given by broiler and layer, because they differ in their requirement and response to electrolyte treatment. So an aqueous solution of electrolyte positively affected growth, performance and production and decreased the mortality in broiler chickens.

The feed deficient in K ions enhances the lysine accumulation in tissues which result in impaired metabolism of lysine and methionine and which ultimately decreases the growth and production performance of poultry birds (Leeson and Summers, 2001). The required and specific concentration of cations and anions in feed can balance the electrolyte differences in the body.

A study was conducted to evaluate the impact of various DCAD levels with different dietary proportions of roughages (60-40%) and concentrates (40-60%) on metabolism of the weaned Holstein calves which were fed diets having DCAD level of -100, +200 and +400 mEq/kg of DM (Saladini et al., 2012).

Potassium being the main intracellular cation and is the 3rd most important and abundant element of living body and involved in many biochemical processes including acid base equilibrium, osmotic pressure regulation, glucose and amino acid absorption, development of membrane potential across the plasma membranes (Leeson and Summer, 2001) who also came to the conclusion that 250 mEq/kg was pertinent level of electrolyte balance for optimum growth in poultry birds.

The basic mechanism of DCAD was studied in chicken by Mogin 1980 (Moncin, 1981) came to the conclusion of description of electrolyte balance with the help of a formula {sum of positive ions (Na and K) minus sum of negative ions (Cl)} involving the important electrolytes.

In tropical countries, dairy animals are subjected to hot and humid environment particularly during summer seasons which results in low feed intake and high water intake (Sano et al., 2010; Rhoads et al., 2009; Salama et al., 2014). To manage heat stress, the animals reduce feed intake and give gaps between two consecutive meals by increasing meal’s mass. This reduction in feed intake is probably to bring down the metabolic heat production (Alam et al., 2013; Shiao et al., 2011; Kadzere et al., 2002). In this scenario, dietary cationic and anionic feeds are supplemented to small and large animals to increase water and DMI (Tucker et al., 2010) which overall improves the rumen function and fermentation (Sharif et al, 2010).

The low concentration of Ca in blood, hypocalcemia, is a critical issue of cows within first 24-48 hours after parturition and sufficient amount of calcium is required for the cow to survive and remain stable in this critical time period (Goff, 2008). The hypocalcemia predisposes the cow to other ailments e.g. RFM, metritis, dystocia, uterine prolapse (Degaris and Lean, 2008; Grohn et al., 1989). The DCAD influences the metabolism and acid base balance and in this way cow attains good health and optimum productivity (Sanches, 2003). The reduction of DCAD when the anionic salts are increased can help in preventing and treating milk fever (Chan et al., 2006). The increased concentration of anions leads to accumulation of more hydrogen ions that induce metabolic acidosis and the this anionic diet supposedly increases resorption of bone, level of calcium in blood and the absorption of calcium from gut (Chan et al., 2006).

***Studies conducted***

An experiment was conducted on 12 early lactating buffaloes to observe the effects of anionic and cationic feeding, acidifying diets, on the parameters of nutrient intake, involution period, follicle growth, ovarian activity and uterus tonicity. The experimental animals were randomly divided in 4 treatment groups each containing 3 buffaloes. The isocaloric and isonitrogenous diets were made having -110, +110, +220 and +330 dietary cation anion difference mEq/kg DM and the groups were named as A, LC, MC and HC respectively. Results showed increased DMI with the increase in DCAD level whereas maximum and minimum DMI was seen in groups fed HC and A respectively. HC diet fed buffaloes showed complete uterus involution, presence of corpus luteum, higher ovarian activity and tonicity when palpated as compared to other diet fed groups. At the end of trial it was concluded that high DCAD diet (HC diet) posed good effects on buffaloes (Sharif et al., 2012).

A research trial was performed to record the impact of different dietary electrolyte balance (DEB) on the parameters of egg weight, egg shell quality, litter dry matter, bone ash and some blood parameters of 216 Lohmann-Brown laying hens. In the treatment group 1, DEB was added 80 mEq/kg with $NH_4Cl$, in treatment group 2, 256 mEq/kg with $NaHCO_3$, in treatment group 3, 330 mEq/kg with $NaHCO_3$ and $KHCO_3$ whereas 170 mEq/kg DEB was supplemented the control group. The results showed that dietary alkaline supplementation partially corrected the metabolic acidosis and excessive chloride ions negatively affected the egg shell. However, a moderate quantity of DEB (256 mEq/kg) improved eggshell quality and maintained acid base balance (Gezen et al., 2005).

In a research trial, two experiments were performed on 24 male weaned Holstein calves to observe the impacts of DCAD and roughages on the metabolism of claves. In the first experiment, the calves were supplemented with DCAD of -100, +200 and +400 mEq/kg of DM having 60% roughages and 40% concentrate whereas in the second experiment, the animals were fed with the same DCAD but with 40% roughages and 60% concentrate. The results showed an increase in blood urea nitrogen according to the increased DCAD in the groups where 60% roughages was fed. It was also noted that change in roughage to concentrate ratio affected the metabolism of calves (Saladini et al., 2012).

A research study was performed on 10 cross bred goats in the period of before parturition under high temperature to observe the effects of DCAD feed on eating patterns, water intake and urination patterns. The treatment diet protocol was (DCAD 22.8 mEq/100 g DM) and high DCAD (DCAD 39.1 mEq/100 g DM) and the diets were composed of 44% corn silage and 56% concentrate. The trial was carried out in hot and humid condition so it led to increased respiration in groups but it was significantly higher in DCAD group. The high DCAD increased feed and water intakes almost 8 weeks after parturition. Significantly bigger meal size and length were recorded in DCAD group (Nguyen et al., 2019).

A trial was conducted on 24 cows which were near to parturition and impacts of DCAD were evaluated on acid base balance, health status, lactation performance, plasma and urine mineral concentration. Both of the group composed of 12 cows each was fed with treatment diet contained either –100 DCAD or +100 DCAD for 60 days before parturition. Both, cationic and anionic groups were fed + 200 DCAD and +400 DCAD respectively for 60 day after parturition. Before parturition the reduction in DCAD led to low DMI, urinary and blood pH, concentration of Na and K in urine was increased. After parturition the +400 DCAD improved the milk fat and total solid concentration, and concentration of Na, K and pH of blood and urine was also increased and the DMI was also increased in this group. Parturient abnormalities was recorded, however, time taken by placenta to be expelled was reduced (Razzaghi et al., 2012).

### *Hypocalcemia*

Hypocalcemia or low concentration of calcium in blood, also called milk fever, is a critical and very important disease of dairy animals which are near to parturition. This can happen at the time of calving when more amount of Ca is required for colostrum production and the cows become unable to fulfill this need. This leads to low concentration of Ca in blood that leads to hypocalcemia or milk fever. The most dangerous type is clinical milk fever while the cows which survive exhibit more chances of retained fetal membranes, mastitis and displaced abomasums (Curtis et al., 1983; Grohn et al., 1989). The first 24-48 hours after parturition are most important and crucial because the cows are more prone to milk fever in this time. Not only hypocalcemia the risk also increases for other ailments as well e.g. displaced abomasums, retained placenta, metritis, mastitis, ketosis, etc (Curtis et al., 1983). By lowering the DCAD with the help of dietary acidity or by anionic salts was proved to be helpful in preventing hypocalcemia. The anionic feeding resulted in almost no cases of milk fever compared with 47% cases of hypocalcemia when cationic feeding was fed to cows (Block, 1984; Oetzel et al., 1988; Pilbeam et al., 2000).

## Conclusion

The cations and anions play very significant and crucial role in equating the acid base equilibrium as well as osmotic pressure in the body. There have been a lot of researches conducted on the topic of pathogenesis of milk fever in cows. To conclude, K ion is the most important to predispose the cows for milk fever. One way to counter the effects of K ions is to increase the anionic concentration of diet but it has also some detrimental effects. This can be done by balancing dietary cationic anionic difference.

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