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Research Article

Metabolomics of Periparturient Holstein-Friesian Cows Associated with Feeding a Negative Dietary Cation-Anion Difference (DCAD)

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Abstract | Fourty-Eight multiparous Holstein cows were randomly selected and enrolled 21 days before calving to determine the effect of feeding negative dietary anion-cation difference (DCAD) diet on prepartum and postpartum blood minerals, calf weight and milk production. Before the trial, all cows were fed a high-forage, low-energy diet. During the trial, cows were fed a diet formulated for late gestation (15CP, %35.7NDF, P % 0.5, and %1.2Ca) according to NRC, with a resulting DCAD (Na + K – Cl – S) of – 50mEq/ 100g of DM (negative DCAD). After calving, cows were fed a diet formulated for early lactation (%16.5CP, %32.4NDF, P %0.4) in feeding dairy cattle is a way to control the sudden decrease in serum Ca before and immediately after parturition, which is caused by rapid transport of large amounts of Ca into the mammary gland related to colostrgenesis. Blood and mid-stream urine samples were collected from 24 cows fed on DCAD ration and 24 cows fed on non DCAD ration daily starting 24h before calving (-1day), the day of parturition (0day), one day after parturition (+1), and second day after parturition (+ 2). Feeding DCAD ration lead to decreased urine pH and urine creatinine, but increase Ca urine execration in the DCAD group. However, the DCAD group showed a significant increase (P<0.05) in Ca, Mg, P, K, Cl, and Na concentration pre and post calving, compared to non DCAD group. Before parturition, feeding on DCAD ration caused a significant increase in urea and creatinine, but decreased bicarbonate compared to non DCAD group. While after parturition urea, creatinine, and bicarbonate were decreased in the DCAD group, compared to the non DCAD group. Milk production was increased for the DCAD group compared with non DCAD group, but no differences were observed in the milk component. In conclusion, feeding negative DCAD in the late gestation period improves the performance and productivity of dairy cows by increasing blood minerals and milk production.

Keywords | Acidogenic, Hypocalcemia, Lactation, Calcium, Health status, Dietary anion-cation

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INTRODUCTION

The percentage of metabolic diseases and health complications increases in the transition period. Reduction of Ca occurs due to an increased calcium excretion in the colostrum, delay within the absorption of Ca from GIT and bone mobilization at parturition (Diehl et al., 2018). Acute and severe hypocalcemia happens once Ca loses 1.9 to 2.8 g/kg of colostrum (Bojkovski et al., 2005; Abd El-Fattah et al., 2012) and 1.1 g/kg of milk

(Tsioulpas et al., 2007). Preserving Ca level depends on the rate of gastrointestinal Ca absorption (Martin-Tereso and Verstegen, variations are constrained by parathyroid hormone (PTH) and calcitriol (1,25 dihydroxy vitamin D3), which are viewed as the principal Ca regulatory hormones in mammals. Calcium homeostasis in periparturient dairy cattle is driven principally by the balance between, iCa admission (a function of the calcium content of the diet and feed intake), Ca absorption from the gastrointestinal tract, Ca mobilization from accessible stores and Ca lost to the fetus, colostrum, bone accretion, and urinary excretion (Martin-Tereso and Verstegen, 2011). Feeding negative DCAD ration prepartum stimulated Ca absorption and mobilization, thus preventing hypocalcemia, and maintained DMI and increased milk production after parturition (DeGroot et al., 2010). Accordingly, several studies were conducted to characterize the change in serum [Ca] in periparturient multiparous Holstein-Friesian cows fed a negative DCAD ration in the close-up period reposing beneficial effects for lactating dairy cows immediately after calving (El-Sheikh et al., 2002; Chan et al., 2005; Hu et al., 2007b). Therefore, the objectives of this study were to determine the effect of feeding a diet with different levels of negative DCAD on the concentration of mineral elements, acid-base balance, calcium homeostasis, milk production, and health status in dairy cows.

MATERIALS AND METHODS

Experimental design

On day 21 before the estimated parturition date, cows were assigned to 1 of 2 treatment groups: Group 1 had 24 cattle were fed an acidogenic TMR with negative-DCAD (dietary cation-anion difference) = −50 mEq/100 g of DM mEq/100g of matter, where DCAD = ([Na+] + [K+]) − ([Cl−] + [S2−]) based on formulations recommended by the National Research Council for close-up cows (Table 1). Group 2 included 24 control cows that fed the ration without DACD(CONT). Multiparous Cattle were fed an acidogenic close-up ration starting 3 wk before parturition. The ration was fed three times daily (every 8h). Cows in both\groups were switched to a lactating cow TMR immediately after parturition based on the formulation recommended by NRC for fresh cows. The time of calving was recorded to the nearest hour, and the calf and dam separated within a few hours of parturition. Calf birth weight was determined as described previously (Hiew et al., 2016). Cows were kept in temperature-controlled individual box stalls for 3 d after parturition or until they had recovered from any postpartum health disorders before being moved to a free-stall barn for lactating cows. After parturition, cows were milked three times daily every 8 h, in a milking parlor. Daily milk production was recorded.

Table 1: Ingredients of the ration for close-up, fresh cows, and control diet.

Ingredients	Kg/day (DM)	Kg/day (As-Fed)	% (DM)
Close-up			
Corn grain, cracked	2.39	2.75	19.46
Soybean meal, solv. 44% CP	1.81	2.00	14.72
Wheat bran	0.89	1.00	7.24
Vitamin premix 1	0.04	0.05	0.36
Sod. bicarbonate	0.00	0.00	0.00
Calcium phosphate	0.06	0.06	0.49
Magnesium oxide	0.00	0.00	0.00
Salt	0.02	0.02	1.16
Alfalfa meal, 17% CP	1.35	1.50	10.98
Beet Pulp	0.46	0.50	3.74
Vegetable oil	0.05	0.05	0.40
Calcium chloride	0.11	0.11	0.89
Limestone	0.16	0.16	1.27
Zinc	0.00	0.00	0.00
Silage	4.95	16.50	40.26
Fresh			
Corn grain, cracked	5.44	6.25	23.38
Soybean, meal, solv.44% CP	4.16	4.60	17.90
Wheat bran	1.29	1.45	5.55
Vitamin premix 1	0.07	0.07	0.28
Sodium bicarbonate	0.20	0.20	0.85
Calcium phosphate (mono-)	0.05	0.05	0.21
Magnesium oxide	0.05	0.05	0.21
Salt	0.09	0.09	0.38
Alfalfa meal, 17% CP	4.05	4.50	17.41
Beet pulp	0.00	0.00	0.00
Vegetable oil	0.51	0.52	2.19
Calcium chloride	0.00	0.00	0.00
Limestone	0.00	0.00	0.00
Zinc	0.01	0.01	0.03
Silage	7.35	24.50	31.60
Control			
Corn grain, cracked	1.2375	1.375	16.86
Soybean meal, solv. 44% CP	0.225	0.25	3.07
Wheat bran	0.2975	0.35	4.05
Vitamin premix 1	0.04	0.05	0.54
Sod. bicarbonate	0.00	0.00	0.00
Calcium phosphate	0.06	0.06	0.82
Magnesium oxide	0.00	0.00	0.00
Salt	0.02	0.02	0.27
Alfalfa meal, 17% CP	1.35	1.50	18.39
Beet pulp	0.46	0.50	6.27
Vegetable oil	0.05	0.05	0.68
Calcium chloride	0.00	0.00	0.00
Limestone	0.00	0.00	0.00
Zinc	0.00	0.00	0.00
Silage	3.6	12	49.05

Animals, housing, and feeding

Fourty-Eight multiparous periparturient Holstein-Friesian cows (4-7y old) from private dairy farm in Sharqia (out of a total of 150 dairy cows) were fed on DCAD ration. The study was conducted between January 2020 and May 2020. All cows were kept in free-stall barns and under similar environmental conditions. Enrolled cows were moved from the outdoor to temperature-controlled individual box stalls (3.1 ×3.1 m) 21 days before the estimated parturition date. All enrolled cows underwent a daily routine health check including a California mastitis test for subclinical mastitis detection and all animals were deemed healthy. Access to clean water was maintained at all times at libitum.

Experimental study and sampling

Urine and blood sampling were performed daily between 09:00 and 11:00 h with the animal gently restrained in a headlock. Mid-stream urine samples were collected by perineal stimulation into a 20-mL plastic collection cup on d −1, 0, +1, and +2 relative to calving (d 0). The vials were completely filled with urine and immediately closed to minimize exposure to air. Urine samples were then placed in a water bath at 38°C and urine pH was measured within 15 min of collection using a pH meter (Orion 20A, Thermo Electron Corp., Beverly, MA). Urine samples were stored at −20°C for further analysis. Blood samples were obtained daily at approximately 08:00 h from the jugular vein on d −1, 0, 1 and 2 relatives to calving using 20-gauge Vacutainer needles, Vacutainer holders, and 10-mL plan blood collection tubes (BD Diagnostics, Franklin Lakes, NJ). The proposed puncture site at the side of the neck was cleared of debris by swabbing the site with gauze containing 70% isopropyl alcohol. Blood samples were centrifuged for 5 min at 1,300 × g within 30 min of collection.

Ethical approval

This longitudinal observational study used a convenience sample of per parturient multiparous dairy cattle. The study design and protocols were performed under the owner's consent, approval of the Internal Ethics Review Committee of Faculty of Veterinary Medicine, Benha University, Benha city, Egypt (No: BUFVTM 11-02-22).

Urine and serum biochemical analysis

Stored urine samples were thawed at room temperature and vortexed for 10 s immediately before biochemical analysis. Urine concentrations of Ca (cresolphthalein), and creatinine (picric acid) concentrations were determined spectrophotometrically (BioTek Instruments Inc., Winooski, VT, USA) at the Veterinary Diagnostic Laboratory, Faculty of Veterinary Medicine Benha University, Egypt. Urine Ca excretion (g/d) for each 24-h period was calculated from two days prepartum to two days postpartum using the measured urine Ca concentration (urine Ca expressed in mg/dL), measured urine creatinine concentration (urine creatinine, expressed in mg/dL).

Serum biochemical analysis

All continuous data were evaluated for normal distribution or homogeneous variances. Log-transformation was used for data that deviated from normality. Data are expressed as mean ± stadard deviation and $P < 0.05$ was assigned as statistically significant. To test the effects of treatment (2 levels) and time (3 levels), and the interaction between treatment and time, with cow nested within treatment, repeated-measures ANOVA was used using the MIXED procedure of SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Whenever the F-test was significant, Bonferroni-adjusted *P*-values were used to assess differences between two treatment groups at a specific time and between times within a treatment group.

RESULTS

Effect of DCAD ration on urine pH, urine Creatinine, and urine Ca

The data in the Table 2 showed that: Cows fed DCAD ration showed a significant decrease (P<0.001) in urine pH at −1 day compared to non-DCAD group at the same time period (Table 2, Figure 1). Urine creatinine showed non-significant changes before parturition (-1 day), and after parturition (+1 day) in cows fed DCAD ration, While urine creatinine in NON DCAD group showed a significant decrease (P<0.001) before parturition (-1 day) compared to zero day but a significant increase (P<0.0001) after parturition (+1 day) and (+2 day) compared to DCAD group (Table 2, Figure 2).Urine Ca execration showed a significant increase before parturition (-1 day) at group fed DCAD ration, compared to the NON-DCAD group (Table 2, Figure 3).

Table 2: Changes in urine pH, urine Ca, urine creatinine during -1,0,1,2 peripartum day in multiparous dairy cattle fed acidogenic and non-acidogenic diets.

Group	Day-spp	Urine pH	urine Ca	Urine creatinine
DCAD	-1	6.6±0.17^{b}	36.59±0.78^{a*}	30.61±0.63^{a}
DCAD	0	7.30±0.51^{a}	20.74±0.67^{b}	33.71±1.44^{a}
DCAD	1	7.36±0.20^{a}	15.87±3.05^{b}	31.54±4.12^{a}
DCAD	2	7.7±0.26a*	13.21±2.23b	16.46±0.76b
Non-DCAD	-1	7.9±0.00a*	12.82±0.16b	37.06±1.29b
Non-DCAD	0	7.66±0.05a	22.23±0.38a	45.08±4.02a*
Non-DCAD	1	7.73±0.64a	16.15±0.59b	53.36±2.49b*
Non-DCAD	2	7.56±0.40a	14.93±0.27b	48.40±0.96b*

a-b Values with different letters within a column are significantly different between zero and other time points for each type of diet (P<0.05). significant increase of Ca in urine occurs at -1 day before parturition. * Values within a column are significantly different between same time points at different diets (P<0.05).

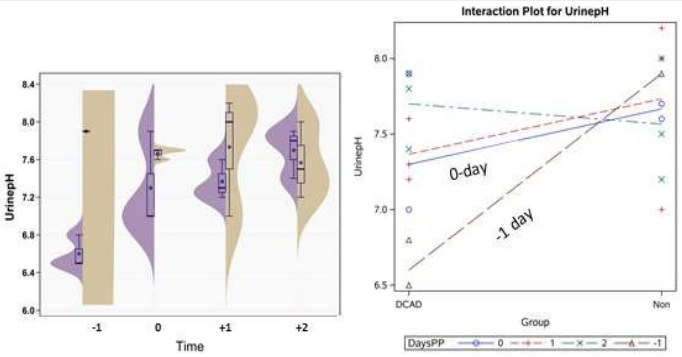

Figure 1: A diagram showing Urine pH for DCAD and NON-DCAD of Holstein- Friesian cattle. There is significant reduction in urine pH at group fed acidogenic diet.

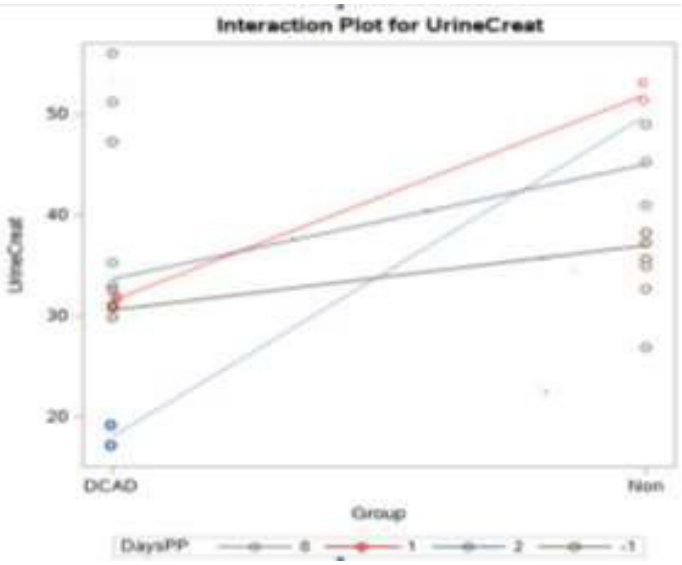

Figure 2: Urine Creat concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

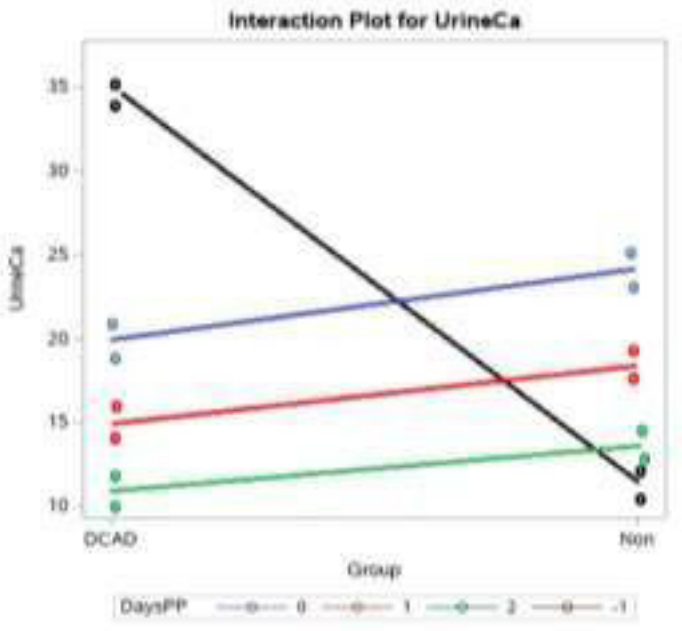

Figure 3: Urine Ca concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

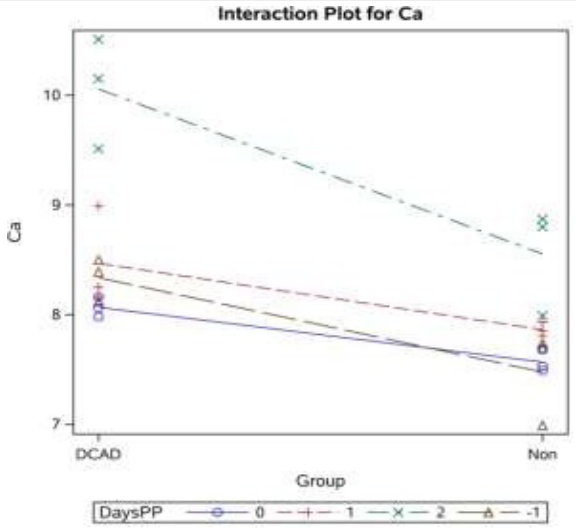

Figure 4: Serum Ca for DCAD and NON-DCAD of Holstein- Friesian cattle. DCAD increases the level of Ca, compared to non-DCAD group.

Effect of DCAD ration on blood minerals, bicarbonate, urea and creatinine

The data in Table 3 showed that serum Ca concentration (Figure 4) showed a significant increase (P<0.05) before and after parturition at the DCAD group, compare to NON-DCAD group. Serum P concentration (Figure 5) showed a significant increase (P<0.05) before and after parturition at group fed DCAD ration, compared to the NON-DCAD group. Serum Mg concentration showed a significant increase (P<0.05) before and after parturition at group fed DCAD ration, compared to the NON-DCAD group. Serum Na concentration (Figure 6) showed a significant increase (P<0.05) before and after parturition at group fed DCAD ration, compared to the NON-DCAD group. Serum K concentration (Figure 7) showed a significant increase (P<0.05) before and after parturition at group fed DCAD ration, compared to the NON-DCAD group. Serum Cl concentration (Figure 8) showed a significant increase (P<0.05) before and after parturition at group fed DCAD ration, compared to the NON-DCAD group. Serum Bicarb concentration (Figure 9) showed significant decrease (P<0.05) at group fed DCAD ration before and after parturition, compared to NON-DCAD group. Serum urea concentration (Figure 9) showed a significant increase (P<0.05) before parturition (-1 day), compared to the NON-DCAD group. Serum creatinine (Figure 10) concentration increased significantly before parturition (-1 day) and decreased after parturition (+1 day) at group fed DCAD ration compared to NON-DCAD group (Table 3).

Effect of DCAD ration on milk production and calf weight

The data in **Table 4** showed non-significant change in the weight of the calf between the two groups (Figure 12). The Milk production (Figure 13) showed a significant increase at group fed DCAD ration compared to the NON-DCAD group.

Table 3: Changes in blood minerals, bicarbonate, urea and creat during -1,0,1,2 peripartum day in multiparous dairy cattle fed acidogenic and non-acidogenic diets.

Parameters	DCAD group				Non-DCAD group			
	-1day	0 day	1 day	2 day	-1 day	0 day	1 day	2 day
Ca (mg/dl)	10.33±0.19^{b*}	9.06±0.09^{b*}	10.46±0.45^{b*}	11.05±0.50^{a*}	7.47±0.42^{a}	6.6±01.10^{a}	7.8±0.06^{a}	7.8±0.06^{a}
P (mg/dl)	5.58±0.56^{b*}	4.85±0.06^{b*}	6.43±0.21^{a*}	6.9±0.13^{a*}	3.61±0.03^{a}	3.06±0.10^{b}	4.05±0.05^{a}	4.55±0.05^{a}
Mg (mg/dl)	3.79±0.09^{b*}	2.81±0.13^{b*}	3.5±0.07^{a*}	3.77±0.10^{a*}	1.36±0.37^{a}	1.03±0.27^{a}	2.05±0.27^{a}	2.75±0.27^{a}
Na (mEq/l)	144.01±4.74^{a*}	133.61±3.54^{a*}	141.90±3.87^{a*}	154.49±2.25^{a*}	127.95±0.66^{b}	124.90±1.17^{b}	131.25±0.72^{a}	131.1±1.83^{a}
K (mEq/l)	5.02±0.62^{a*}	4.56±0.12^{b}	5.24±0.09^{a}	5.54±0.30^{a}	4.06±0.07^{a}	3.53±0.04^{a}	3.85±0.05^{a}	3.93±0.04^{a}
Cl (mEq/l)	120.84±1.67^{a*}	100.19±1.75^{a*}	124.28±1.66^{a*}	126.77±1.56^{a*}	100.08±0.08^{a}	92.16±1.28^{b}	98.01±0.23^{a}	99.76±0.49^{a}
Bicarb(mg/dl)	27.38±3.61^{b}	30.88±0.69^{b}	33.53±2.15^{a}	34.64±1.90^{a}	30.60±0.53^{b*}	32.77±1.27^{b*}	35.95±0.43^{a*}	36.94±0.55^{a}
Urea (mg/dl)	51.69±6.84^{b*}	62.45±0.59^{a}	41.72±0.45^{b*}	31.76±0.46^{b}	47.15±1.55^{b}	72.04±1.56^{a*}	37.01±0.06^{b}	32.46±2.45^{b}
Creat (mg/dl)	2.47±0.45^{a*}	2.71±0.07^{a}	1.46±0.17^{b*}	0.94±0.05^{b}	1.85±0.04^{b}	2.90±0.05^{a}	0.86±0.03^{b}	0.81±0.15^{b}

a-b Values with different letters within a column are significantly different between zero and other time points for each type of diet (P<0.05). * Values within a column are significantly different between same time points at different diets (P<0.05).

Table 4: Calf weight, Milk weight during 0, 1, 2, -1 peripartum day in multiparous dairy cattle fed acidogenic and non-acidogenic diets.

Group	Dayspp	Calf weight (Kg)	Milk weight (Kg)
DCAD	-1	-	-
DCAD	0	40±5^{a}	30.33±0.57^{a*}
DCAD	1	40±5^{b}	32.66±0.57^{a*}
DCAD	2	40±5^{a}	34.66±0.57^{b*}
Non-DCAD	-1	-	-
Non-DCAD	0	41.66±1.52^{a}	21.66±1.52^{a}
Non-DCAD	1	41.66±1.52^{a}	23.33±1.15^{a}
Non-DCAD	2	41.66±1.52^{a}	25.0±5.55^{a}

a-b Values with different letters within a column are significantly different between zero and other time points for each type of diet (P<0.05). * Values within a column are significantly different between same time points at different diets (P<0.05).

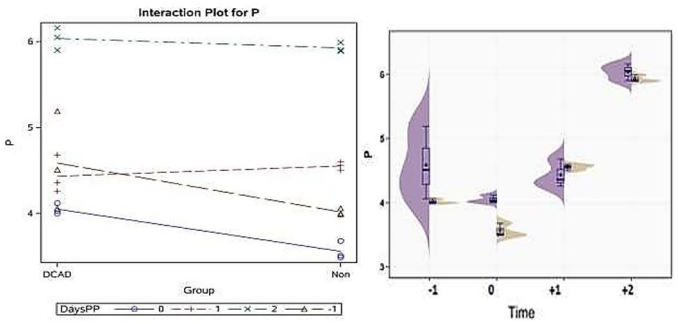

Figure 5: Serum phosphorus concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

DISCUSSION

One of the recurring problems in dairy farms, especially those with high production Holstein-Friesian cows, is the emergence of Ca deficiency cases, in late gestation. One of the ways that dairy farms help reduce cases of hypocalcemia

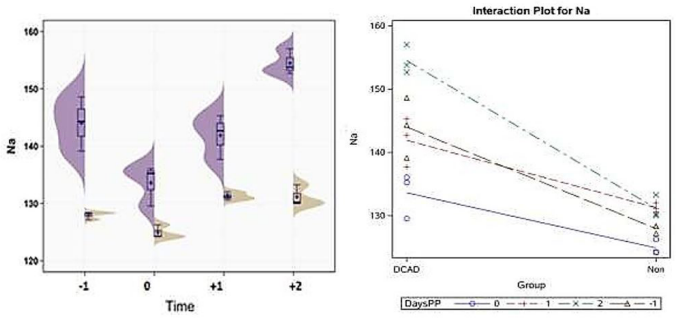

Figure 6: Serum Na concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

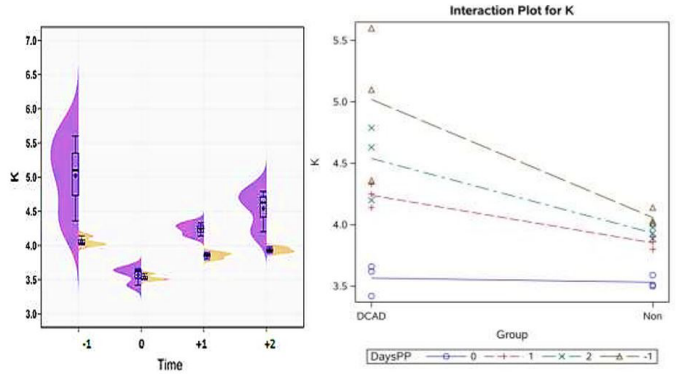

Figure 7: Serum potassium concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

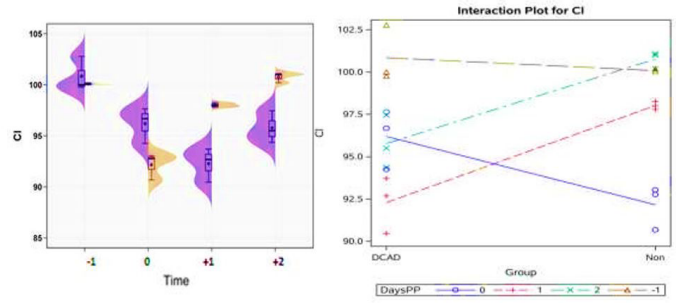

Figure 8: Serum Chlorid Concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

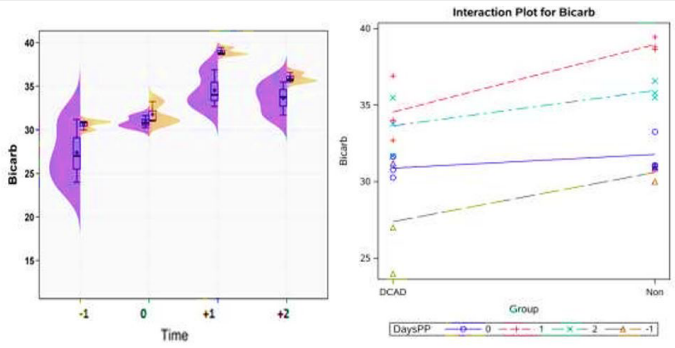

Figure 9: Serum bicarbonate concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

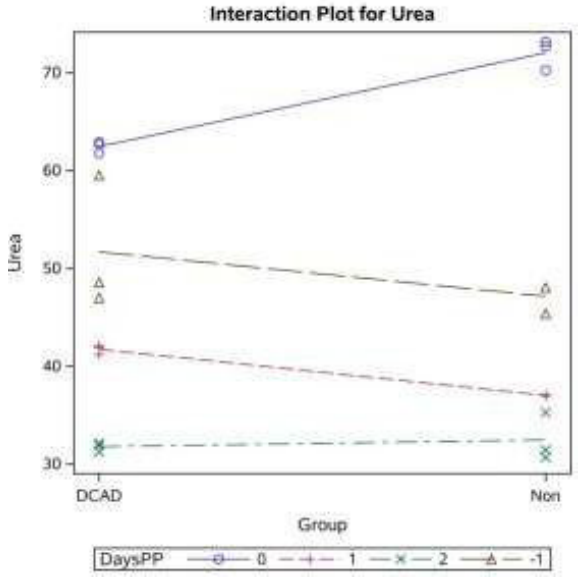

Figure 10: Serum urea concentration for DCAD and NON-DCAD of Holstein- Friesian cattle.

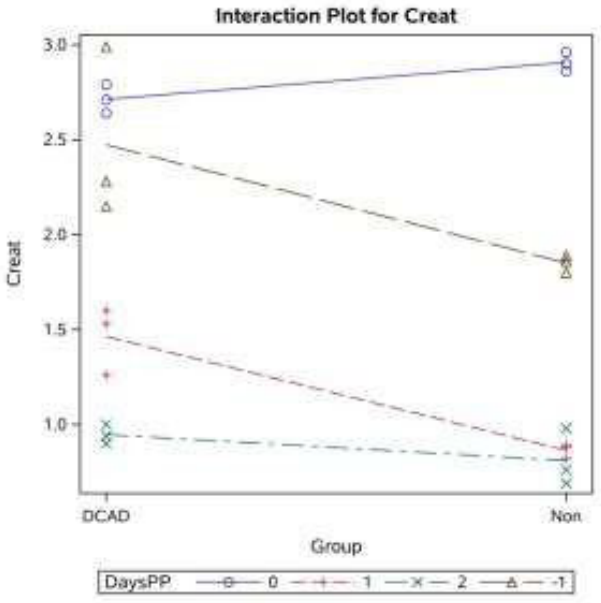

Figure 11: Serum creatinine concentration for DCAD and non-DCAD of Holstein- Friesian cattle, showing significant increase in DCAD group group compared to non-DCAD group at -1 day.

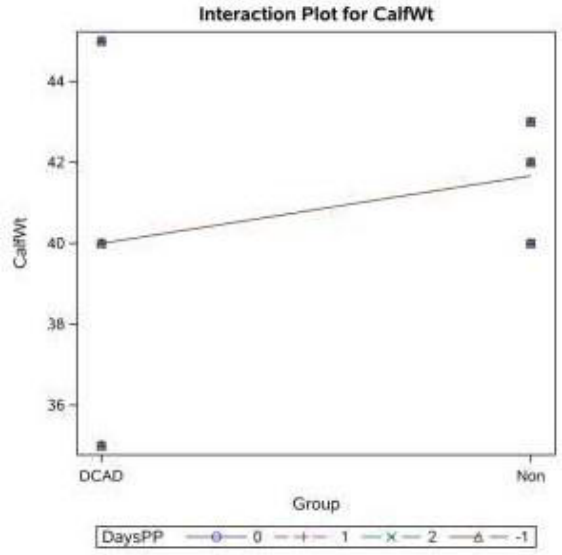

Figure 12: Calf Wt for DCAD and NON-DCAD of Holstein- Friesian cattle, showing non-significant change.

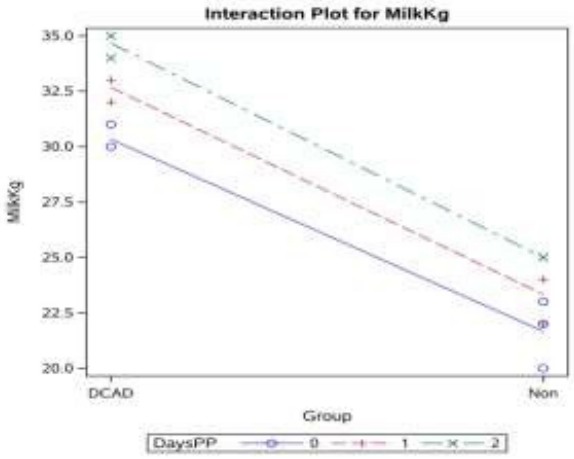

Figure 13: Milk kg for DCAD and NON-DCAD of Holstein- Friesian cattle, showing significant increase in milk production in DCAD group.

in multiparous cattle is to use Negative DCAD diets, which increase blood calcium concentrations postpartum. That leads to enhance health outcomes, improved production, and reproduction. The discovery of improved turnover can stimulate systemic acidsis. In addition, (Goff et al., 2014) state that dietary metabolic acidosis activates the PTH vitamin D axis, increasing intestinal Ca absorption and renal Ca reabsorption. This study found that prepartum feeding of the DCAD diet on dairy farms reduced urinary pH and increased urinary Ca excretion. Moore et al. (2000); Charbonneau et al. (2006) reported that increased acidity in the diet leads to mild compensatory metabolic acidosis that lowers urinary pH. Aciduria is caused by an excessively acidic diet that causes excessive proton excretion in the urine. The decrease in urine pH at peripartum intervals observed in this study is consistent with previous findings that urinary pH in cows fed an acidogenic diet in the late dry season did not change until 12- 24 hours

after parturition (DeGaris and Lean, 2008; Grünberg et al., 2011). Elevated H + levels in the distal tubules block the ability of Ca receptors to reabsorb Ca, causing hypercalcemia (Zahed and Chehrazi, 2017). This study found that feeding a DCAD diet reduced levels of HCO3. (Oberleithner et al., 1982) stated that there was less iCa complex with bicarbonate, resulting in more iCa available in the blood (Roche et al., 2003), with changes in urinary pH. By changing changes in blood pH, the kidneys play an important role in minimizing this change by making urine pH alkaline, excreting more HCO3-, and conserving H +. The feeding of the DCAD diet before parturition in dairy cows helps to reduce cases of hypocalcemia in periparturient Holstein-Friesian cows. Charbonneau et al. (2006) said that feeding an acidogenic diet lowers the decrease in serum calcium 24 hours after parturition and reduces the incidence of prepartum and postpartum hypocalcemia from 16.4% to 3.2%. As a result, the serum calcium concentration before and after parturition was significantly increased in the DCAD distribution group compared to the NON-DCAD group. El-Sheikh et al. (2002) and Couto-Serrenho et al. (2021) found that a negative prepartum DCAD diet increased postpartum serum Ca levels and reduced the incidence of mastitis, abomasum dislocation, and clinical mastitis (Reinhardt et al., 2011; Miltenburg et al., 2016). Negative relationship between serum Ca before and after confinement, (Espino et al., 2003) maintains the ability of bovine Ca homeostasis obtained by acidification promoting the mobilization by removing calcium from bone (Goff, 2000; Espino et al., 2003) by promoting the action of PTH on bone and kidney or by the role of bone in buffering. This study found that prepartum feeding an acidogenic diet increased serum P levels before and after parturition (Ramos-Nieves et al., 2009). Agree with some previous studies (Ramos-Nieves et al., 2009; Vieira-Neto et al., 2021). Recently, it was reported that serum P concentration was negatively correlated with urinary pH (Vieira-Neto et al., 2021). However, these results reports are in contrast to previous studies that reported a direct association between DCAD reduction and P concentration (Castro et al., 2004). As mentioned earlier, metabolic acidosis and cystinuria promote renal Pi loss, so take an acidogenic diet before parturition (Grünberg et al., 2011). This study found that feeding a prepartum acidogenic diet increased serum Mg levels around calves (Goff, 2008). Similarly, in this study, high serum Mg levels in cattle fed an acidogenic diet were observed in previous studies (Goff and Horst, 2003; Farnia et al., 2018; Megahed et al., 2018; Rodney et al., 2003, 2018). Transient hypermagnesemia is most often due to increased renal Mg reabsorption in response to decreased blood Ca levels that stimulate PTH release (Rodney et al., 2018). Interestingly, cows fed an acidogenic diet showed increased serum Na and K levels around the calf compared to NON-DCAD cows. Metabolic acidosis has a dual effect on electrolyte balance, and increased electrolyte levels around calves are likely to be of renal origin (Stacy and Wilson, 1970). High serum levels in DCAD cattle are likely due to high Cl content in low DCAD diet (El-Sheikh et al., 2002; Grünberg et al., 2011). Renal function indices which includes serum urea and creatinine used to evaluate the functional integrity of the kidney, with expanded values being a demonstration of defective functional state (Yakuba et al., 2003). Linearly multiplied serum urea and the tendency to linearly increase creatinine concentrations found on this study also additionally mean some degree of renal toxicity imposed by negative DCAD. The urinary pH to as little as 5.5. By decreasing the pH from ordinary values 8.5 to values near 5.5 (3 Ph units), an immoderate load is imposed at the kidneys, as they need to excrete 1,000 instances the extra H+ produced by the body (Goff, 2018). The most negative DCAD also caused some indications of liver and kidney damage. This study found that feeding a prepartum acidogenic diet increased postpartum milk yield in calves (DeGroot et al., 2010). Postpartum (Puntenney, 2006) stated that acidifying the diet before parturition reduces the incidence of clinical and asymptomatic hypocalcemia and increases postpartum DMI and milk yield.

CONCLUSION

Feeding diets-induced mild metabolic acidosis during the close-up period enhances minerals homeostasis around calving, particularly calcium level, DCAD di*et al*so enhanced milk production in dairy cattle fed acidogenic diet in late gestation. However, mild adverse effect on kidney function was detected. Further investigation on required adjust the doses of DCAD for dairy cows to overcome this effect.

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NOVELTY STATEMENT

The authors declared that the results of this study are novel specially the effect of DCAD on the liver and kidney function and its addition to lactating cows should be under caution.

AUTHOR'S CONTRIBUTION

AF design and perform the study. MG revised the study design and write the draft with graphing. YA revised the manuscript, HE review the study design and statistics,

AM revised the manuscript and help in practical part. HE review the results and interpretation.

Conflict of interest

The authors have declared no conflict of interest.

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