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DIETARY CATION-ANION DIFFERENCE IN RATIONS FOR PREGNANT DRIED OFF COWS

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ABSTRACT

On a farm with 230 Friesian cows, winter and summer nutrition of highly pregnant dry cows was studied. Dietary cation-anion difference in the rations (DCAD) was calculated to estimate its possible connection with the incidence of milk fever and hypocalcaemia in cows. In winter season daily ration was composed of 3 kg of hay, 10-13 kg of grass silage and 10-13 kg of maize silage, with 1 kg of concentrate and 50 g of min.-vit. mixture. During summer season cows grazed and were additionally fed 3 kg of hay and 8 kg of maize silage till mid June, then until the end of season the maize silage was replaced by 10 of grass silage. A week before expected date of calving, cows were fed an additional 2 kg of concentrate. Throughout the dry period the cows were also fed 100 g of min.-vit. mixture. Dietary cation-anion difference was estimated as milliequivalent (meq) per kg of DM $[(K^{+}+Na^{+}) - (Cl^{-}+S^{--})]$ (Oetzel, 1993). In winter months (November-February) dietary cation-anion difference ranged from 365 to 373 meq kg^{-1} DM. In studied months of winter season 83 cows calved, 9 of which were treated for milk fever and 5 for hypocalcaemia. In summer season (May-September) dietary cation-anion difference ranged from 27 to 238 meq $^{-1}$kg DM. In studied months of summer season 73 cows calved, 6 of which were treated for milk fever and 3 for hypocalcaemia.

Key words: cattle / cows / dairy cows / dried off cows / pregnancy / animal nutrition / feed / cation-anion difference.

KATIONSKO-ANIONSKA RAZLIKA V OBROKIH ZA PRESUŠENE KRAVE

IZVLEČEK

Na farmi z 230 kravami črno-bele pasme je analizirana zimska in poletna prehrana visokobrejih presušenih krav. Izračunana je kationsko-anionska razlika v obrokih (Dietary cation-anion difference-DCAD) z namenom, da bi ocenili njeno možno povezanost s pojavi poporodne pareze in hipokalcemije pri kravah. V zimski sezoni je bil dnevni obrok sestavljen iz 3 kg sena, 10-13 kg travne silaže in prav toliko koruzne silaže, 1 kg krmne mešanice in 50 g min.-vit. mešanice. V poletni sezoni so bile krave na paši, dokrmljevali pa so jim 3 kg sena in 8 kg koruzne silaže do sredine junija, nato pa je koruzno silažo v obroku zamenjalo 10 kg travne silaže. Teden dni pred pričakovano telitvijo so krave dnevno dobivale še 2 kg krmne mešanice, ves čas presušitve pa 100 g min.-vit. mešanice. Kationsko-anionska razlika v obrokih je ocenjena kot miliekvivalent (meq) na kg SS $[(K^{+}+Na^{+}) - (Cl^{-}+S^{--})]$ (Oetzel, 1993). V zimskih mesecih (november-februar) se je kationsko-anionska razlika v obrokih gibala od 365 do 373 meq kg^{-1} SS. V obravnavanih mesecih zimske sezone je telilo 83 krav, 9 od teh je bilo zdravljenih za poporodno parezo, 5 krav pa za hipokalcemijo. V poletni sezoni (maj-september) je bila kationsko-anionska razlika v obrokih od 27 do 238 meq $^{-1}$kg SS. V obravnavanih mesecih poletne sezone je telilo 73 krav, 6 od teh je bilo zdravljenih za poporodno parezo, 3 krave pa za hipokalcemijo.

Ključne besede: govedo / krave / molznice / presušene krave / brejost / prehrana živali / krma / kationsko-anionska razlika.

INTRODUCTION AND LITERATURE SURVEY

In the last decade several studies investigated the influence of nutrition on incidence of milk fever and hypocalcaemia in dried-off cows (Gregorović, 1992). The importance of calcium and the ratio of calcium to phosphorus in a ration has been emphasised by new information on pathogenesis of this disease.

Goff and Horst (1991) and Oetzel (1991) reported that besides calcium other components of a ration significantly influenced the incidence of milk fever. Oetzel studied various factors that caused milk fever in 1100 cows. The nutrition statistically significantly affected relations between the content of sulphur, dietary cation-anion difference, contents of calcium and crude fibre on one side and milk fever on the other.

Oetzel did not notice a negative correlation between the dietary calcium and milk fever, the relative risk being higher at 1.16% calcium content in dry matter of a ration. The incidence of milk fever diminished when there was more or less than 1.16 % of dietary calcium.

Block (1984), Oetzel *et al.* (1988), Gaynor *et al.* (1989), Goff and Horst (1991), Oetzel (1991), Goff (1992) and Block (1994) reported that dietary cation-anion difference(DCAD) for dried-off cows could be more responsible for milk fever than the content of calcium. Oetzel informed that of all nutritional factors studied in his research, dietary sulphur and cation-anion difference, calculated as milliequivalent per kg of DM ((K^+ + Na^+) - (Cl^- + S^{--})), are the most correlated with milk fever. Green *et al.* (1981), Block (1984), Gaynor *et al.* (1989), Leclerc and Block (1989) and Block (1994) reported on similar findings. Hence the dietary calcium is not as important factor for milk fever as acid-base conditions of a cow post partum are (Block, 1994).

It can be concluded that the influence of nutrition of dried-off cows on milk fever could be prevented by diminishing the amounts of dietary calcium (Allen and Sansom, 1985, Oetzel, 1993). Rations with little calcium prevent that active absorption of calcium in the intestine and its mobilisation from bones stopped and could not respond to unexpected higher secretion of calcium with milk. Nevertheless it is not possible to diminish calcium effectively without disturbing the balance of other nutrients in the ration (Oetzel, 1993).

Theories on DCAD role in the pathogenesis of milk fever state that changes in cations and anions that influence the metabolic acid-base balance in a body affect also the bone ability to resorb calcium in the partum period. Cows that consumed more dietary cations especially sodium and potassium had target tissues less sensitive to parathormone (PTH) than cows that consumed more dietary anions, especiall chlorine and sulphur (Goff and Horst, 1991). The response of 1.25 dihydroxycholecalciferol on hypocalcaemia significantly diminished in cation rich rations (Goff and Horst, 1994).

Rations with more anions than cations cause slight metabolic acidosis (Brand, 1997) that improves the resorption of calcium from bones, stabilises the concentration of blood at calving and diminish the risk of hypocalcaemia. It has been reported that addition of anion acids to the rations for dried-off cows helped to increase the concentration of 1.25 dihydroxycholecalciferol in blood (Gaynor *et al.,* 1989) and increased the absorption of calcium from digestive tract (Freeden et *al.,* 1988).

The best method to predict the incidence of milk fever on the base of DCAD has not been discovered yet. A few models that include various cations (potassium and sodium; potassium, sodium, calcium and magnesium) and anions (chlorine; chlorine and sulphur; chlorine, sulphur and phosphorus) are already known. When Oetzel (1991) estimated DCAD as meq ((K^+ + Na^+)-(Cl^- + S^{--})) he discovered its connection to milk fever on the level r = 0.330, P = 0.0038. Even higher correlation with milk fever had sulphur as an independent ion (r = -0.425, P = 0.0001). Higher dietary sulphur was connected to fewer insidence of milk fever, which confirmed the DCAD theory on milk fever pathogenesis in which the dietary sulphur acts as a strong anion and diminishes the risk. Besides sulphur and DCAD also calcium (r = 0.233, P = 0.0441) and crude fibre ($r = -0.241$, $P = 0.0376$) were connected to incidence of milk fever in rations analysed by Oetzel.

The aim of dietary cation-anion balance in dried-off cows is to prevent the milk fever (Bayers, 1992). Dishington (1975) reported that milk fever was prevented in 92 % cases if dried-off cows consumed rations with a negative DCAD and a lot of calcium. Block (1984) proved 47 % of milk fever in DCAD = +330.5 meq kg^{-1} DM in rations, but he never proved DCAD = -128.55 meq kg^{-1} DM. Oetzel *et al.* (1988) proved the cases of milk fever regardless the dietary calcium with DCAD = -75 meq kg^{-1} in comparison to the rations with DCAD = +189meq kg^{-1} DM.

Block (1984) and Goff and Horst (1991) reported that the concentration of calcium in blood was higher in cows with a negative DCAD. Oetzel *et al.* (1988) reported higher concentration of ionised calcium in blood at calving in cows with rations with a negative DCAD. When milk fever was prevented by a negative DCAD the rations contained a lot of calcium (1.5 %). Wang and Beede (1992, 1992a), and Delaquis and Block (1995) noticed that rations with a negative DCAD increased the secretion of calcium with urine. If in the case of a negative DCAD the ration contains little calcium, hypocalcaemia occurs regardless the milk fever. If DCAD theory in milk fever prevention is successful, the rations should contain more calcium and phosphorus in the negative DCAD (Delaquis and Block, 1995).

A negative DCAD for dried-off cows prevents decrease of calcium in blood at the beginning of lactation directly with mobilisation of calcium from bones, indirectly by increased mobilisation of calcium from bones due to higher secretion of calcium (lower retention rate) or with absorption of calcium from intestine (Block, 1994).

The DCAD in the rations was estimated in practice in dried-off cows in certain months of winter and summer season to establish its contingent connection to incidence of milk fever and hypocalcaemia on the studied farm.

MATERIAL AND METHODS

On the farm with 230 Friesian cows, winter and summer nutrition of high pregnant and dried-off cows was studied as well as incidence of milk fever and hypocalcaemia respectively.

In the winter season (November - February) cows were fed 3 kg of hay, 10 to 13 kg of grass silage and the same amount of maize silage, 1 kg of concentrate and 50 g of min.-vit. mixture a day.

In the summer season (May - September) cows were on pasture, while some concentrates were fed in stall. From May till the mid of June each cow was fed 3 kg of hay and 8 kg of maize silage a day, from mid of June till the end of September 3 kg of hay and 10 kg of grass silage. A week before expected calving cows were moved to the maternity stall where hay and silage were fed ad libitum besides 2 kg of concentrate for production. Also 100g of min. vit. mixture was fed every day.

The compositions of both min.-vit. mixtures were different.

From the results of chemical analyses on the contents of calcium and sodium in fodder (Rajčevič *et al.,* 1997), data from daily consumed sodium and chlorine in winter min.-vit. mixture and sodium, chlorine and sulphur in summer min.-vit. mixture and references from literature on the contents of chlorine and sulphur (NRC, 1988), were used to estimate the DCAD in rations for the studied months. DCAD was calculated using the equation meq per kg DM = $((K^{+} + Na^{+}) - (Cl^{-} + S^{--}))$ that is mostly used for dried-off cows (Oetzel, 1993).

Correlations among components of rations and incidence of milk fever and hypocalcaemia were calculated.

RESULTS

Table 1 shows the average amounts of daily consumed nutrients and minerals per cow from October to February as well as estimated DCAD per month. October represented a transitional period from summer to winter feeding regime.

Table 1. Average daily consumed nutrients and minerals and DCAD per cow and a month in winter season (per kg DM)

	Oct.	Nov.	Dec.	Jan.	Feb.
Dry matter, kg	11.10	11.62	11.50	11.70	11.65
Crude fibre, %	22.90	23.48	23.40	23.80	23.70
Crude protein, %	14.00	13.69	13.30	14.45	14.11
NEL, MJ	5.70	5.90	5.95	5.87	5.90
Calcium, %	0.49	0.52	0.51	0.54	0.53
Phosporus, %	0.31	0.32	0.32	0.34	0.33
Ca:P ratio	1.58	1.62	1.59	1.59	1.60
Potassium, %	1.75	1.89	1.90	1.91	1.90
Sodium, %	0.10	0.11	0.10	0.11	0.11
K:Na ratio	17.50	17.10	19.00	17.40	17.27
Magnesium, %	0.19	0.19	0.19	0.20	0.20
Chlorine, %	0.22	0.22	0.20	0.23	0.22
Sulphur, %	0.17	0.16	0.16	0.17	0.16
DCAD, meq	322	369	373	365	372

Table 1 shows that cows consumed recommended amounts of dry matter (Van Saun, 1996, DLG, 1997). The content of potassium in dry matter of ration exceeds the standard. On the farm, grasslands are manured by pig and cattle slurry and mineral fertilisers. Such a high content of potassium in a ration, the contents of magnesium and sulphur require between 0.3 and 0.35 % of sulphur in DM (Van Saun, 1996). Cows consumed too low amounts of magnesium and sulphur. According to Brand's recommendations (1997) the rations with such a high DCAD should contain less calcium and phosphorus two weeks before calving (daily 33 to 42g of calcium and 20 to 26g of phosphorus). The studied cows consumed on average 60 g calcium and 37 g phosphorus during the dried-off period. According to NRC (1988) and DLG (1997) daily needs of calcium and phosphorus of cows in the dried-off period are lower.

In the investigated winter months (November - February) DCAD ranged between 365 and 373 meq kg^{-1} DM. Rations for dried-off cows are often alcalogen (Brand, 1997), their cation-anion difference ranges from +50 to +300 meq kg^{-1} DM or more, calculated as meq $((K^+ + Na^+)) - (Cl^- + S^{--}))$. To prevent milk fever, dried-off cows should have rations with a negative DCAD, ranging between - 10 and -20 meq kg^{-1} DM (Brand, 1997).

There were 83 calvings between the beginning of November and the end of February, 9 cows were treated for milk fever (three of them were slaughtered later), and 5 cows got hypocalcaemia. Our results match the findings of Block who already in 1984 reported on frequent incidence of milk fever with rations with DCAD higher than 300 meq kg^{-1} DM.

There is a statistically significant correlation (P = 0.05) between the content of potassium in rations and the incidence of milk fever and hypocalcaemia respectively.

Table 2 shows the average daily amounts of consumed nutrients and minerals per cow in summer season as well as the evaluation of DCAD per month.

Table 2. Average daily consumed nutrients and minerals and DCAD per cow and a month in summer season (kg DM^{-1})

	May	June	July	Aug.	Sept.
Dry matter, kg	9.27	9.45	9.68	9.30	8.95
Crude protein, %	14.20	15.92	17.63	16.94	16.26
Crude fibre, %	23.79	25.20	26.60	26.55	26.52
NEL,MJ	6.30	6.00	5.79	5.75	5.70
Calcium, %	0.32	0.45	0.57	0.53	0.50
Phosphorus, %	0.36	0.37	0.38	0.36	0.34
Ca:P ratio	0.89	1.20	1.50	1.50	1.47
Potassium, %	1.42	1.20	0.94	0.80	0.73
Sodium, %	0.26	0.28	0.29	0.29	0.28
K:Na ratio	5.46	4.28	3.24	2.76	2.61
Magnesium, %	0.15	0.20	0.24	0.23	0.22
Chlorine, %	0.49	0.50	0.53	0.55	0.58
Sulphur, %	0.16	0.16	0.17	0.17	0.19
DCAD, meq	238	187	110	69	27

Table 2 shows that cows consumed too small amounts of dry matter during the season, and in the second part of the studied period the amount of energy was also too small, while there were too much proteins (Van Saun, 1996, DLG, 1997).

The amounts of the consumed potassium exceeded the recommended values in the first part of the season, while they were normal in the second one. The amounts of the average consumed sodium exceeded the recommendations (Van Saun, 1996); there were 16 g of sodium in 100 g of min.-vit. mixture. Referring to data from literature (Van Saun, 1996) cows consumed too small amounts of dietary sulphur, while the amounts of chlorine were too high; there were 26 g of chlorine in 100 g of min.-vit. mixture. DCAD was +238 meq kg^{-1} DM at the beginning of the season and it diminished to +27 meq kg^{-1} till the end of the season.

During the summer season 73 cows calved. In May, June and July 6 cows were treated for milk fever and 3 for hypocalcaemia. In August and September no cases of milk fever and hypocalcaemia were noted.

CONCLUSION

In practice it is very difficult to compose such rations with available fresh fodder for dried-off cows that ensure suitable metabolic acid-base conditions after the calving.

On the studied farm, dried-off cows consumed rations that were rich with potassium and had a high DCAD especially during winter season. Regarding the data from literature, cows with so high DCAD should consume less calcium and phosphorus at least the last two weeks before calving.

The analysed rations showed that the increased amount of potassium was not followed by increased amounts of sulphur and magnesium as recommended.

Milk fever and hypocalcaemia appeared during winter and summer seasons except August in September on the studied farm. The DCAD was positive but significantly lower than in the other studied months.

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