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Effects of prepartum treatment with monensin or propylene glycol mixed with concentrate on milk yield and blood NEFA and BHBA levels in dairy cows

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Abstract: Sixty multiparous Holstein–Friesian dairy cows made up the study sample. Group M (n = 20) received 300 mg/day monensin (Kexxtone, Elanco) for 21 days prior to the expected calving date. Group PGC (n = 20) received propylene glycol, mixed with concentrate and fed separately from total mixed ration (TMR) twice a day in the last 21 days of gestation. The control group, Group C (n = 20) did not receive any treatment prior to parturition. Cows in all three groups received PG (300 mL/day) for 5 days after parturition. Blood samples were collected 21 and 7 days prior to the expected calving date, as well as 7 and 14 days after parturition. NEFA and BHBA levels did not differ between the treatment groups. However, milk yield of Group M was significantly higher than that of Group C during weeks 3, 4, and 5 of lactation. Although NEFA and BHBA levels were similar in both treatment groups, higher milk yield in monensin-treated cows could be related to an increase in glycogenic precursors resulting from favorable effects of monensin on ruminal bacterial flora.

Key words: Propylene glycol, monensin, dry period, NEFA, BHBA, milk yield

1. Introduction

High-producing dairy cows have to cope with extremely high metabolic stress during the periparturient period. High energy and protein demands required for milk synthesis are fulfilled by mobilization of body reserves. Excessive mobilization of stored body fat reserves could result in the emergence of postpartum metabolic diseases, such as ketosis and fatty liver disease, which are associated with decreased milk yield and high herd removal rates (1–3). As elevated blood ketone bodies are also related with decreased neutrophil function, ketotic animals are prone to suffer from postpartum infectious diseases such as mastitis and metritis (4,5). Strategies that can be implemented to minimize the metabolic stress during the periparturient period are a subject of extensive research. Using monensin and/or propylene glycol in order to increase available glucose and decrease body fat mobilization is one of these measures (6,7).

Monensin is an ionophore antibiotic used for altering rumen flora in order to increase the molar concentration of propionate and decrease the acetate and butyrate proportion of the flora (8). Increase in rumen propionate concentration is directly linked to elevated blood glucose and lower incidence of fat metabolism-related diseases such as ketosis and fatty liver syndrome. Levels of metabolites used for interpretation of energy balance in cattle, such as beta-hydroxybutyric acid (BHBA) and nonesterified fatty acids (NEFA), are reported to decrease in cattle receiving monensin in the periparturient period (9). Effects of monensin on milk yield and milk constituents are demonstrated in many studies. Duffield et al. (10) reported that projected 305-day milk yield significantly increased in cows that received monensin controlled-release capsules (CRC) 3 weeks prior to the expected parturition date. However, milk fat and protein percentage were not affected by monensin treatment. On the other hand, He et al. (11) did not observe any effects of monensin on milk yield and constituents.

Propylene glycol (PG) is a glycogenic precursor used in cattle for prevention and control of ketosis and fatty liver syndrome. Administration of PG in the dry period is shown to significantly decrease BHBA and NEFA levels by reducing fat mobilization. By improving the metabolic status of dairy cows, use of PG could result in elevated milk yields in herds suffering ketosis (12). However, some researchers found that, while improving periparturient metabolic status, administration of PG in different periods did not result in significant increases in milk yield (13). PG is generally administered orally in a 300 mL/day dose. However, this administration route is time consuming

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and labor intensive, especially when PG is used for longer periods. On the other hand, oral administration of PG could result in aspiration pneumonia, especially when administered by inexperienced staff (14).

The objective of the present study was to compare the effects of prepartum administration of monensin or PG mixed with concentrate on the blood NEFA and BHBA levels and milk yields in the first 8 weeks postpartum in Holstein–Friesian dairy cattle.

2. Materials and methods

Sixty multiparous Holstein–Friesian cattle with body condition score (BCS) between 3.25 and 3.50 were selected from the same herd for this study. Mean lactation of the selected animals was 2.7 ± 0.2 while the mean milk yield in the previous lactation was measured as 9867 (305-day) per cow. All animals were fed the same dry close-up and fresh rations. Their diets were formulated according to the NRC (2001) recommendations and were delivered as a total mix ration (Table 1). All cows were housed in free-stall barns. Cows were randomly assigned to one of the three study groups, each consisting of 20 animals. Group M received monensin in CRC (Kexxtone, Elanco) 21 days prior to the expected calving date to deliver approximately 300 mg/day monensin. Group PGC received propylene glycol, mixed with concentrate and fed separately from the total mixed ration (TMR) twice a day in the last 21 days of gestation. Animals in Group PGC were fed with close-up TMR after they consumed propylene glycol mixed with concentrate. The control group (Group C) did not receive any treatment prior to parturition. Cows in all three groups received PG (300 mL/day) for 5 days after parturition. All cows were housed in the same barn for 5 days after parturition and were milked twice a day. On day 6, all cows were transferred to a fresh cow barn and were milked three times a day. Milk yield of all groups was recorded for 8 weeks.

Blood samples of all cows were collected from the coccygeal vein into tubes without anticoagulant 21 and 7 days before the expected calving date, as well as 7 and 14 days after parturition. Blood samples for NEFA analysis were collected before the morning feeding (0600–0700), while those for BHBA were taken 3 to 4 h after the morning feeding (1100–1200). All blood samples were centrifuged at 1500 × *g* for 20 min and serum was stored at –20 °C until required for analysis. Blood NEFA (CK-E90284, Eastbiopharm, China) and BHBA (CK-E9043, Eastbiopharm, China) concentrations of collected samples were measured using commercial bovine ELISA kits as per the manufacturer's instructions.

All the data passed normality and homogeneity tests. The three groups' NEFA and BHBA levels and mean weekly milk production values were compared using one-way repeated measures analysis of variance (one-way RM ANOVA), along with Tukey's test as a post-hoc test. Differences with $P \leq 0.05$ were considered statistically significant. Statistical analyses of the results were performed using Sigma Plot 12 software (Systat Software Inc., San Jose, CA, USA).

Table 1. Ingredient and nutrient composition of experimental diets.

Ingredients (kg)	Early Lactation	Prepartum
Corn silage	16.000	8.000
Alfalfa hay	4.750	2.000
Oat hay	0.250	0.500
Wheat straw		1.000
Barley	1.450	0.500
Molasses	0.500	0.200
Corn	4.500	1.500
Hydrolyzed tallow fatty acids	0.600	
Sunflower meal, 32% CP	0.600	0.750
Corn gluten meal	0.650	
Soybean meal, 48% CP	1.500	0.650
Full fat soybean	1.040	0.375
Wheat bran	1.300	0.940
Corn dry distiller grain	1.300	
Calcium carbonate	0.210	0.063
Magnesium oxide, MgO	0.050	
Sodium Bicarbonate, $NaHCO_3$	0.200	
Salt	0.070	0.015
Vitamin mineral mix	0.020	0.010
Magnesium sulfate	-	0.300
Nutrients	Early lactation	Prepartum
NEL, Mcal/kg DM	1.67	1.56
CP, % DM	17.8	15.5
EE, % DM	6.0	3.0
NDF, % DM	32.0	39.2
ADF, %DM	20.5	25.4
NFC, %DM	38.0	34.4
Ca, % DM	0.9	0.7
P, % DM	0.4	0.4

3. Results

Mean body conditions of cows at the beginning of the study, 21 days before the expected parturition date, were 3.33 ± 0.08, 3.38 ± 0.11, and 3.36 ± 0.06 for groups M, PGC, and C, respectively. Prepartum treatment with monensin started 22 ±1.8 days before and PG mixed with

concentrate 20 ± 2 days before the actual calving date. The mean body condition scores and days of treatment prior to the actual calving date did not differ significantly between treatment groups (P = 0.91 and P = 0.62 respectively). Consumption of PG mixed with concentrate by animals in Group PGC was observed after feeding and none of the animals refused to ingest the mixture.

Prepartum serum NEFA concentrations, measured on days 21 and 7 before the expected calving date, did not differ between the treatment groups (Table 2). Similarly, serum BHBA concentrations measured on days 21 and 7 prepartum and 7 and 14 postpartum did not differ between the two treatment groups. Average weekly milk yields were higher (P ≤ 0.05) in Group M when compared to Group C at weeks 3, 4, and 5 following parturition (Table 3).

4. Discussion

Owing to the constantly increasing milk yields of dairy cattle, strategies aimed at controlling the negative energy balance (NEB) and related metabolic and infectious diseases in the early postpartum period are rapidly gaining significance. Although the clinical and economic consequences of NEB are mainly observed in early lactation, dry period management plays a crucial role in the control of NEB. Labor requirement is one of the most important factors when considering which strategy would be the most suitable for a particular herd. Monensin treatment in the form of CRC is demonstrated as effective in improving energy status in early lactation (15). PG is widely used for control of NEB in dairy herds. Juchem et al. (16) reported that oral drenching of cattle with 300

Table 2. Mean (±SEM) NEFA (mmol/L) levels on days 21 and 7 before parturition and BHBA (mmol/L) levels on days 21 and 7 before parturition and 7 and 14 after parturition.

	Periparturient days			
BHBA	–21	–7	7	14
M	0.62 ± 0.02a	0.69 ± 0.04a	0.86 ± 0.05a	0.82 ± 0.08a
PGC	0.65 ± 0.04a	0.81 ± 0.06a	0.88 ± 0.05a	0.73 ± 0.05a
C	0.68 ± 0.04a	0.82 ± 0.09a	0.78 ± 0.05a	0.82 ± 0.09a
NEFA				
M	0.51 ± 0.02a	0.50 ± 0.07a		
PGC	0.54 ± 0.02a	0.61 ± 0.06a		
C	0.56 ± 0.02a	0.54 ± 0.09a		

a,b: Differences between the values involving different letters in the same column are statistically significant (P < 0.05)

Table 3. Mean (kg ±SEM) milk yields of animals in the M, PGC, and C groups in the first 8 weeks of lactation.

Week	M	PGC	C
1	23.6 ± 1.32a	20.63 ± 1.29a	19.83 ± 1.64a
2	30.06 ± 1.09a	27.82 ± 1.30a	26.75 ± 2.19a
3	36.2 ± 1.93a	33.81 ± 1.45ab	30.44 ± 2.07b
4	41.2 ± 2.24a	36.4 ± 2.35ab	34.13 ± 2.23b
5	43.57 ± 2.31a	41.21 ± 2.35ab	36.64 ± 2.39b
6	45.12 ± 2.21a	42.52 ± 2.81a	38.82 ± 2.44a
7	45.31 ± 2.03a	43.0 ± 3.42a	39.72 ± 2.11a
8	46.03 ± 2.06a	44.03 ± 3.40a	38.66 ± 4.40a

a,b: Differences between the values involving different letters in the same row are statistically significant (P < 0.05)

mL/day PG for 21 days before parturition resulted in decreased serum BHBA and NEFA levels. Although these results are promising, drenching cows for 21 days is very labor intensive. Christensen et al. (17) compared three different methods of PG delivery based on blood NEFA concentrations in feed-restricted cows and reported that PG mixed with concentrate and fed separately from forage is as effective as oral drenching. As this method of delivery is much more labor effective, we aimed to compare the effectiveness of two different dry period control strategies that are reported to improve energy metabolism and production indices (7,18). In order to observe the effects of prepartum treatments, all three groups received oral drenching with 300 mL/day PG for 5 days after parturition. Aspiration pneumonia related to PG drenching did not occur in our study.

BHBA levels of all groups were similar during the study period. Duffield et al. (19) reported lower BHBA levels in postpartum dairy cows treated with monensin in the dry period. Similarly Green et al. (20) noted 35% reduction in the BHBA levels following monensin administration in cows with subclinical ketosis. However, more recently, Duffield et al. (21) reported that metabolic effects of monensin are dependent on mode of delivery and diet. They thus concluded that monensin's effects on BHBA are reduced when it is administered via CRC when compared to bolus administration. In the same metaanalysis, Duffield et al. (21) reported that impact of monensin on BHBA is higher in pasture-based fed cattle. BCS exceeding 3.5 at the time of parturition is associated with increased risk for ketosis in dairy cows (22). Duffield et al. (10) reported that positive effects of monensin are more pronounced in animals with preexisting metabolic disturbances. Similar BHBA levels in all groups detected in our study could be related to lower risk for NEB, as the mean BCS of cattle selected for the study ranged from 3.25 to 3.5.

In the present study, milk yield of Group M was significantly higher in weeks 3, 4, and 5 when compared to Group C. A metaanalysis of the impact of monensin on production traits demonstrated that monensin increased milk yield by 0.7 kg and improved milk production efficiency by 2.5% (21). Dubuc et al. (23) reported that the effects of monensin on milk yield are closely related with the stage of lactation and concluded that monensin increased milk production in the first 150 days of lactation. This assertion is supported by the results yielded by the present study, in which effects of monensin on milk yield were observed between weeks 3 and 5 of the study. Positive effects of monensin on milk production are mainly attributed to increases in glycogenic precursors resulting from the favorable monensin effects on bacterial populations that synthesize propionic acid. (24). PG as a glycogenic precursor is also demonstrated to increase milk yield by 3% to 6% when fed mixed with concentrate (25). Increased milk yield of Group M compared to Group C could be attributed to longer treatment with a glycogenic precursor, as animals in Group C received glycogenic precursor PG in the first 5 days of lactation only. On the other hand, animals in Group M received monensin in the first 70 days of lactation, as the CRC used in this group delivers 300 mg of monensin per day for about 90 days.

In conclusion, to our knowledge, this is the first study comparing the effects of monensin and PG mixed with concentrate administered in the dry period. We did not observe any effects of dry period treatment on NEFA and BHBA levels. However, studies conducted on larger cattle populations and in herds with more pronounced metabolic disturbances could elucidate significant differences between these strategies. As the positive effect of monensin on milk yield in the first weeks of lactation was an important finding, comparing effects of monensin and PG mixed with concentrate in lactation could be the focus of future studies.

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