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RESEARCH ARTICLE

Effects of Prepartum Monensin Feeding on Energy Metabolism and Reproductive Performance of Postpartum High-Producing Holstein Dairy Cows

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ABSTRACT

This study was designed to determine the effects of monensin in preparturient diet on postpartum milk production, energy metabolism, and reproductive performance of Holstein dairy cows. Forty Holstein dairy cows on close-up period were randomly divided into monensin treated (300 mg/day in close-up ration, top dress) and control groups. Body condition score (BCS) was estimated three weeks before and three weeks after calving. Milk production and milk fat percentage were recorded in both groups within 3 weeks postpartum. Blood samples were collected from five randomly selected cows of each group three weeks after calving. Serum concentrations of insulin like growth factor-I (IGF-I), insulin, glucose, and beta-hydroxybutyrate (BHBA) were measured. Calving to the first observed estrus interval and calving to conception interval were compared between two groups. The results of the experiment showed that loss of BCS (P=0.3), increase of milk production (P=0.9), and milk fat percentage (P>0.05) were not significantly different between two groups during the period of study. In addition, mean serum glucose concentration (P=0.001) and serum insulin concentration (P=0.01) in monensin group were significantly higher than control cows in the first week postpartum. Moreover, serum BHBA concentration did not significantly change in monensin group. Serum IGF-I concentration in monensin group was significantly higher than control group in three weeks postpartum (P<0.01). The present study indicated that monensin treatment decreased calving to the first observed estrus interval (P=0.05) and calving to conception interval (P=0.002). In conclusion, supplementing the close-up ration can increase postpartum serum IGF-I concentration and prevent the increase of serum BHBA concentration. These may result in enhancement reproductive performance of high-producing dairy cows.

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INTRODUCTION

The transition to lactation results in many metabolic changes in dairy cows. During this physiological stress period, a cow may be predisposed to health disorders and limit milk production (Karcher *et al.*, 2007). Because this period has the highest impact on reproduction and milk production, different studies have been conducted on nutrition and physiology of transition cows. Furthermore, in early lactation period, Holstein dairy cows face a severe negative energy balance that affects both health status and productivity. Therefore, management and nutrition strategies during the transition and lactation periods are crucial for productivity and optimize reproductive performance in dairy cows.

Ionophores are feed additives that alter rumen microbial populations through ion transfer across cell membranes. Monensin, a monocarboxylic acid ionophore, effectively enhances the energy metabolism level in peripartum period of dairy cow. It can alter propionate production in the rumen, resulting in improved glucose level and energy status (Duffield *et al.*, 2003; Mohebi *et al.*, 2008). It can reduce the percentages of acetate and butyric acid in the rumen (Neto *et al.*, 2009). Thus, application of monensin supplementation in dairy cows diet improves energy balance in early lactation and this may reduce the risk of energy associated diseases and metabolic diseases such as abomasal displacement, retained placenta, and clinical and subclinical ketosis (Duffield *et al.*, 2002; Duffield *et al.*, 2003). There have been several papers published on the effects of monensin on digestion, metabolism, and milk production in lactating dairy cattle; however, there is heterogeneity between the results of these studies (Duffield *et al.*, 2008a). The positive relationship between high postpartum serum insulin-like growth factor-I (IGF-I) concentrations and normal luteal activity, and better reproductive performance has been reported in high-producing dairy cows (Tamadon *et al.*, 2011). Limited researches have been carried out on the effects of monensin supplementation on IGF-I in livestock (Peclaris *et al.*, 1999). The objectives of the current study were to determine the effects of monensin in preparturient diet on milk production, some energy metabolites and hormones and reproductive performance of postpartum high-producing Holstein dairy cows.

MATERIALS AND METHODS

Forty Holstein dairy cows during close-up period were randomly selected from a commercial dairy farm, in Shiraz, Fars province, Iran (29°50′N, 52°46′E). Throughout the year, cows were kept under roofed structures (open shed barns). They had free access to water. Cows were fed a control diet to meet National Research Council (NRC) recommendations and the ration (total mixed ration) components are presented in Table 1. Cows were equally and randomly assigned to monensin and control groups. Each cow in the monensin group received 300 mg/day of monensin (top dress) in the morning total mixed ration feeding. Administration of monensin continued to the calving time. After calving, the cows were fed three times daily with post-parturition diet to meet NRC recommendations (Table 1). Body condition score (BCS) was assigned in 0.25-unit increments (Ferguson *et al.*, 1994) for each cow at two times intervals, three weeks before calving and three weeks after calving, during August to September 2009. Cows were machine-milked three times daily. Milk measurements were recorded daily from 1 to 21 days. Milk samples were stored at +4°C until analyzed for milk fat concentration using Milko-Scan 133B (Foss Electric, Hillerfd, Denmark).

Blood samples were collected weekly from five randomly selected cows in both groups through the coccygeal vein from the first to the third week postpartum. The serum was separated by centrifugation (for 10 min at 3,000 ×g) and frozen at −20°C until analysis to measure serum concentrations of glucose, beta-hydroxybutyrate (BHBA), insulin, and IGF-I. Serum BHBA concentration was determined by commercial kit (Cat # H7587; Pointe Scientific, Inc., Lincoln Park, MI) with enzymatic-colorimetric method (Mikkelsen and Corton, 2004). Serum glucose concentration was determined using Sigma kit (Cat # 315; Sigma Chemical Co., St. Louis, MO) based on the Trinder reaction (Mikkelsen and Corton, 2004). IRMA kit (Cat # IM 3210; Immunotech; Prague, Czech Republic) and standard ELISA methods were used to measure the serum insulin and IGF-I concentrations, respectively.

Reproductive performance of experimental cows was evaluated using the following parameters; calving to the first observed estrus interval and calving to conception interval (days from calving to conception as defined by pregnancy detection based on transrectal ultrasonography at day 40 post service).

Table 1: Diet composition of close up dry cow and lactating transition high-producing Holstein dairy cows

Item	Close up dry cow	Lactating transition cow
Ingredient (% of dry matter)		
Alfalfa	15	18
Corn silage	3	4.5
Concentrate	7	12
Concentrate composition (%)		
Corn	29.61	24.89
Barley	29.61	16.38
Beet pulp	14.8	9.83
Wheat	7.4	4.13
Cotton seed	5.92	11.14
Soybean	7.4	14.41
Fish meal	1.48	1.97
Fat powder	1.48	2.62
Sodium bicarbonate	-	1.31
Calcium carbonate	0.74	0.66
Sodium chloride	-	0.52
Zinc oxide	0.07	0.03
Anionic supplement	0.5	-
Vitamins & minerals supplement	-	1.31
Blood powder	1.48	0.66
Nutrient composition (% of dry matter)		
Crude protein	15.7	17.6
Neutral detergent fiber, NDF	30.7	29.8
Acid detergent fiber, ADF	18.3	18.1
Calcium	0.7	0.9
Phosphorus	0.4	0.5

Mean (± SD) of milk yield, milk fat concentration, BCS, and serum metabolites and hormones concentrations of monensin and control groups in the same week were statistically compared using independent sample T-test. Paired T-test was used to compare these parameters between different weeks in each group separately. Changes in the milk yield, milk fat concentration, serum metabolites and hormones concentrations during the period of the study in the monensin and control groups were statistically analyzed using ANOVA for repeated measures (SPSS for Windows, version 11.5, SPSS Inc, Chicago, Illinois). Statistical comparisons (mean ± SD) for calving to conception interval and calving to the first observed estrus interval were also performed between monensin and control groups using the Mann-Whitney test. Values of $P \leq 0.05$ were considered significant.

RESULTS

In the present study, cows were in 3rd to 5th (mean=3.7) lactation. Although the means of BCS in cows three weeks postpartum were significantly less than their three week prepartum BCS in both groups ($P<0.001$), but loss of BCS was not significantly different between two groups (P=0.3, Fig. 1a). The mean milk production in monensin treated group was approximately 1 kg more than control cows, however the results of repeated measure ANOVA showed that the increase of milk yield between two groups was not significantly different during the three week postpartum (P=0.9, Fig. 1b). Similarly, milk fat percentage was not significantly affected by prepartum monensin supplementation of the diet in comparison with control group (P>0.05, Fig. 1c). However, results of paired T test showed that milk fat concentrations significantly decreased in monensin group two weeks postpartum (P=0.001).

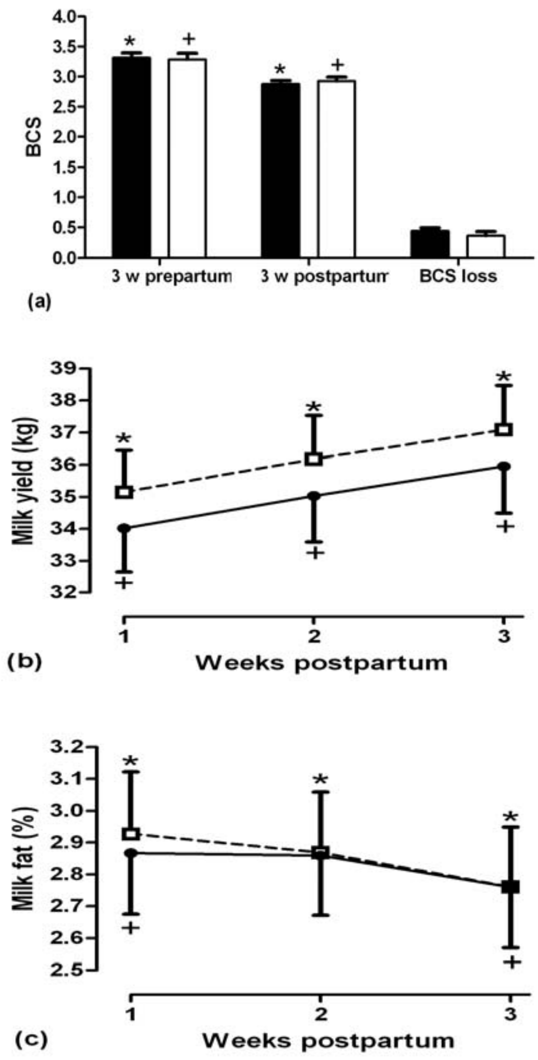

Fig. 1: Comparison of body condition score (BCS; a), milk yield (b), and milk fat concentrations (c) in prepartum monensin additive (n=20; □) and control (n=20; ●) groups. The same symbols (* or +) indicate significant statistical differences between specific weeks or groups (P<0.05).

Mean serum glucose concentration in monensin group was significantly higher than control cows in the first week postpartum (P=0.001, Fig. 2a). One week later, serum glucose concentration in monensin group significantly decreased in comparison with its increase in control group (P=0.02). Moreover, serum BHBA concentration did not significantly change in monensin group, but in control group it significantly increased during three weeks postpartum (P=0.05, Fig. 2b). In addition, serum insulin concentration in monensin group was significantly higher than control group in the first week postpartum (P=0.01), but it significantly decreased during the period of study (P=0.01, Fig. 2c). Serum IGF-I concentration in monensin group was higher than control group three weeks postpartum (P<0.01, Fig. 2d).

Control group had significantly greater calving to the first observed estrus interval compared to that of the cows which consumed monensin at prepartum period (36.6 ± 1.8 vs 35.5 ± 1.5 days, respectively, P=0.05). Moreover, control cows had a greater calving to conception interval compared to that of the monensin group (109.0 ± 13.9 vs 104.1 ± 1.6 days, respectively, P=0.002).

DISCUSSION

This study has identified several important findings with respect to the influence of monensin on reproductive parameters in Holstein dairy cows during the close-up period. Monensin treated cows had better energy status in the first week postpartum, as indicated by significantly higher serum glucose, insulin, and IGF-I concentrations. In early lactation period, Holstein cows usually experience a severe negative energy balance, consequently they show the catabolic effects of lower IGF-I and insulin levels (Roche *et al.*, 2000; Andersen *et al.*, 2004). Recent investigations determined that high-producing dairy cows with higher postpartum serum IGF-I concentrations have earlier commencement of luteal activity and subsequently show normal pattern of progesterone profile and more optimal indices of reproductive performance (Tamadon *et al.*, 2011). The results of serum analysis in the present study clearly identified the positive effect of monensin on increasing serum IGF-I concentration. Moreover, the results of the present study indicated that control group had significantly greater calving to the first observed estrus interval and calving to conception interval compared to that of monensin group.

It has been shown that monensin had no effect on serum insulin concentration (Duffield *et al.*, 2008a). Conversely, our study showed significant increase in serum insulin on day 7 post calving between two groups. This is probably the consequence of elevated serum glucose level in this period in monensin receiving group. Meta-regression analysis of the effect of monensin treatment obtained from the metabolic data indicated that this feed additive increased glucose 3% (Duffield *et al.*, 2008a). In the present study, serum glucose concentration increased only on 7^{th} day post calving and one week later, it decreased in comparison with its increase in control group. This trend may be related to the change of propionic acid being available for synthesis of glucose (Neto *et al.*, 2009).

Serum BHBA concentration did not change in monensin group, but in control group it increased during three weeks postpartum. Similarly, Hayes *et al.* (1996) did not find any positive effect of intraruminal monensin capsules on BHBA. Duffield *et al.* (2008a) indicated that monensin caused significant reduction (13%) in BHBA blood concentration of lactating dairy cows. However,

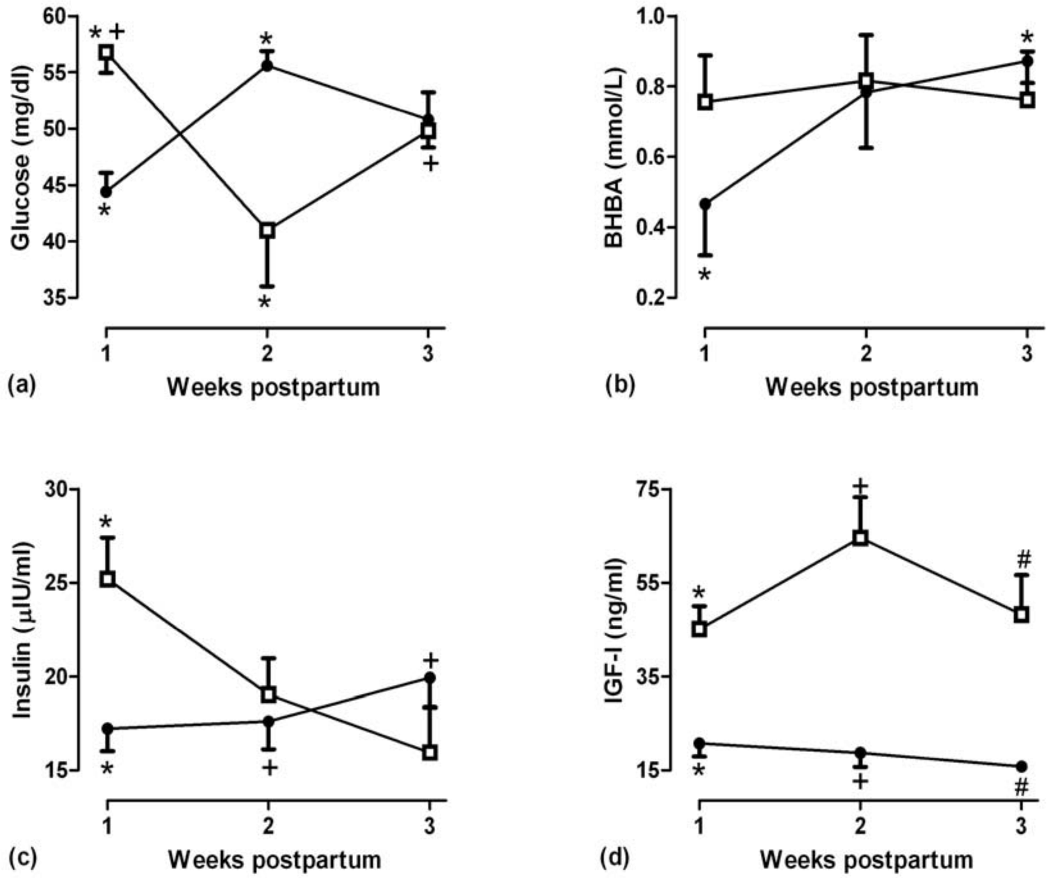

Fig. 2: Comparison of serum concentrations of a; glucose, b; beta-hydroxybutyrate (BHBA), c; insulin, and d; insulin like growth factor-I (IGF-I) in prepartum monensin additive (n=20; □) and control (n=20; ●) groups. The same symbols (*, +, or #) indicate significant statistical differences between specific weeks or groups (P<0.05).

variable response of monensin on the serum BHBA concentration has been reported. The main reasons for this heterogeneity could be related to daily dose (controlled release capsule or top dress), early lactation cows (within 30 d of calving), and pasture feeding (Duffield *et al.*, 2008a).

The positive effect of monensin on energy metabolism and daily weight gain in finishing animals has been reported (Stephenson *et al.*, 1997), however, loss of BCS was not different between two groups. Melendez *et al.* (2004) reported no increase in BCS for monensin premix and boluses in treated animals compared with control animals. The mean BCS decreased significantly in each group. Postpartum negative energy balance may be the main reason for this change.

Milk production in monensin group was approximately 1 kg more than control cows; however, the increase of milk yield between two groups was not different during the three weeks postpartum. The effect of monensin on milk production is related to its mechanism, but this benefit has not been consistent. This feed additive increases the supply of glucogenic precursors resulting from changes in pattern of rumen fermentation (Neto *et al.*, 2009). In some earlier trials, monensin resulted in increased milk yield (Hayes *et al.*, 1996; Duffield *et al.*, 1999; Phipps *et al.*, 2000); while in others it caused decreased milk production (Zahra *et al.*, 2006). These different responses may also be due to some factors such as herd size (Lean *et al.*, 1994), BCS (Duffield *et al.*, 1999) and genetic merit (Van der Werf *et al.*, 1998). Moreover, milk fat percentage was not affected by prepartum monensin adding to the diet, which is in consistent with previous study by Ramanzin *et al.* (1997). However, milk fat concentrations decreased in monensin group two weeks postpartum. There was significant heterogeneity between studies for both milk fat percentage and milk yield in animals treated with monensin (Duffield *et al.*, 2008b).

It can be concluded that monensin treatment increased serum glucose, insulin, and IGF-I concentrations. Consequently, reproductive parameters such as calving to the first observed estrus interval and calving to conception interval can be shortened by monensin feeding during the close-up period. However, BCS, milk production, milk fat percentage and BHBA were not affected by monensin treatment. The study period in the present work was limited and additional investigations are needed to evaluate the effect of monensin on these parameters for more than three weeks postpartum.

REFERENCES

Andersen JB, NC Friggens, T Larsen, M Vestergaard and KL Ingvartsen, 2004. Effect of energy density in the diet and milking frequency on plasma metabolites and hormones in early lactation dairy cows. J Vet Med A, 51: 52-57.

Duffield T, R Bagg, L DesCoteaux, E Bouchard, M Brodeur, D DuTremblay, G Keefe, S LeBlanc and P Dick, 2002. Prepartum monensin for the reduction of energy associated disease in postpartum dairy cows. J Dairy Sci, 85: 397-405.
Duffield TF, S LeBlanc, R Bagg, K Leslie, J Ten Hag and P Dick, 2003. Effect of a monensin controlled release capsule on metabolic parameters in transition dairy cows. J Dairy Sci, 86: 1171-1176.
Duffield TF, KE Leslie, D Sandals, K Lissemore, BW McBride, JH Lumsden, P Dick and R Bagg, 1999. Effect of prepartum administration of monensin in a controlled-release capsule on milk production and milk components in early lactation. J Dairy Sci, 82: 272-279.
Duffield TF, AR Rabiee and IJ Lean, 2008a. A meta-analysis of the impact of monensin in lactating dairy cattle. Part 1. Metabolic effects. J Dairy Sci, 91: 1334-1346.
Duffield TF, AR Rabiee and IJ Lean, 2008b. A meta-analysis of the impact of monensin in lactating dairy cattle. Part 2. Production effects. J Dairy Sci, 91: 1347-1360.
Ferguson JD, DT Galligan and N Thomsen, 1994. Principal descriptors of body condition score in Holstein cows. J Dairy Sci, 77: 2695-2703.
Hayes DP, DU Pfeiffer and NB Williamson, 1996. Effect of intraruminal monensin capsules on reproductive performance and milk production of dairy cows fed pasture. J Dairy Sci, 79: 1000-1008.
Karcher EL, MM Pickett, GA Varga and SS Donkin, 2007. Effect of dietary carbohydrate and monensin on expression of gluconeogenic enzymes in liver of transition dairy cows. J Anim Sci, 85: 690-699.
Lean IJ, M Curtis, R Dyson and B Lowe, 1994. Effects of sodium monensin on reproductive performance of dairy cattle. I. Effects on conception rates, calving to conception intervals, calving to heat and milk production in dairy cows. Aust Vet J, 71: 273-277.
Melendez P, JP Goff, CA Risco, LF Archbald, R Littell and GA Donovan, 2004. Effect of monensin controlled-release capsule on rumen and blood metabolites in Florida Holstein transition cows. J Dairy Sci, 87: 4182-4189.
Mikkelsen SR and E Cortón, 2004. Bioanalytical Chemistry. Wiley-Interscience, New York, USA.
Mohebi FM, S Nazifi, SS Shekarforoush, N Moghimi and M Nikbakht, 2008. Effects of oral administration of monensin on serum glucose, AST, and arginase of Holstein cows during transition period. J Vet Res, 63: 1-5.
Neto GB, Berndt A, Nogueira JR, Nogueira JC and Demarchi JJAA, 2009. Volatile fatty acids in cattle supplemented with protein-enriched salt and sodium monensin. S Afr J Anim Sci, 39: 284-288.
Peclaris GM, K Koutsotolis, K Seferiadis, A Mantzios, E Nikolaou and G Kolios, 1999. Effect of monensin and progesterone priming on ram-induced reproductive performance of boutsiko mountain breed ewes. Theriogenology, 51: 531-540.
Phipps RH, JID Wilkinson, LJ Jonker, M Tarrant, AK Jones and A Hodge, 2000. Effect of monensin on milk production of Holstein-Friesian dairy cows. J Dairy Sci, 83: 2789-2794.
Ramanzin M, L Bailoni, S Schiavon and G Bittante, 1997. Effect of monensin on milk production and efficiency of dairy cows fed two diets differing in forage to concentrate ratios. J Dairy Sci, 80: 1136-1142.
Roche JF, D Mackey and MD Diskin, 2000. Reproductive management of postpartum cows. Anim Reprod Sci, 60: 703-712.
Stephenson KA, IJ Lean, ML Hyde, MA Curtis, JK Garvin and LB Lowe, 1997. Effects of monensin on the metabolism of periparturient dairy cows. J Dairy Sci, 80: 830-837.
Tamadon A, M Kafi, M Saeb, A Mirzaei and S Saeb, 2011. Relationships between insulin-like growth factor-I, milk yield, body condition score, and postpartum luteal activity in high-producing dairy cows. Trop Anim Health Prod, 43: 29-34.
Van der Werf JHJ, LJ Jonker and JK Oldenbroek, 1998. Effect of monensin on milk production by Holstein and Jersey cows. J Dairy Sci, 81: 427-433.
Zahra LC, TF Duffield, KE Leslie, TR Overton, D Putnam and SJ LeBlanc, 2006. Effects of rumen-protected choline and monensin on milk production and metabolism of periparturient dairy cows. J Dairy Sci, 89: 4808-4818.