

Effects of monensin on production and energy metabolism in early lactation cows

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The aim of the research was to investigate effects of monensin controlled-release capsules on production and metabolism in early lactation cows, with relation to the time of administration of monensin. The study was performed in 2014 (from 01/05/2014 to 01/10/2014) at a Lithuanian cattle farm having 500 dairy cows. Four experimental groups were applied as follows: 1) Group 1 (G1) control (no supplementation, $n = 20$); 2) Group 2 (G2) with supplementation of monensin (32.4 g monensin controlled-release capsule (MCRC), $n = 20$). Both groups were on 30th day before expected calving; 3) Group 3 (G3) control (no supplementation, $n = 10$); 4) Group 4 (G4) with supplementation of monensin (32.4 g monensin controlled-release capsule (MCRC), $n = 10$). Both groups were on day 1 post partum. Group 2 (G2) received MCRC 30 days before calving, Group 4 (G4) 1 day after calving. Experimental and control cows received the same diet and were exposed to the same environment and management conditions during the entire experimental protocol. Blood samples were collected from the coccygeal vessels: G1 and G2 cows from day -30 (before expected calving, prior to supplementation), each day, up to 30 days post partum; G3 and G4 from day 1 post partum, each day, up to 30 days post partum. Blood serum was tested for beta-hydroxybutyrate (BHB) and glucose concentration. The daily milk yield was measured electronically (DairyPlan C21, Westfalia Surge Inc., GEA). Milk was sampled once monthly. Samples were analyzed for contents of fat, protein, lactose, urea, and somatic cells count. The BHB concentration decreased more efficiently after the supplementation of MCRC after calving. After supplementation with monensin on the first day after calving, it has been identified that the BHB concentration in serum of experimental group (G4) cows statistically significantly decreased after 3 days ($p < 0.05$). During this period, the average BHB concentration of control group (G3) cows was $0.414 (\pm 0.05)$ mmol/l, while the BHB concentration of experimental group (G4) cows was $0.27 (\pm 0.03)$ mmol/l. Statistically significant differences between the experimental and the control groups were observed during the entire study ($p < 0.05$).

After calving, cows supplemented with monensin showed statistically significant higher production of milk ($p < 0.05$) than the control group. Statistically significant differences in the blood glucose and BHB concentration, quantity of milk and production average between two experimental groups (G2 and G4) were not identified.

Key words: cows, monensin, BHB, glucose, production

INTRODUCTION

Metabolic diseases are of great economic impact; it usually affects the animals about to reach their maximum potential production. Food consump-

tion cannot be harmed in the coming days to calving and early lactation, since this is a critical period in the nutrition of females (Leilson et al., 2014). Approximately 80% of the diseases or disorders in adult cows occur during the first 100 days

of lactation (DeGaris et al., 2010). In early lactation, dairy cows high-yielding production suffers a variety of metabolic changes derived from energy deficiency, due to poor dry matter ingestion and high milk production, which are factors that predispose to ketosis (Chapinal et al., 2011).

Basically, ketosis is the result of an imbalance between energy demand, increased fat mobilization and increased hepatic ketogenesis. Ketosis in dairy cattle frequently occurs between 2 and 7 weeks post-partum and animals can recover with or without treatment, but it results in a loss in the productive potential of each animal (Iwersen et al., 2009). Energy deficiency can be indicated by an increase in the concentrations of nonesterified fatty acids (NEFA) and beta-hydroxybutyrate (BHBA) in blood (Ospina et al., 2010).

Clinical ketosis is produced by excessive production of ketone bodies ($\text{BHB} \geq 3 \text{ mM}$) and characterized for anorexia and depression (Ospina et al., 2010). Subclinical ketosis (SCK) is an increase in the concentration of ketone bodies ($\text{BHB} \geq 1.2 \text{ mM}$) in the absence of clinical signs (Haghighat-Jahromi et al., 2011; Sakha et al., 2007).

Adding ionophores to transition cow diets may help to modulate effects of NEB by increasing glucose availability (Pettersson-Wolfe et al., 2007). Monensin (M), an ionophore, is a carboxylic polyether that is produced naturally from a *Streptomyces cinnamomensis* strain. Monensin alters the rumen micro-flora by selectively inhibiting the growth of gram-positive bacteria (acetate and hydrogen producers), resulting in an increase of the rumen bacteria that will increase the production of propionate, which is the primary glucose precursor (Dubuc et al., 2009).

It has not one point about the time of administration of monensin. Prepartum administration of monensin significantly increased projected 305-d milk production in cows from herds at increased risk of ketosis (Leslie et al., 1999). Treatment with monensin had no significant effect on either milk fat percentage or milk protein percentage. According to T. B. Duffield et al. (2003), monensin significantly improved indicators of energy balance in both the immediate precalving and postcalving periods, delivered in a controlled-release capsule 3 weeks precalving. According to F. D. Sauer et al. (1989), monensin is possible to administer to 3 weeks postpartum. Monensin administered for

lactating cows significantly increased milk yields and milk protein (Lyncha et al., 1990). Cow treatment with monensin can reduce cost with sustaining effectiveness of treatment.

The aim of the research was to investigate effects of monensin controlled-release capsules on production and metabolism in early lactation cows, with relation to the time of administration of monensin.

MATERIALS AND METHODS

The study was performed in 2014 (from 01/05/2014 to 01/10/2014) at a Lithuanian cattle farm Grinaičiai having 500 dairy cows. For the study, Lithuanian Black and White cows of 2.5 lactations and the average annual milk yield of 8 100 kg were selected. The cows were kept in extensive environment. For the study, slow release rumen preparation, which emits approximately 335 mg doses of monensin daily during the period of 95 days, when administered with an oral balling gun following manufacturer instructions, was used. Four experimental groups were applied as follows: 1) Group 1 (G1) control (no supplementation, $n = 20$); 2) Group 2 (G2) with supplementation of monensin (32.4 g monensin controlled-release capsule (MCRC), $n = 20$). Both groups were on -30 day before expected calving. Experimental (G2) and control cows (G1) received the same diet and were exposed to the same environment and management conditions during the entire experimental protocol; 3) Group 3 (G3) control (no supplementation, $n = 10$), 4) Group 4 (G4) with supplementation of monensin (32.4 g monensin controlled-release capsule (MCRC), $n = 10$). Both groups were on day 1 post partum. Experimental (G4) and control cows (G3) received the same diet and were exposed to the same environment and management conditions during the entire experimental protocol.

Group 2 (G2) received MCRC 30 days before calving, Group 4 (G4) 1 day after calving.

Blood samples were collected from the coccygeal vessels, using vacuum testing tubes without an anticoagulant (BD Vacutainer, England): G1 and G2 cows from day -30 (before expected calving, prior to supplementation), each day, up to 30 days post partum; G3 and G4 from day 1 post partum, each day, up to 30 days post partum. Biochemical blood tests of the cows were performed

at the Clinical Trials Laboratory of Department of Non-Infectious Diseases, Veterinary Academy, Lithuanian University of Health Sciences. Blood serum was tested for serum beta-hydroxybutyrate (BHB) and glucose concentration. The blood serum was measured by a computerized analyzer Hitachi 705 (Hitachi, Japan) using DiaSys (Diagnostic Systems GmbH, Germany).

All cows were milked three times daily for 100 days of the lactation phase of the trial. Daily milk yield was measured electronically (DairyPlan C21, Westfalia Surge Inc., GEA). The daily milk yield was the sum of the three milkings. Milk was sampled once monthly. The samples were analyzed for contents of fat, true protein, lactose, urea, and somatic cells count. Milk composition analysis was performed by VĮ Pieno Tyrimai in compliance with the approved methodologies.

Time from calving to the first insemination was recorded, and the index of insemination was calculated.

Data obtained through investigation was processed using the statistical software package SPSS (SPSS for Windows 15.0, SPSS Inc., Chicago, IL, USA, 2006). The data were considered to be statistically reliable at $p < 0.05$.

Research was conducted following the provisions of the Law of the Republic of Lithuania No. 11-2271 on Protection, Keeping and Use of Animals, dated 03/10/2012 (*Valstybės Žinios* (official gazette) No. 122-6126 dated 20/10/2012) and

of the by-laws, Education and Training Purposes of Animals Used in Storage, Maintenance and Conditions of Use No. B1-866, dated 31/10/2012 (*Valstybės Žinios* (official gazette) No. 130-6595 dated 10/11/2012).

RESULTS AND DISCUSSION

Serum beta-hydroxybutyrate (BHB) values were insignificantly higher in G1 – 11.43% more than in G2 on Day –21 but increased significantly by day 7 (G1 100.00% more than in G2) and remained insignificantly higher on day 30 (G1 40.00% more than in G2) (Fig. 1).

After supplementation with monensin on the first day after calving, it has been identified that the BHB concentration in the serum of G4 cows statistically significantly decreased after 3 days ($p < 0.05$). During this period, the average BHB concentration of G3 cows was 0.42 ± 0.05 mmol/l, while the BHB concentration of G4 cows was 0.27 ± 0.03 mmol/l (Fig. 2). Statistically significant difference between the experimental and the control groups was observed during the entire study ($p < 0.05$).

Elevation of ketone bodies in dairy cows frequently occurs in early lactation, usually concomitantly with a lack of energy and glucose (Zarzin et al., 2013). The evaluation of NEFA and BHB represents a strategy for the monitoring of subclinical ketosis and prepartum negative energy balance in dairy cows (Contreras et al., 2010). BHBA

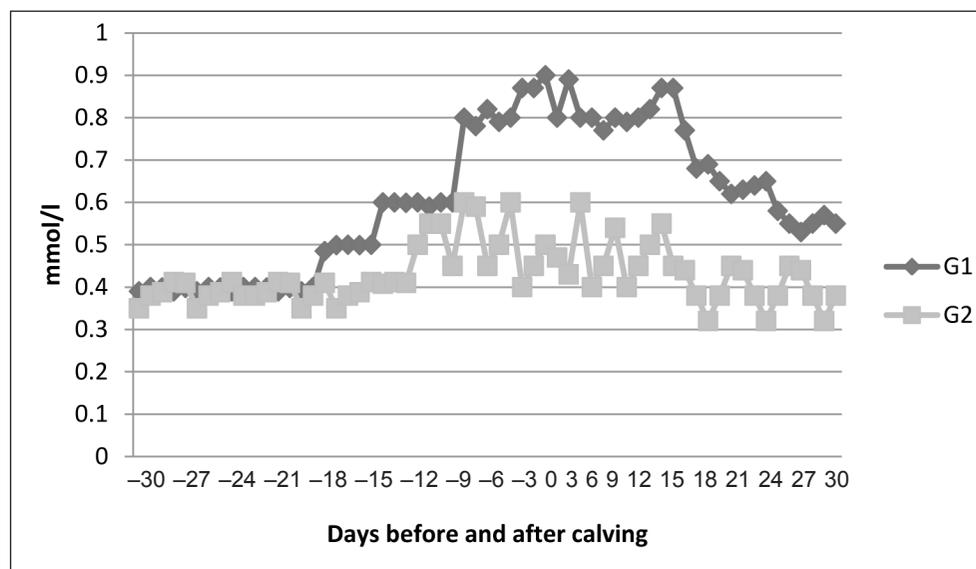


Fig. 1. BHB variation in the blood serum of Group 1 and Group 2 cows ($p < 0.05$)

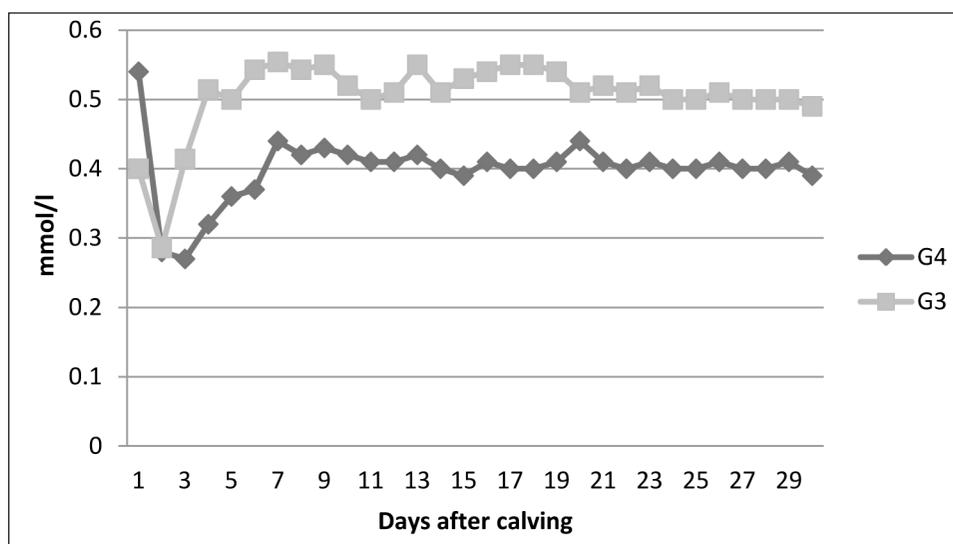


Fig. 2. BHB variation in blood serum of Group 3 and Group 4 cows ($p < 0.05$)

detection in blood has been used as an index to distinguish between cows with and without subclinical ketosis (Zhang et al., 2011). Subclinical ketosis can decrease economic income through decreased milk production (Oetzel et al., 2007), impaired reproductive performance (Walsh et al., 2007), increased risk of displaced abomasum, mastitis (Moyes et al., 2009) and higher risk of clinical ketosis (Iwersen et al., 2009).

The blood glucose level was insignificantly higher in cows G2 – 4.25% more than in control cows (G1). No difference was found on day 7. Statistically reliable difference ($p < 0.05$) remained on day 30, the blood glucose level in cows G2 was observed to increase insignificantly higher – 5.11% more than in G1. Statistically significant difference of blood glucose level in the cows studied was not identified. Blood glucose concentrations in ketosis diagnosis may be an important predictor of cure of subclinical ketosis and early lactation milk production (Gordon, 2013).

A summary of the results of milk yield for cows with or without MCRC in the lactation experiment can be found in the Table.

The production average in cows G2 increased significantly higher from day 7 to day 90 (Table). There was a tendency ($p < 0.05$) for the cows with supplementation of MCRC during 100 d of the lactation phase to have higher milk yields – 35.03% more than cows that were not supplemented with MCRC (Fig. 3). After calving, cows supplemented with monensin showed statistically significant higher production of milk ($p < 0.05$) than the control group. Statistically significant differences between the two test groups (G2 and G4) were not identified. The negative impacts of subclinical ketosis on milk yield are well-known (Oetzel, 2013). J. A. A. McArt et al. (McArt et al., 2012) found that cows testing positive (>1.2 mmol/l BHB) for subclinical ketosis within the first week of lactation produced 2.2 kg/day less milk for the first 30 days of lactation. Monensin resulted in increased milk

Table. Milk yield average of cows ($p < 0.05$)

Days	Milk yield average, kg/d.			
	G1 (without monensin)	G2 (with monensin)	G3 (without monensin)	G4 (with monensin after calving)
7	18.18 ± 3.68	19.34 ± 1.87	18.9 ± 1.4	19.2 ± 1.5
30	23.79 ± 4.68	31.05 ± 2.10	22.89 ± 2.1	31.15 ± 2.0
60	26.27 ± 4.31	33.29 ± 2.21	28.3 ± 2.0	33.4 ± 1.5
90	26.92 ± 5.47	33.14 ± 1.97	27.45 ± 2.5	35.2 ± 2.2

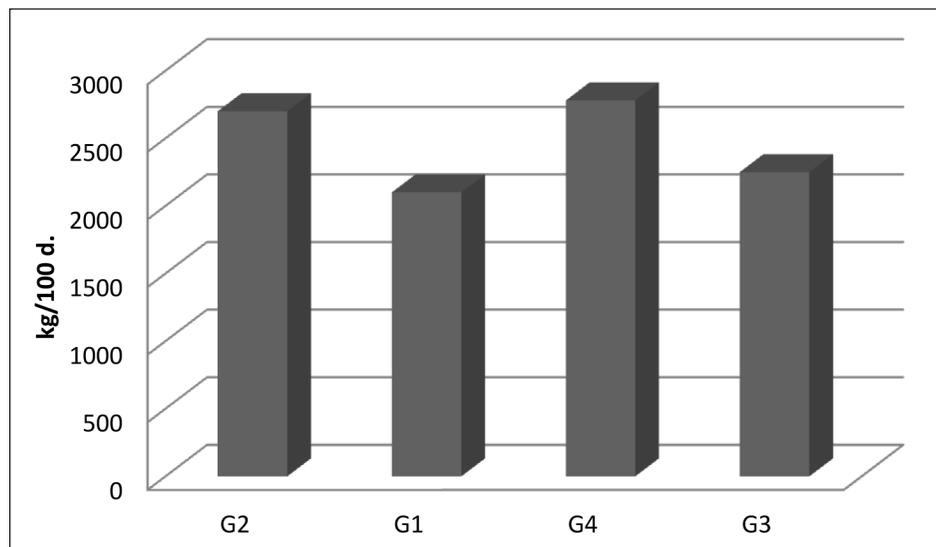


Fig. 3. Total milk yield during 100 days of lactation of Group 1 and Group 2 cows ($p < 0.05$)

yield (Phipps et al., 2000); while in others it caused decreased milk production (Zahra et al., 2006).

Milk fat, protein, lactose, urea, and somatic cells count ($p < 0.05$) was not significantly affected by cows with supplementation of MCRC. In some trial milk fat concentrations decreased in the 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., 2008).

Time from calving to the first insemination and the index of insemination ($p < 0.05$) were not significantly affected by cows with supplementation of MCRC.

CONCLUSIONS

Cows with supplementation of MCRC showed the following: BHB concentration decreases more efficiently after the supplementation of MCRC after calving. After supplementation with monensin on the first day after calving, it has been identified that the BHB concentration in the serum of G4 cows statistically significantly decreased after 3 days ($p < 0.05$). During this period, the average BHB concentration of G3 cows was $0.414 (\pm 0.05)$ mmol/l, while the BHB concentration of G4 cows was $0.27 (\pm 0.03)$ mmol/l (Fig. 2). Statistically significant difference between the experimental and the control groups was observed during the entire study ($p < 0.05$). It suggests that ketosis of

cows is a possible treatment if monensin is administered after calving.

After calving, the cows supplemented with monensin showed statistically significant higher production of milk ($p < 0.05$) than the control group. Statistically significant differences in the blood glucose and BHB concentration, quantity of milk and production average between the two experimental groups (G2 and G4) were not identified.

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MONENZINO POVEIKIS ŠVIEŽIAPIENIŲ KARVIŲ ENERGIJOS APYKAITAI IR PRODUKTYVUMUI

Santrauka

Tyrimo tikslas buvo įvertinti nuolatinio atpalaidavimo didžiojo prieskrandžio priemonės – monenzino – poveikį šviežiapienių karvių produktyvumui ir sveikatingumui, priklausomai nuo monenzino panaudojimo laiko. Tyrimas atliktas 2014 m. gegužės 1 – spalio 1 d. Lietuvos galvijų ūkyje, turinčiame 500 melžiamų karvių. Buvo sudarytos keturios tiriamosios grupės: I grupė (G1) – kontrolė (be papildu, n = 20), II grupė (G2) – su monenzino papildu (32,4 g monenzino nuolatinio atpalaidavimo didžiojo prieskrandžio priemonė (MCRC), n = 20). Abiejų grupių karvės – 30 dienų prieš numatomą apsiveršiamą. III grupė (G3) – kontrolė (be papildu, n = 10), IV grupė (G4) – su monenzino papildu (32,4 g monenzino nuolatinio atpalaidavimo didžiojo prieskrandžio priemonė (MCRC), n = 10). G2

grupei monenzino priedas buvo panaudotas likus 30 dienų iki apsiveršavimo, G4 tas pats priedas panaudotas praėjus vienai dienai po apsiveršavimo. Bandomosios ir kontrolinės grupių karvės gavo tą patį racioną ir buvo laikomos tokiomis pačiomis sąlygomis visą bandymo laikotarpį. Kraujo mėginiai buvo imami iš uodegos venų: G1 ir G2 karvėms kiekvieną dieną nuo 30 dienos (iki numatomo veršiamosi) iki 30 dienos po apsiveršavimo; G3 ir G4 karvėms kiekvieną dieną nuo 1 dienos po apsiveršavimo iki 30 dienos po apsiveršavimo. Kraujo serume buvo ištirta beta hidroksibutiratų (BHB) ir gliukozės koncentracijos. Dienos primilžiai matuoti elektroniniu būdu (DairyPlan C21, Westfalia Surge Inc., GEA). Pieno mėginiai buvo imami kartą per mėnesį. Tirta: riebumas (%), baltymingumas (%), laktozė (%), šlapalas (mg/%) ir somatinių ląstelių skaičius (tūkst./ml). Nustatyta, kad BHB koncentracija labiau sumažėja panaudojus MCRC po apsiveršavimo. Nustatyta, kad panaudojus monenziną pirmą dieną po apsiveršavimo bandomosios grupės karvėms (G4) BHB koncentracija kraujo serume statistiškai patikimai sumažėjo po 3 dienų ($p < 0,05$). Šiuo laikotarpiu BHB koncentracijos vidurkis kontrolinių karvių (G3) buvo 0,414 ($\pm 0,05$) mmol/l, o bandomųjų karvių (G4) BHB koncentracijos vidurkis – 0,27 ($\pm 0,03$) mmol/l. Pastebėtas statistiškai patikimas skirtumas tarp bandomųjų ir kontrolinių karvių grupių visą tiriamąjį laikotarpį ($p < 0,05$). Karvių, kurioms panaudotas monenzinas po apsiveršavimo, pieno produkcija buvo statistiškai patikimai didesnė ($p < 0,05$) nei kontrolinės grupės karvių. Statistiškai patikimų skirtumų tarp dviejų bandomųjų grupių (G2 ir G4) nenustatyta.

Raktažodžiai: karvės, monenzinas, BHB, gliukozė, produkcija