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Case Report – Effects of an Unintended High Dose of Monensin on Milk Production and Milk Fat in a Dairy Herd

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Abstract

Lactating dairy cows were accidently fed monensin at a dose of 32.7 g per ton (36 ppm) of feed for three weeks. This resulted from a mixing error when monensin was added to the mineral premix, as well as an error in the amount of mineral fed to the lactating cows. A decrease in dry matter intake was noticed during the first three days following the mixing error. Bulk-tank milk fat percentage decreased by 0.6, but daily milk production increased by 6.9 lb (3.1 kg)/cow/day during this period, and for an additional two weeks. A residual effect on milk production and fat percentage was observed for three weeks after monensin intake returned to the prescribed dosage of 14.5 g per ton (16 ppm). This residual effect was more pronounced during the first week following resumption of the prescribed intake of monensin.

Keywords: bovine, monensin, overdose, milk production

Résumé

Les effets du prémélange monensin, administré par erreur à une dose élevée, sur la production de lait et de gras d'un troupeau laitier. Un troupeau laitier a reçu accidentellement une dose 36 ppm de monensin[a] pendant 3 semaines. La concentration trop élevée du monensin dans le minéral et une quantité excessive de minéral administré par le producteur dans le mélangeur de la ration totale ont été les causes de ce problème. Les vaches ont présenté une diminution de la consommation volontaire de matière sèche dans les premiers trois jours suivant le début de la surdose. Le pourcentage de matières grasses du réservoir de lait de la ferme a chuté de 0,6 et la production laitière a augmenté de 3,1 kg par vache par jour suite à cette surdose. Un effet résiduel du monensin sur la production de lait et de gras a été noté suite à la correction de la surdose. Cet effet résiduel a été particulièrement important dans la première semaine qui a suivi le retour à la dose prescrite. (Traduit par Docteur Jocelyn Dubuc)

Introduction

Monensin is a biological product produced by *Streptomyces cinnamonensis*,[13] and is classified as a monovalent carboxylic polyether ionophore.[5] Monensin modifies the movement of ions across membranes of rumen bacteria, therefore changing the dynamics of populations of bacteria in the rumen.[14] In 2004, monensin[a] premix was approved for use in dairy cows in both Canada and the United States. In the US, the new claim is "for increased milk production efficiency at a dose of 11 to 22 g per ton[b] (12 to 24 ppm)". In Canada, three claims were received: "for the reduction of milk fat percentage in lactating dairy cows, at the dose of 14.5 to 22 g per ton US (16 to 24 ppm)"; "for minimizing loss of body condition during lactation, at the dose of 7 to 22 g per ton US (8 to 24 ppm)"; and "for improving feed efficiency of milk protein production at the dose of 14.5 to 22 g per ton US (16 to 24 ppm)". Monensin is safe when used at recommended dosages in target species.

Many experiments have evaluated the effects of monensin on milk and milk fat production in lactating dairy cows. The effect of monensin on milk production is variable; some studies have shown increased milk production, and others have not.[10] A significant decrease in milk fat percentage (MF%) has been reported with doses of monensin as low as 7 g per ton (8 ppm).[12]

Two theories are proposed to explain the reduction of MF% when animals are fed monensin premix. The

most popular one is that it causes a reduction of biohydrogenation of the fatty acids in the rumen.[3] The less popular theory is that monensin causes a change in proportion of rumen volatile fatty acids (VFA).[7] It is well documented that monensin increases molar proportion of propionate while decreasing molar proportions of acetate and butyrate.[6,7] Propionate is the precursor of lactose, and has a positive influence on milk production. Acetate is the major precursor for synthesis of milk fat.[5]

Monensin toxicity in cattle is dose-dependent, and clinical signs usually appear within 24 to 48 hours.[2,9] In a study looking at potential monensin residues in milk and milk production of lactating dairy cows fed high doses of monensin, Bagg *et al* showed that cows fed monensin at 65, 130 and 218 g per ton (72, 144 and 240 ppm) exhibited a rapid decrease in feed intake and milk production.[2] No monensin residues were found in milk when cows were fed doses as high as 218 g per ton (240 ppm).[2] Other reported clinical signs of monensin toxicosis in dairy cows include lethargy, diarrhea, weakness, ataxia, dyspnea and death. Gonzalez *et al* estimated the LD_1 to be 3300 mg for a mature dairy cow.[9]

Many papers have been published about the effect of monensin on milk production and composition. However, not much information about monensin overdose in dairy herds is available for veterinary practitioners. The objective of this report is to describe the observed effects of an accidental overdose of monensin on production of milk and milk fat in a dairy herd.

History

During March of 2006, 120 lactating Holstein cows were accidentally fed a ration containing excessive levels of monensin for three consecutive weeks. The cows were housed in a conventional tie-stall barn in Quebec, Canada, and averaged 160 days-in-milk (DIM). Average parity was 2.6. Average parity, DIM and number of cows in lactation varied little during the time cows were overdosed, and during the following weeks. Cows were fed a one-group total mixed ration (TMR) twice daily. The lactating cow diet and the nutrient composition of the TMR are described in Tables 1 and 2. The diet remained unchanged during the period described in this report (weeks 1 to 15). TMR particle size evaluation was performed at week 6 using the technique described by Lammers[c,11] (Table 3). The customized mineral premix contained 18% calcium and 5% phosphorus (dry matter basis).

Prior to the accidental overdose, cows were fed the prescribed dose (PD) of 14.5 g monensin per ton (16 ppm) for three weeks (weeks 1 to 3). Bulk-tank MF% was 3.6%, and average daily bulk-tank milk production was 54.0 lb (24.5 kg) per cow. Bulk-tank milk protein percentage (MP%) was 3.29%.

Table 1. Composition of lactating cow TMR diet.

Feed ingredient	Quantity (as fed basis)		Quantity (dry matter basis)	
	lb	kg	lb	kg
Grass silage	35.3	16.0	10.9	5.0
Corn silage	33.1	15.0	11.9	5.4
High-moisture corn	17.2	7.8	11.5	5.2
Protein supplement	8.2	3.7	7.7	3.5
Timothy hay	7.3	3.3	5.6	2.5
Whole roasted soybean	5.1	2.3	4.6	2.1
Mineral	0.4	0.2	0.4	0.2
Total	106.6	48.3	52.6	23.9

Table 2. Nutrient content of lactating cow TMR diet (dry matter basis).

Nutrient	TMR
Dry matter	52.0
Neutral detergent fiber	35.8
Crude protein	17.3
Total fat	5.0
Total non-fiber carbohydrate	35.9
Starch	25.1
Net energy of lactation (Mcal/lb)	0.75
Percentage of concentrate	49.7
Calcium	1.02
Phosphorus	0.44

Table 3. TMR particle size evaluation.[c]

	TMR sampled (%)	TMR recommended (%)
Upper sieve (>0.75 inch)	4.6	6-10
Middle sieve (0.75-0.31 inch)	52.1	30-50
Bottom pan (<0.31 inch)	43.3	40-60

The herd was accidentally fed a high dose (HD) of 32.7 g of monensin per ton (36 ppm; 830 mg/hd/day) for three weeks (weeks 4 to 6). At week 6, the dose of monensin was reduced to the PD of 14.5 g per ton (16 ppm; 370 mg/hd/day), and maintained at that level for the following nine weeks (weeks 7 to 15). A summary of this timetable is presented in Figure 1.

Clinical Findings

The producer noticed a drop in dry matter intake (DMI) within three days following the feed mixing error. Changes were also noticed in milk production and MF% (Figure 1).

Bulk-tank milk fat percentage

Within a week after cows were first fed the HD, MF% had dropped. The MF% decreased from 3.6% to 3.1% during the three-week HD period (weeks 4 to 6), and continued to decline in the week following return to the PD level. The MF% slowly increased after cows were offered the PD level of monensin in their diet, and returned to the initial level after three weeks.

Average daily milk production per cow

Average daily milk production increased 3.1 lb (1.4 kg) (54.0 vs 57.1 lb; 24.5 vs 25.9 kg) during the three-week HD period (weeks 4 to 6). Although the monensin dose was reduced to the PD at the end of week 6, average milk production increased to 60.9 lb (27.6 kg) during week 7, a difference of 6.9 lb (3.1 kg) when compared to week 3. At that time milk production slowly decreased, but always remained at a higher level than before the HD period. Milk production stayed over 55.1 lb (25 kg) per day for the following nine weeks (weeks 7 to 15).

Bulk-tank milk protein percentage

Milk protein percentage data were only available on a monthly basis. During the three-week HD period (weeks 4 to 6), MP% decreased from 3.29% to 3.22%. MP% was 3.23% during the period when cows were fed the PD level (weeks 8 to 11). No data were available for subsequent months.

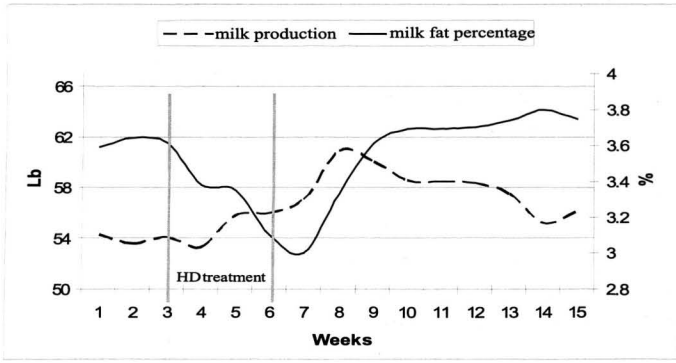

Figure 1. Average daily milk production and bulk-tank milk fat percentage for a Quebec dairy herd fed excess levels of monensin.

Validation of Herd and Production Data

MF% was tested on a weekly basis using bulk-tank milk samples, while MP% was tested on a monthly basis. These samples were shipped to the official laboratory of the Fédération des producteurs de lait du Québec[d] (Dairy Farmers of Quebec) for standard analysis of milk components. These analyses and bulk-tank collection volume were used weekly to calculate the milk payment for dairy producers. The number of lactating cows, DIM and other individual cow information was collected using DS@HR[e] software. Information on dates, doses and production data was also validated with the producer, nutritionist, veterinarian and the monthly reports from Valacta (Quebec DHI[f]).

Herd Investigation and Management

Herd investigation on possible feeding problems was done with the participation of the herd veterinarian, nutritionist, the lead author (JD) and the technical services veterinarian from Elanco Animal Health. In addition to possible problems with monensin, investigators looked for other causes of reported problems, such as subacute ruminal acidosis, errors in ingredient proportions and changes in nutrient evaluation of the diet. The investigation revealed two abnormalities. First, concentration of monensin in the mineral was higher than expected. On a daily DM basis, the mineral delivered 21.8 g per ton instead of the intended 14.5 g per ton (24 ppm instead of 16 ppm). In addition, the amount of mineral put in the TMR mixer by the producer exceeded the recommended amount (150 g per day instead of 100 g per day). As a result, the total concentration of monensin in the ration was 32.7 g per ton (36 ppm). Adjustments were made to reach the PD of 14.5 g per ton (16 ppm) by the end of week 6, including verification of procedures with the feed mill and proper weighing of mineral at the farm. After the dose of monensin was corrected, the DMI of lactating cows returned to previous levels within three to four days.

Discussion

When feeding monensin, a spontaneous decrease of 20% or more in DMI can be an indicator of monensin overdose.[2,9] In this case, the producer suspected something was wrong with the lactating cow diet within three days of the dosing error. The effect on milk production and MF% were seen in the first two weeks (Figure 1). The increase in milk production was contrary to other studies where a decrease in milk production was reported.[2,9] However, these studies were done with monensin doses ranging from 65 to 454 g per ton (72 to 500 ppm), which were at least two times the dose fed in this case.

The HD of 32.7 g of monensin per ton of feed (36 ppm) caused a decrease in MF%. Other studies have reported similar effects of monensin on lactating dairy cows at lower doses, but not as extensive.[10,12] The decrease in MF% seems to be dose-related.[2,12] It is also strongly suspected that polyunsaturated fatty acids (PUFA) contained in vegetable oils could affect MF% when fed with monensin.[4] Soybean oil is suspected to interact with monensin and to cause greater milk fat depression when the two are fed together.[1] On average these cows consumed 5.1 lb (2.3 kg) of whole roasted soybeans on an as-fed basis each day, which contain 20% fat on a dry matter (DM) basis. Total fat content of the diet was 5.0% of DM. This level is not considered excessive, but a possible interaction between monensin and soybean oil could explain the milk fat depression. The starch level in the diet could also interact with monensin and lower MF%. The starch level of the diet was 25.1% (Table 2), which is considered normal.

Particle size evaluation of the TMR diet was also considered normal, with 56.7% of particles on the top 2-sieves (Table 3). However, when less than 6% of particles are on the top screen, there is increased chance of depression of MF%.[8]

The residual effect of MF% persisted for three weeks. This effect was most pronounced the week following correction of the monensin dosage. After correction of the monensin dosage in the diet, it took up to two weeks for the MF% to return to near-normal levels. Interestingly, MF% remained 0.1 higher in weeks 9 to 15 than in weeks 1 to 3, long after the dosage had been corrected. The residual effect on average daily milk production lasted for eight weeks. To our knowledge, these residual effects have not been reported previously.

Milk production of the cow is driven by lactose production in the mammary gland. Propionate is the precursor of glucose, which is needed for production of lactose; therefore, increased proprionate can have a positive influence on milk production.[12] Adaptation of rumen bacteria to monensin could have selected higher propionate-producing bacteria during the HD treatment. This change could increase production of propionate in cows receiving monensin at a lower dose (14.5 g per ton; 16 ppm), leading to higher milk production. In the same way, the higher MF% after HD treatment may also be explained by the adaptation of rumen bacteria. The decrease in MF% caused by monensin is believed to result from a reduction of biohydrogenation of fatty acids in the rumen.[3] Adaptation of rumen bacteria to monensin may enhance the biohydrogenation procedure and minimize the production of incomplete biohydrogenated fatty acids. Others have proposed that a different type of bacteria may begin to digest cellulose when monensin is fed continuously.[14]

Because the duration of this monensin overdose was only three weeks, it is difficult to speculate how the cows would have responded to a longer period of exposure. Considering the increase in milk production in this case, a similar increase in milk production would be expected to happen during a longer period of HD treatment. No problems with reproductive efficiency or disease were noticed in the five-month period following the overdose.

Conclusions

Monensin is used in lactating dairy cows to improve milk production efficiency. When feeding monensin to dairy cows, caretakers should monitor changes in DMI, and monensin levels should be examined if feed intake decreases for no obvious reasons. Milk components should also be checked weekly to monitor such things as MF%. Following a monensin overdose, MF% should be expected to return to initial levels within three weeks after correction of the dose. When an overdose of monensin is suspected, investigators must not overlook other possibilities, such as subacute ruminal acidosis, errors in ingredient proportions and changes in nutrient evaluation of the diet.

Acknowledgement

The authors want to thank François Dubois for the technical procedures conducted on feedstuffs. No external funding was used in the preparation of this manuscript.

Endnotes

[a] Rumensin® Premix, Elanco Animal Health, Division of Eli Lilly Canada Inc., Guelph, ON, Canada.
[b] Dosage based on US tons.
[c] Penn State Particle Separator, Nasco Farm & Ranch, Fort Atkinson, WI, USA.
[d] Fédération des producteurs de lait du Québec (FPLQ), Longueuil, QC, Canada.
[e] Dossiers de Santé Animale (DS@HR), Saint-Hyacinthe, QC, Canada. (Software used by veterinarians in Quebec to record and follow herd health status).
[f] Valacta (Quebec DHI), Sainte-Anne-de-Bellevue, QC, Canada.

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Abstract

An evaluation of the relative efficacy of tulathromycin for the treatment of undifferentiated fever in feedlot calves in Nebraska

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Can Vet J (2007) 48:600-606

A field trial was performed under commercial feedlot conditions in central Nebraska to assess the relative efficacy of tulathromycin (TULA) to florfenicol (FLOR) for the treatment of undifferentiated fever (UF) in feedlot calves that did not receive a metaphylactic antimicrobial or vaccines/bacterins containing *Mannheimia haemolytica* or *Histophilus somni* at feedlot arrival by comparing animal health, feedlot performance, and carcass characteristic variables. Two hundred recently weaned, auction market derived, crossbred beef calves that met the study-specific case definition of UF were randomly allocated in a 1:1 ratio to 1 of 2 experiemtnal groups as follows: TULA, which received tulathromycin administered subcutaneously at the rate of 2.5 mg/kg body weight (BW) once at the time of allocation; or FLOR, which received florfenicol administered subcutaneously at the rate of 40 mg/kg BW once at the time of allocation.

In terms of animal health, the first UF relapse (RR=0.65), overall mortality (RR=0.33), and BRD mortality (RR=0.29) rates in the TULA group were significantly ($P<0.05$) lower than in the FLOR group. There were no significant ($P\geq0.05$) differences between the TULA and FLOR groups for the other animal health variables measured. There was no significant ($P\geq0.05$) difference in average daily gain between the TULA and FLOR groups. There were no significant ($P\geq0.05$) differences in the overall distributions of quality grade and yield grade between the experimental groups; however, a significantly ($P<0.05$) higher proportion of carcasses in the TULA group graded yield grade USDA-4 as compared with the FLOR group.

In the economic analysis, the benefits observed resulted in an economic advantage of $52.50 USD/animal in the TULA group due to lower first UF relapse and overall mortality rates, even though the occurrence of yield grade USDA-4 carcasses increased and the initial UF treatment cost was higher.