

Impact of Rumensin® on the Health of the Transition Dairy Cow

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■ Take Home Message

- ▶ Rumensin® administered in the transition period improves energy balance in early lactation.
- ▶ Improved energy balance reduces the risk of energy associated disease such as ketosis, abomasal displacement and retained placenta.
- ▶ The Rumensin® controlled release capsule (CRC) has been studied more extensively than feed delivered monensin for its impact on health.
- ▶ The Rumensin® CRC ensures a consistent daily dose of monensin that is independent of variable feed intake fluctuations both before and after calving.

■ Introduction

Ionophores have been used extensively in the beef industry in Canada since 1977. Until recently, there has been no label indication for use of ionophores in lactating dairy cattle. Ionophores are feed additives that alter rumen microbial populations through ion transfer across cell membranes. In Canada, the label warning prohibiting the use of Rumensin® premix in lactating dairy cattle was removed in June 1996. Following this, a controlled release capsule containing monensin was approved for use in dairy cattle as an aid to prevent subclinical ketosis, in December 1997. This paper discusses the health benefits of feeding or administering monensin to the transition dairy cow.

■ Effects of Ionophores on Ruminant Digestion and Metabolism

Monensin and lasalocid are the most commonly used feed additives in cattle (Tyler et al, 1992). Monensin is a carboxylic polyether ionophore produced by a naturally occurring strain of *Streptomyces cinnamonensis* (Haney and Hoehn, 1967) and is provided to cattle, orally, as a sodium salt (Donoho, 1984). Lasalocid is closely related but produced by a different strain of *Streptomyces*. The basic function of ionophores is to create a flux of ion transport across cell membranes. Monensin binds to bacterial cell membranes and first causes an efflux of potassium from the cell and an influx of hydrogen into the cell (Russell, 1996). The increased hydrogen is exported out of the cell either by active transport involving adenosine triphosphate or passively via sodium entry into cells in exchange for hydrogen. In order to maintain inner cell equilibrium, the bacterial cell expends energy and this results in death or reduced growth of the bacterium (Bergen and Bates, 1984). Lasalocid is similar to monensin and also causes ion flux across cell membranes but can translocate both monovalent and divalent cations (Bergen and Bates, 1984). Since gram-negative bacteria have complex outer cell membranes, they are usually more resistant to the action of ionophores than are gram-positive bacteria. Ionophores, therefore, selectively inhibit gram-positive bacteria rather than gram-negative bacteria because of differences in bacterial cell wall structure.

Monensin exerts its many effects by shifting the microbial populations in the rumen (Bergen and Bates, 1984). Bergen and Bates (1984) identified 3 major areas of animal metabolism influenced by monensin. These include increased efficiency of energy metabolism, improved nitrogen metabolism, and general digestive effects, including reductions in both bloat and lactic acidosis. Schelling (Schelling, 1984) described monensin as having several modes of action, including modified volatile fatty acid production, modified feed intake, changes in gas production, modified feed digestibilities, and alterations in both rumen fill and rate of passage. Monensin changes the ratio of volatile fatty acids in the rumen, increasing propionic acid and reducing the molar percentages of butyric and acetic acid (Richardson et al, 1979). Increased rumen propionic acid improves gluconeogenesis (Schelling, 1984). Direct effects on rumen bacteria are probably responsible for the so called protein sparing effect (Duffield et al. 1998b, 1999), and monensin studies in steers and lambs have demonstrated higher circulating urea and lower rumen ammonia levels in treated animals (Erasmus et al. 1993; Fairries et al. 1993; Duffield et al. 1998b). A reduction in rumen methane production has also been observed with monensin (Schelling, 1984). Monensin slightly improves feed digestibility, reduces rumen turnover, and may reduce feed intake, especially on high concentrate diets (Schelling, 1984). During the adaptation period, monensin may depress intake and reduce feed digestibility (Schelling, 1984). Other effects of monensin include a reduction in 3-methylindole production (Schelling,

1984) and a reduction in face fly and horn fly numbers (Herald et al, 1982). Monensin is also used extensively to help control bovine coccidiosis (Tyler et al, 1992).

■ Improved Energy Metabolism

The gluconeogenic potential of monensin has attracted researchers to investigate its possible role as an antiketogenic agent in dairy cattle. Rogers and Hope-Cawdery (1980) were the first to describe the beneficial effects of monensin for reducing the effects of ketosis in a herd with a clinical ketosis problem. This report was not a controlled randomized trial. The antiketogenic properties of monensin were later investigated in a Canadian trial involving 2 levels of monensin and 3 groups of 12 Holstein cows (Sauer et al, 1989). Monensin included at 30 grams per ton of total ration (high group), decreased the incidence of subclinical ketosis and significantly reduced blood beta-hydroxybutyrate (BHB) levels in the first 3 wk postpartum (Sauer et al, 1989). The incidence of subclinical ketosis defined as total blood ketones > 9 mg/100 ml (900 μ mol/L) was decreased and blood BHB levels were reduced by 40% for the high monensin group. The lower monensin dose did not significantly impact blood BHB or subclinical ketosis in this study. Based on the average feed intakes observed in this trial, the low monensin group received approximately 208 mg of monensin per animal per day and the high group 399 mg per animal per day (Sauer et al, 1989).

A German study involving 23 German Black and White dairy cows given 240 mg per day of monensin in the ration, also reported an antiketogenic effect (Farries and Smidt, 1993). Animals receiving doses of 10 and 20 mg monensin per kg of feed, commencing precalving and continuing into early lactation, showed significant reductions in blood acetone and acetoacetate but no significant effect on BHB (Erasmus et al, 1993). Monensin treatment, commencing at 2 to 4 wk prior to calving, reduced serum BHB and non-esterified fatty acids (NEFA) in lactating dairy cows during the first 28 days postpartum, when monensin was fed at 300 or 450 mg/animal/d but not by a daily dose of 150 mg/animal/d of monensin (Thomas et al, 1993). Serum glucose was not influenced by feeding monensin.

Several studies involving intraruminal controlled release capsules (CRC) have been used to evaluate the metabolic, health and production effects of monensin in dairy cattle. This spring loaded capsule contains 32 g of monensin in a hexaglycerol distearate matrix core (Cameron and Malmo, 1993). In Canadian studies, it has been demonstrated that a CRC containing monensin delivers a constant daily dose of approximately 335 mg for about 95 d in dairy cows (Provel, 1998). Cows in Australia treated with a monensin CRC during the first week postcalving had significantly lower plasma BHB levels and tended to have higher glucose concentrations than did controls receiving no monensin (Abe et

al, 1994). Monensin-treated cows had significantly higher levels of serum urea, however, no significant effects of monensin on glucose or BHB were shown in a New Zealand trial (Hayes et al, 1996). In this study, monensin CRCs were administered one month prior to artificial insemination. This time of administration would likely have been beyond the first 30 d after calving, which is the primary risk period for subclinical ketosis. Therefore, cows in this study were probably not in a negative energy balance during monensin-treatment.

Green (1997) reported that administration of a monensin CRC 3 wk prior to expected calving, significantly reduced the concentrations of BHB and increased those of glucose. Monensin treatment in this study was also reported to reduce both the onset and severity of subclinical ketosis when cows were restricted to 90% of ad libitum feed intake commencing at 2 wk postcalving. Duffield et al (1998b) reported that monensin CRC administration at 3 wk prior to calving reduced the incidence, prevalence, and duration of subclinical ketosis in a 1010-cow multi herd field study. Monensin treatment also significantly reduced the concentrations of serum BHB and aspartate aminotransferase, and increased the concentrations of serum glucose and urea (Duffield et al, 1998a).

Stephenson et al (1997) conducted a small study involving 24 cows from 2 farms where monensin CRCs were administered 50 d precalving. A significant decrease in non-esterified fatty acids, BHB and glucose were noted in the precalving period. No significant effects on these energy indicators were observed post calving. However, a significant elevation in ceruloplasmin concentration was noted in monensin-treated cows, post calving. The authors suggested that this increase in copper absorption may assist the cow in fighting oxidative challenges. Cows from this study were also evaluated for their neutrophil function. Monensin significantly improved the chemotactic function of neutrophils (Stephenson et al, 1996), indicating that monensin may improve immune function indirectly via an improvement in energy status. A summary of monensin's effect on energy metabolism in dairy cattle is reported in Table 1.

Table 1. Summary of the metabolic effects of differing doses of monensin in lactating dairy cattle reported from various international studies

Year	Country	N ^a	Dose ^b	Ketone bodies	Glucose
1989	Canada	36	16 ppm 33 ppm	↓Total Ketones & ↓BHB (S) only for 33 ppm	NS
1993	S. Africa	60	10 ppm 20 ppm	BHB (NS), ↓ACAC (S) ↓ Milk acetone (S)	NS
1993	United States	47	150 mg 300 mg 450 mg	↓BHB (S) only for 300 and 450 mg	NR
1994	Australia	16	CRC	↓BHB (S)	↑ (Trend)
1996	N. Zealand	120 ^c	CRC	BHB (NS)	NS
1997	U.K.		300 mg	↓BHB (S)	NR
1997	Australia	24	CRC	↓BHB (S) Precalving	↓ (S) Precalving
1997	Canada	1010	CRC	↓BHB (S), Milk Ketones (S)	↑ (S)
1997	Canada	52	CRC	↓BHB (S)	↑ (S)
1998	Netherlands	80	300 mg	↓BHB (S), ↓ACAC (S)	↑ (S)

^a Number of animals in the study.

^b Dose: mg = mg/cow/day, CRC = controlled release capsule (335 mg/cow/day), ppm = concentration in mg/kg of total feed.

^cA subsample from each herd was evaluated

NS = Not statistically significant, S = Statistically significant (P < 0.05), NR = Not reported. BHB = beta-hydroxybutyrate ACAC = acetoacetate

■ Health

A CRC containing monensin has been found efficacious for the prevention of pasture bloat in dairy cattle, in several studies conducted in Australia and New Zealand.

Monensin has also been reported to reduce the incidence of subclinical ketosis. Sauer (Sauer et al, 1989) reported a reduction in subclinical ketosis from 6 out of 12 in the untreated group to 4 and 1 out of 12 in the low (208 mg/cow/d) and high (399 mg/cow/d) monensin groups respectively. This was a relatively small trial conducted in one research herd. The high dose of monensin did significantly reduce the incidence of subclinical ketosis, however, at the low dose the incidence of subclinical ketosis was not significantly different from that of control. Duffield et al (1998b) reported that monensin delivered in a controlled release capsule (335 mg) reduced the incidence of subclinical ketosis by 50%, at threshold values for defining subclinical ketosis of 1200, 1400, and 2000 $\mu\text{mol/L}$ BHB in 1010 cows from 25 commercial dairy farms. Monensin also significantly reduced the duration of subclinical ketosis.

The use of Rumensin® CRC's precalving has been shown to significantly reduce the risk of abomasal displacement and multiple illness (more than one disease in early lactation)(Duffield et al, 1999). In the same study, there was a tendency for monensin-treated cows to be at reduced risk of clinical ketosis and culling. These health effects were presumably associated with the observed reduced incidence of subclinical ketosis. Pooled analysis of the 1010 cow study in 1995 in Ontario and a 1999 study involving 1156 cows in Ontario, Quebec, and the Maritimes has shown that the Rumensin® CRC significantly reduces both the incidence of abomasal displacement and clinical ketosis by approximately 40% (Duffield, unpublished data 2000). The work of Beckett et al (1998) demonstrated no significant health effects of the Rumensin® CRC when it was administered 40 d prior to expected calving. However, disease incidence was substantially lower in this study than would be expected for typical North American dairies. Interestingly, the incidence of retained placenta in monensin-treated cows was numerically lower in this study. This tendency has also been observed in both the 1995 study (Duffield et al, 1999) and in a recent field study (Duffield, unpublished data 2000).

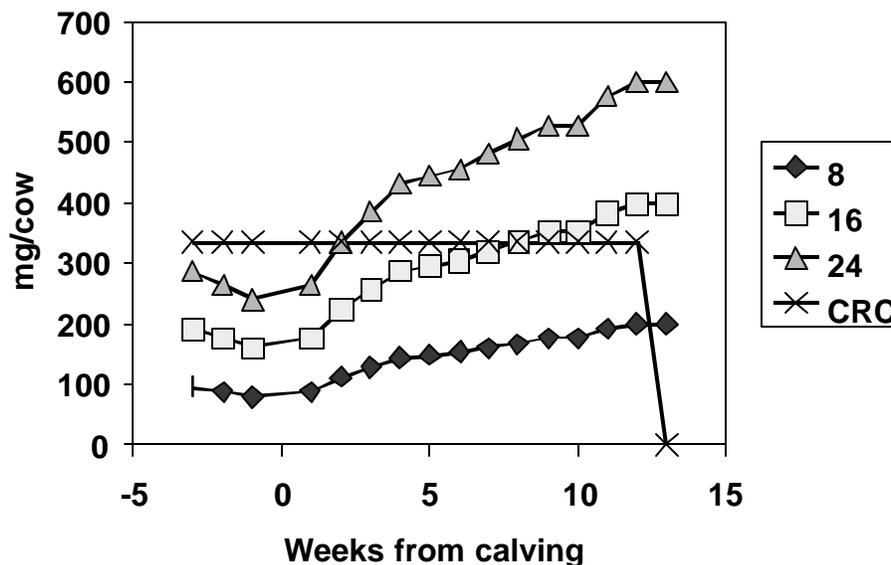
In feedlot steers, monensin has an impact on reducing rumen acidosis. In one study that measured continuous 24 h rumen pH, monensin reduced the time rumen pH fell below 5.6 and was associated with a more consistent feed intake pattern (Cooper and Klopfenstein, 1996). These effects are thought to be mediated through monensin's effect on reducing lactic acid-fermenting bacteria and enhancing lactic acid utilizers. In the only study to date on the effects of monensin use on rumen pH in dairy cattle, significantly higher rumen pH values were observed, postcalving, in monensin-treated cows (Green, 1997).

However, both placebo (CRC not containing monensin) and monensin groups had point sample rumen pH values well above 6.0. Further work will be needed to investigate the potential of ionophores in preventing rumen acidosis in lactating dairy cattle.

■ Method of Ionophore Delivery

The impacts of monensin on health have been primarily observed with use of the controlled release capsule. This device provides a consistent daily dose of monensin that is independent of feed intake fluctuations around calving. A comparison of monensin levels in mg/day around calving with three different feed concentrations and with the CRC is illustrated in Figure 1. It may be incorrect to assume that the same health effects can be achieved with feed delivered monensin. While this may be true on some farms, delivery and intake of monensin will be the key to success. To date there is no published research on the health impacts of ionophores fed through the diet in lactating dairy cattle. By contrast, the health impacts of the Rumensin® controlled release capsule have been proven in a field situation and repeated in subsequent research.

Figure 1 A comparison of monensin dose in mg per cow per day between feed delivered monensin in a total mixed ration (8, 16 and 24 ppm of monensin) and the controlled release capsule (CRC) around the time of calving.



■ Conclusions

The literature strongly supports that monensin administered precalving has positive effects on energy metabolism in early lactation. These effects include a reduction in circulating ketone body concentrations and an increase in serum glucose. In addition, administration of the Rumensin® controlled release capsule has been shown to reduce the incidence and duration of subclinical ketosis, and the risk of several periparturient diseases, including clinical ketosis and abomasal displacement. It appears that improved health would be the primary benefit of monensin when used in early lactation. Although studies in Australia indicate that monensin reduces the risk of bloat and studies in beef cattle suggest that monensin may be helpful in managing rumen acidosis, further work needs to be done in the areas of rumen health in dairy cattle. In addition, the utility of lasalocid needs to be more completely assessed before its use in dairy rations can be recommended.

The use of monensin in dairy cattle appears to have many applications and thus implementation strategies will vary with each farm and depend on the dairy producers' goals. Based on the current literature, monensin will be helpful in reducing the incidence of subclinical ketosis and other associated periparturient diseases, when treatment commences a few weeks precalving and extends toward peak lactation. Monensin will be of particular benefit to moderately and overly conditioned cows.

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