MONENSIN: AN OVERVIEW OF ITS APPLICATION IN LACTATING DAIRY COW DIETS

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Summary

The efficiency of feedstuff utilization by ruminal microorganisms and the cow's genetic ability to convert feed nutrients into milk and milk components are major factors that influence the profitability of a dairy herd. Monensin's ability to modify the movement of ions across biological membranes leads to alterations in bacterial populations and subsequent changes in the proportion of volatile fatty acids produced during ruminal fermentation. Manipulating ruminal microbial populations with ionophores has the potential to improve performance by reducing ketosis, acidosis, and bloat and increasing digestive efficiency. Monensin improves fiber digestion by preventing suboptimal ruminal pH, enhances amino acid use by reducing the degradation of dietary protein, and improves the energy status of periparturient animals. Monensin is not approved for use in diets for lactating dairy cows at this time, but its status is currently under review by the U.S. Food and Drug Administration. If approved, monensin will provide another management tool to the dairy industry.

(Key Words: Ionophore, Health, Efficiency.)

Introduction

The profitability of a dairy herd is a function of the mail box price at the farm level and the cost of production (overhead and operational). The herd manager can influence the cost of production but has little influence on the price received for milk. An analysis of individual items contributing to the total cost of production reveals that feed cost constitutes approximately 50% (range of 35-60%). Thus, the efficient use of feedstuffs is a high priority issue for dairy producers and researchers.

Feed efficiency is defined herein as pounds of energy-corrected milk produced per pound of feed consumed. Energy-corrected milk is used, because it accounts for volume and energy content of milk (fat, protein, and lactose). Feed consumed is less than feed offered, but feed wasted during handling and feeding is a separate management issue. Milk and milk component yield by the dairy cow is a function of her genetic makeup and environment. The diet fed to the cow is a major aspect of the environmental factors that influence her performance. If we assume that the cow is fed a properly formulated diet and other environmental factors are favorable, then her response to the diet depends on the efficiency of feedstuff utilization by ruminal microorganisms and the cow's genetic ability to convert feed nutrients into milk

The purpose of this review is to explore the implications of including monensin in diets for lactating dairy cows, because it is under review by the U.S. Food and Drug Administration (FDA) as a potential feed additive.

Monensin's Mode of Action

Monensin and other ionophores have been used as growth promotants in livestock production systems for decades. However, monensin is known most notably for its ability to alter the ruminal microbial population, leading to increased proportions of the gluconeogenic precursor propionate. An ionophore's mode of action is to modify the movement of ions across biological membranes. Two major classes of bacteria exist in the rumen: gram negative and gram positive. Gram positive bacteria (cells possessing a complex outer membrane) are resistant to ionophores, whereas gram negative bacteria are susceptible. Bacterial cell membranes consist of a lipid bilayer that regulates nutrient exchange across the membrane. Ionophores bind to gram-negative bacteria and disrupt nutrient exchange that interferes with proper cell function and can result in cell death. Alterations in bacterial populations lead to changes in the proportions of volatile fatty acids (VFAs) produced during ruminal fermentation.

Effects on Animal Health Status

Management tools such as DHI records, rBST, and a solid preventive herd health program play a vital role in achieving higher production efficiencies. Monensin is yet another management tool that could enhance production efficiency and improve animal health status. As the dairy cow progresses through various production phases (i.e., dry period, early, mid-, and late-lactations) she experiences a wide array of physiological and dietary changes. These changes require intense nutritional management to prevent herd health problems and maximize performance. Manipulating the ruminal microbial population with ionophores could improve performance by reducing ketosis, acidosis, and bloat and increasing digestive efficiency.

The transition from a nonlactating to a lactating state increases nutrient demand at a time when intake is less than optimal. The cow responds by mobilizing tissue to support lactation, which increases the risk of metabolic disorders such as ketosis and fatty liver. Monensin has the potential to reduce the incidence of ketosis, because it increases the proportion of propionate, a gluconeogenic precursor, whereas total ruminal VFA concentrations either increase or remain unchanged. Increasing ruminal production of propionate (contributes to glucose production) reduces the need to synthesize glucose from the amino acid pool in order to maintain adequate concentrations of blood glucose.

Feeding diets containing an adequate supply of nonstructural carbohydrates to meet the lactational demand of the high-producing dairy cow often predisposes the animal to borderline acidosis. The initial onset of ruminal acidosis stems from an overproduction of VFAs that lowers ruminal pH (<5.5). This affects the ruminal microbial population, allowing lactic acid producers to outnumber lactic acid utilizers. Monensin decreases the *Streptococcus bovis* population, a major lactate producer, and enhances the lactic acid utilizers. The net effect of monensin on ruminal acidosis yields a more desirable ruminal pH (<5.8) for improved fiber digestion.

Monensin also has demonstrated the ability to reduce bloat. Two major products resulting from ruminal fermentation are acids and gases. The inability to eructate free gas from the rumen results in bloat. This inability is caused by an accumulation of fluids, solids, foam, and(or) slime that prevents the free gas from reaching the cardia to be expelled via eructation. Monensin reduces the production of methane, and carbon dioxide, the rate of rumen fill, and growth of microbial species responsible for slime production. A reduction in these bloat-provocative substances reduces the incidence of bloat within the herd.

Monensin also has a protein-sparing effect and reduces ruminal ammonia production. Its depressive effect on overall ruminal cell numbers reduces activities of proteolytic and deaminative enzymes, thus, increasing the quantity of dietary protein escaping ruminal degradation. This dietary protein then would be available for postruminal absorption. Other researchers have found that monensin reduces protozoan numbers *in vivo*. Because protozoa play a role in bacterial protein recycling, ruminal ammonia concentration is lower for cattle receiving monensin.

Feeding Recommendations

Monensin has not been cleared for use in lactating dairy cow diets in the U.S. However, data have been submitted to the U.S. Food and Drug Administration for review. Monensin has been cleared for use in other countries, and the feeding recommendations contained herein are based on their findings.

The impact of monensin on the digestion of other dietary ingredients should be considered. Incorporating monensin into a high-fiber diet generally will result in increased milk production because of increased energy (in the form of glucose) available for milk synthesis. However, when monensin is formulated into an energy-dense diet, dry matter intake is reduced and milk production unchanged, resulting in increased production efficiency. Monensin also improves protein nutrition of the dairy cow, because more amino acids are absorbed postruminally and made available for milk protein synthesis or gluconeogenesis rather than being degraded by ruminal microbes. This protein-sparing effect is primarily due to a reduction in protein deamination activity in the rumen, making more effective use of amino N. Therefore, diets designed for monensin inclusion should contain sufficient high quality protein to ensure the availability of essential amino acids.

Because monensin enhances the energy status of the cow, the greatest response to feeding monensin is observed during the first 3 to 4 wk after calving and continues until peak milk production. During the immediate prepartum period, the cow is in a negative energy balance as fetal growth is maximized and the mammary gland is preparing for the subsequent lactation. This energy imbalance continues during early lactation. Therefore, the positive effect of monensin on performance will continue until peak lactation (usually 50 to 60 days postpartum). Shortly after this time, feed intake is sufficient to meet the demand for milk synthesis. Generally, no response in milk production has been observed after peak milk production but increases in body weight and body condition resulted from the increased energy available to the cow.

The amount of monensin to include in the diet will be determined during the FDA review process. Doses used in research trials have ranged from 10 ppm (equivalent to 10 mg/kg of feed dry matter) to 450 mg per head per day. Research indicates that an interaction may occur between dose and other factors such as diet and stage of lactation. In general, feeding monensin at different amounts has decreased milk fat percentage but had an insignificant effect on milk protein content. Feeding monensin under conditions known to decrease milk fat (low fiber, high grain diets, and heat stress) has shown the greatest negative impact on milk fat.

In conclusion, a recent review indicated that monensin increased milk yield by approximately 2 lb per day. Most importantly, monensin could be useful in the prevention of periparturient diseases, which are oftentimes invisible costs impacting the efficiency of production. If it is approved for use in the U.S., diet formulation strategies will vary between farms based on production goals. In the end, monensin's impact on the efficiency of milk production should help improve the dairy farm balance sheet.