Application of Ionophores in Cattle Diets[1]

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Introduction

Ionophores are feed additives used in cattle diets to increase feed efficiency and body weight gain. They are compounds that alter rumen fermentation patterns. Ionophores can be fed to any class of cattle and can be used in any segment of the beef cattle industry. Similar to many other feed additives, ionophores are fed in very small amounts and supplied via another feedstuff as carrier for intake. Ionophores decrease incidence of coccidiosis, bloat, and acidosis in cattle.

Mode of Action

Commercially-available ionophores include monensin (Rumensin®), lasalocid (Bovatec®), and laidlomycin propionate (Cattlyst®). Ionophores are classified as carboxylic polyether antibiotics, and they disrupt the ion concentration gradient (Ca^{2+}, K^+, H^+, Na^+) across microorganisms, which causes them to enter a futile ion cycle. The disruption of the ion concentration prevents the microorganism from maintaining normal metabolism and causes the microorganism to expend extra energy. Ionophores function by selecting against or negatively affecting the metabolism of gram-positive bacteria and protozoa in the rumen. The affected bacteria are those that decrease efficient rumen digestive physiology and the energy supplied from the ruminal digestion of feedstuffs. By controlling certain protozoa and bacteria in the rumen, less waste products (methane) are generated (Guan et al. 2006) and ruminal protein breakdown is decreased, which results in decreased ammonia production. The shift in ruminal bacteria population and metabolism allows beneficial bacteria to be more efficient through an increase in the amount of propionic acid and a decrease in the production of acetic acid and lactic acid. Therefore, cattle experience an increase in the overall energy status and use feed resources more efficiently.

Ionophores are classified as an antibiotic, but they are not therapeutic antibiotics. Antibiotic resistance is an increasing concern in public discourse. However, the increase in antibiotic-resistant bacteria as a result of ionophore use is not well supported for a number of reasons: 1) ionophores have never been (nor are likely to be) used as antimicrobials for humans; 2) ionophores have a very different mode of action from therapeutic antibiotics; 3) ionophore resistance in bacteria seems to be an adaptation rather than a mutation or acquisition of foreign genes (Russell and Houlihan 2003); 4) ionophores can translocate across cell membranes of animals, which limits their use as therapeutic antibiotics; and 5) ionophore resistance in targeted bacteria shows complexity and a high degree of specificity (Callaway et al. 2003).

Applications

Ionophores can be fed to cattle in a number of different ways. Most frequently, ionophores are included in either dry or liquid manufactured supplements, allowing for

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specific formulations of ionophore concentrations and the option to control intake of the supplement. Ionophores can also be included in loose mineral mixtures, which can be used to limit intake of the mineral. This is particularly true when monensin is used because of the palatability characteristics associated with monensin in loose form. Ionophores are included in small amounts when mixed in formulated supplements. Additionally, ionophores are a medicated ingredient, and the government regulates the manufacture of feeds that contain ionophores. Thus, ranch mixing is not allowed for feed or mineral supplements. Ionophores have no withdrawal time relative to sale or slaughter of cattle. This means that cattle can consume ionophore-containing feedstuffs up to the day of sale or slaughter.

Ionophores are used in a variety of cattle production scenarios. Growing cattle consume the majority of ionophores; however, mature cows can also benefit from the consumption of ionophores. Table 1 demonstrates the variety of feeding scenarios in which ionophores have been offered to cattle on forage-based diets. It is appropriate to use ionophores in cattle consuming nearly every forage type and quality. The carrier or supplement that contains the ionophore should complement the forage base and cattle requirements. However, cattle that consume ionophores are generally not eligible to enter natural programs and are excluded from organic market production chains.

Equine and swine should not consume ionophores or feeds containing ionophores. Both equine and swine are incapable of metabolizing ionophores in the concentrations formulated for cattle diets. In cattle, sheep, chickens, dogs, and other animals, the ionophores can be absorbed across the small intestine, transported to the liver, metabolized, and excreted in bile with the ultimate elimination through feces.

Animal Response

Reviews of numerous grazing trials using steers and heifers indicate that supplementation with 155 mg/day of monensin results in an improvement in average daily gain of 0.18 lb/day or a 13.5% increase compared to non-supplemented control cattle (Kunkle et al. 2000). When the amount of monensin increased to 200 mg/day, cattle gained an additional 0.20 lb/day or a 16% improvement compared to cattle not offered an ionophore. Offering supplements containing monensin at 200 or 400 mg/day on alternate days can increase growing calf gain by 0.17 and 0.18 lb/day, respectively (Muller et al. 1986). The preceding responses were collected over a variety of pasture forage qualities.

Cattle grazing bermudagrass and supplemented 200 mg/day of monensin in the summer have been reported to increase daily gain by 0.22–0.46 lb/day or a 24%–44% increase over cattle consuming supplement without monensin (Rouquette et al. 1980; Oliver 1975). Table 1 provides a summary of growing cattle performance when offered an ionophore.

Ionophores have been used to positively affect reproductive processes in the beef cow herd. The postpartum interval can be decreased in cows gaining body weight and body condition score as a result of improved nutritional status associated with ionophore supplementation. However, the change in cow body weight and condition score during the supplementation period strongly influenced overall postpartum interval response (Sprott et al. 1988). Onset of puberty in growing heifers can be hastened by supplementation with ionophores. Research has demonstrated that age at puberty can be decreased in growing heifers gaining at acceptable growth rates (0.75–1.32 lb/day) and the percentage of heifers pubertal at target breeding body weight is increased.

Economics of Performance Response

In stocker cattle and replacement heifers, the use of ionophores increases average daily gain by 5%–15% and improves feed efficiency by 8%–12% (Lawrence and Ibarburu 2008; Elam and Preston 2004). The economic effect on stocker cattle is an impact of 1.46% on the breakeven price, and $11.51 effect on the cost of production (See Table 2). In the feedlot sector, ionophores improve average daily gain by 1%–6% and improve feed efficiency by 3.5%–8% (Lawrence and Ibarburu 2008; Elam and Preston 2004). Similar to the stocker sector, ionophores in the feedlot sector contribute a smaller but significant effect on breakeven price and production cost per head differential (1.18% and $12.43, respectively) compared to not using ionophore technology. Production practices that combine the use of ionophores and implants likely result in a synergetic effect on growth performance of cattle (Elam and Preston 2004). Ionophores increase the amount of energy available from the diet, and the application of implants stimulates lean tissue growth, which uses the increased available energy.

Conclusion

Incorporating ionophores into beef cattle supplements and diets elicits a positive increase in growing cattle performance. Beef cattle producers should consider using ionophores to increase calf gain and gain efficiency in a cost-effective manner. The response to ionophores is related to forage availability, forage quality, and concentration of ionophore used.

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Table 1. Effect of the concentration of ionophores during supplementation on growing calf gain offered different diets.

Diet	Ionophore	Concentration, mg/day	Calf body weight, lb	Control suppl. gain, lb/day	Ionophore suppl. gain, lb/day	Ionophore gain differential, lb/day
Bermudagrass[1]	Monensin	200	550	0.93	1.04	+0.11
		200	573	1.04	1.50	+0.46
Bermudagrass[2]	Monensin	25	343 to 518	1.24	1.55	+0.31
		50			1.61	+0.37
		100			1.72	+0.48
		200			1.56	+0.32
Bermuda-Bahiagrass[3]	Monensin	180	457	0.76	0.52	-0.24
Bahiagrass[4]	Lasalocid	50	480	0.76	0.66	-0.10
		100			1.02	+0.26
		200			0.71	-0.05
		300			0.82	+0.06
	Monensin	200	480	0.76	0.91	+0.15
Stargrass[4]	Lasalocid	50	480	1.25	1.34	+0.09
		100			1.35	+0.10
		200			1.27	+0.02
		300			1.33	+0.08
	Monensin	200	480	1.25	1.50	+0.25
Wheat pasture[5]	Monensin	180	542	1.81	2.03	+0.22
Prairie hay	Monensin	200	460	0.55	0.55	0.0
Dormant range[6]	Monensin	150	474	0.64	0.92	+0.28

[1] Rouquette et al. 1980
[2] Oliver 1975
[3] Imler 2011
[4] Kunkle et al. 2000
[5] Fieser 2007
[6] Horn, Hersom, and Cox 2000

Table 2. Effect of ionophore technology on average daily gain (ADG) and estimated cost of production in the stocker and feedlot segment compared to no use.[1]

Industry section	Estimated improvement to ADG, %	Estimated decrease in breakeven price, %	Estimated dollar increase if ionophore was removed, cost per head, $
Stocker	7.74	1.46	11.51
Feedlot	2.90	1.18	12.43

[1] Adapted from Lawrence and Ibarburu (2008).