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Abstract

Cattle have the innate ability to recycle nitrogen absorbed post-ruminally back to the rumen as endogenously synthesized urea. Urea returning to the rumen provides an additional opportunity for ruminal microbes to benefit from nitrogen absorbed postruminally. Urea recycling may provide a significant benefit to cattle when protein requirements of ruminal microbes are high or when large amounts of the dietary protein escape ruminal degradation.

Keywords

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Effect of Nitrogen Supplementation and Zilpaterol-HCl on Urea Recycling in Steers Consuming Corn-Based Diets[1]

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Introduction

Cattle have the innate ability to recycle nitrogen absorbed post-ruminally back to the rumen as endogenously synthesized urea. Urea returning to the rumen provides an additional opportunity for ruminal microbes to benefit from nitrogen absorbed post-ruminally. Urea recycling may provide a significant benefit to cattle when protein requirements of ruminal microbes are high or when large amounts of the dietary protein escape ruminal degradation.

Zilmax (Intervet/Schering-Plough Animal Health, Millsboro, DE) is the brand name for zilpaterol-HCl, an orally active β-adrenergic agonist approved as a feed additive for beef cattle in the United States. Orally active β-adrenergic agonists repartition nutrients from lipid accretion toward skeletal muscle growth. When fed during the final 20 to 40 days on feed, Zilmax has been shown to increase average daily gain and feed efficiency of cattle consuming corn-based diets and has been shown to either have little effect on or slightly reduce dry matter intake. This repartitioning of nutrient use in Zilmax-fed cattle clearly increases net protein deposition.

As use of ethanol fermentation coproducts (e.g., distillers grains) increases in finishing cattle diets, dietary nitrogen available to ruminal microflora may be reduced compared with that available from traditional sources of supplemental protein. Urea recycling may be more important when finishing cattle consume supplemental proteins with low ruminal degradability. The goal of our study was to better quantify the amount of urea recycled in growing cattle fed corn-based diets supplemented with different sources of protein with or without Zilmax.

Experimental Procedures

Two sets of six steers were blocked into pairs on the basis of pretrial voluntary feed intake and used in two replicates of similarly designed trials conducted at different times. Within each replicate, three steers (one randomly selected from each blocked pair) were fed 60 mg/day zilpaterol-HCl (1.25 g/day Zilmax) throughout the trial, and the remaining 3 steers received no Zilmax. Thus, the Zilmax treatment was provided in a randomized block design.

Within each group of three steers receiving the same Zilmax treatment, steers were used in a 3 × 3 Latin square concurrent with an identical Latin square involving the group of three steers receiving the other Zilmax treatment. Treatments within each square were three corn-based diets: control (9.6% crude protein), urea (12.4% crude protein), or dried distillers grains with solubles (13.7% crude protein).

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Steers were housed in metabolism crates to allow for total collection of urine and feces. Steers were fed twice daily in equal amounts at 12-hour intervals. The amount of feed offered was near voluntary intake for each individual steer prior to the experiment.

Intake, digestion, and nitrogen balance were measured for all treatments. Urea that was composed of heavy isotopic nitrogen (^{15}N) was infused intravenously to measure urea kinetics.

Results and Discussion

Effects of Diet

Nitrogen intake (Table 1) was greatest with dried distillers grains with solubles (176 g/day), intermediate with urea (161 g/day), and least with the control (120 g/day). These differences were expected. Additions of supplemental nitrogen as dried distillers grains with solubles increased (72 g/day) nitrogen retention compared with the control (37 g/day), and urea was intermediate (61 g/day). Increases in response to dried distillers grains with solubles probably represent responses to increases in metabolizable protein supply.

Urea production was numerically greater for dried distillers grains with solubles (193 g/day) than for the control (141 g/day) or urea (138 g/day). Digestive tract entry of urea (recycling) also was also was numerically greater for dried distillers grains with solubles (151 g/day) than for urea (101 g/day) or the control (111 g/day).

Cattle fed dried distillers grains with solubles tended ($P=0.16$) to capture more recycled urea in ruminal microbes than cattle fed the other diets (data not shown).

Effects of Zilmax

Dry matter intake of steers fed Zilmax was greater ($P<0.01$) than that of steers not fed Zilmax (8.5 vs. 6.6 kg/day, respectively). Differences in dry matter intake were due to unexpected greater refusals by steers not receiving Zilmax compared with steers receiving Zilmax (27% vs. 7%, respectively) rather than to differences in the amount of feed offered. Differences in intake due to Zilmax were not expected and are contrary to results of previous research. Zilmax increased ($P<0.01$) nitrogen intake (171 vs. 134 g/day). Increases in nitrogen intake in response to Zilmax were not expected but were proportional to the increase in dry matter intake.

No measureable effects of Zilmax were observed for urea kinetics. Zilmax unexpectedly increased intakes in our experiment, and it is difficult to separate the effects of Zilmax from those of increased intakes. Interestingly, Zilmax had no effects on urea production or recycling of urea to the digestive tract despite the greater nitrogen intake of steers fed Zilmax. Similar research demonstrated that increases in nitrogen intake lead to increases in urea production and urea recycling in cattle. Zilmax repartitions nitrogen such that more nitrogen is directed to lean tissue accretion (i.e., muscle growth). Our initial hypothesis was that increases in nitrogen retention in response to Zilmax would lead to less catabolism of amino acids, less urea production, and less urea recycling to the digestive tract. In light of the greater nitrogen intake of Zilmax-fed cattle and the lack of change in urea produced and recycled to the digestive tract, it is possible that the effects of nitrogen intake and Zilmax counteracted one another in this experiment.

Implications

Understanding the effects of β-adrenergic agonists, such as Zilmax, on nitrogen recycling will allow nutritionists to formulate diets that more closely match the nutrient needs of finishing cattle. Appropriately matching dietary nutrients with cattle's requirements may prevent costly overfeeding of nitrogen and wasteful nitrogenous excretions.

Table 1. Effects of nitrogen supplementation and dietary zilpaterol-HCl (Zilmax) on intake, digestion, and nitrogen retention in steers consuming corn-based diets supplemented with no protein (Control), dried distillers grains with solubles (DDGS), or urea

	Zilmax			No Zilmax				P-value		
Item	Control	DDGS	Urea	Control	DDGS	Urea	SEM	Zilmax	Diet	Interaction
Dry matter intake, lb/day	18.8	18.8	18.6	14.2	14.3	15.2	1.1	<0.01	0.76	0.61
Dry matter digestion, %	77.4	77.4	76.4	76.2	79.1	77.8	2.4	0.80	0.65	0.62
Nitrogen intake, g/day	138	198	177	102	155	145	11	<0.01	<0.01	0.79
Nitrogen retained, g/day	49	87	75	26	57	47	17	0.05	0.10	0.97
Urea production, g nitrogen/day	156	169	134	126	217	142	52	0.80	0.36	060
Urea recycling, g nitrogen/day	126	132	109	97	169	93	47	0.94	0.39	0.58