Evaluation of an exogenous enzyme combination in forage-based growing diets fed to growing beef cattle

Madeliene Nichols[1], Grady Gullickson[1], Yssi Entzie[1], Sarah Underdahl[1], Lydia Hansen[1], Jessica Syring[1], Joshua Wianecki[1], Danielle Jensen[1], Kathlyn Hauxwell[1], Tommy Winders[2] and Zachary Carlson[1]

The objective of this experiment was to evaluate the effects of exogenous fibrolytic enzymes and wheat straw inclusion level on the performance of growing beef steers receiving forage-based growing diets. The results indicate that supplementing exogenous fibrolytic enzymes did not affect growth performance or feed intake but did affect plasma metabolites in a way that suggests greater dietary energy was derived when including exogenous fibrolytic enzymes in the diet. Increasing wheat straw levels decreased average daily gain and dry matter intake.

Summary

Seventy-three crossbred steers were in an 84-day study to evaluate the influence of exogenous fibrolytic enzymes and wheat straw inclusion in forage-based growing diets fed to growing beef steers. Steers were assigned to one of four treatments arranged as a 2 × 2 factorial with two levels of wheat straw inclusion: 5% or 15% of diet dry matter, and two levels of exogenous fibrolytic enzymes: 0 g or 750 g/metric ton of diet (Bovizyme CX; Danisco Animal Nutrition and Health; Wilmington, DE). Body weights and blood samples were collected every 28 days. Individual intake data were collected using an automated feeding system (Insentec Roughage Intake Control, Hokofarm B.V., Marknesse, The Netherlands). Statistical analysis showed no wheat straw × exogenous fibrolytic enzymes interactions ($P \geq 0.18$) for ending body weight (EBW), average daily gain (ADG), dry matter intake (DMI), feed-to-gain ratio (F:G), plasma glucose (GLC), plasma urea nitrogen (PUN) or plasma non-esterified fatty acids (NEFA). Supplementing exogenous fibrolytic enzymes did not affect ($P \geq 0.15$) growth performance or intake but increased GLC and decreased NEFA concentrations in the blood. Increasing wheat straw inclusion from 5% to 15% negatively affected growth performance, decreasing EBW by 5%, ADG 16%, DMI 8% and F:G 9%.

Introduction

Forages are an integral part of beef cattle diets as they often are the main source of carbohydrates, are the main substrate utilized by ruminal microbes, and provide physical fiber needed to stimulate rumination and reticuloruminal motility (NRC, 2016). However, feeding forage as an energy source may limit the supply of energy and nutrients because of the naturally high cell wall concentration of forages. Cell walls contribute 40% to 70% of forage dry matter, and cell wall digestibility is typically less than 65% in ruminants (NRC, 2016).

The need to enhance cell wall digestibility in ruminants has led to the investigation of exogenous fibrolytic enzymes, which are proteins produced from microbial cells that degrade fiber. Fibrolytic enzymes were originally developed for use in swine and poultry diets to decrease the antinutritional properties of fiber and to degrade the pericarp of grain, but enzymes developed for ruminants have focused on improving fiber digestibility. Although exogenous fibrolytic enzymes have been shown to increase dry matter digestibility (Arriola et al., 2011), stimulate dry matter intake (Beauchemin et al., 1995; Arriola et al., 2011) and improve feed efficiency (Beauchemin et al., 1995; Holtshausen et al.) in beef and dairy cattle, results have been inconsistent. This stems from several factors including, but not limited to, product formulation, inclusion level, delivery method, diet composition and energy status of the target animal (Beauchemin et al., 2003).

The objective of this experiment was to evaluate the effects of exogenous fibrolytic enzymes (Bovizyme™ CX) and wheat straw inclusion level on the performance of growing beef steers receiving

[1]Department of Animal Sciences, North Dakota State University, Fargo, ND 58102
[2]Danisco Animal Nutrition and Health (IFF), Wilmington, DE 19803

forage-based growing diets. It was hypothesized that 1) steers receiving exogenous fibrolytic enzymes would have greater growth performance and intake than those not receiving exogenous fibrolytic enzymes, 2) steers consuming low-straw diets would have greater growth performance and intake than those receiving high-straw diets and 3) steers receiving the combination of exogenous fibrolytic enzymes and high-straw diet would not differ in growth performance compared to steers fed the no exogenous fibrolytic enzymes and low-straw diet.

Materials and Methods

All procedures were approved by the North Dakota State University Institutional Animal Care and Use committee. Seventy-three crossbred beef steers (633 ± 42 pounds initial body weight [BW]) were blocked by initial BW (n = 3) and source (n = 2; NDSU Central Grasslands Research Extension Center [n = 38] or NDSU Beef Unit [n = 35]) and randomly assigned to four dietary treatments arranged as a 2 × 2 factorial consisting of two levels of wheat straw: either 5% or 15% of diet dry matter, and two inclusion rates of exogenous fibrolytic enzymes: either 0 g/metric ton or 750 g/metric ton of diet. The study took place at the NDSU Beef Cattle Research Complex. The enzyme product was mixed with the grower supplement and delivered via the total mixed ration (TMR).

Steers were implanted on day –2 with 80 mg of trenbolone acetate and 16 mg of estradiol (Revalor-IS, Merck Animal Health, Summit, NJ). On day 0, steers began receiving their designated treatment diet for ab libitum intake. Individual intake data were collected using an automated feeding system (Insentec Roughage Intake Control, Hokofarm B. V., Marknesse, The Netherlands). Body weights were recorded every 28 days to monitor interim performance. Plasma samples were collected every 28 days to measure plasma urea nitrogen (PUN), plasma glucose (GLC) and plasma non-esterified fatty acids (NEFA). Net energy for gain (NEg) was calculated using gain and dry matter intake (NRC, 2016).

Data were analyzed as a randomized complete block design using SAS. Significance was set at $P \leq 0.05$ and tendency at $P > 0.05$ and ≤ 0.10.

Results and Discussion

There were no wheat straw × exogenous fibrolytic enzyme interactions for EBW, ADG, DMI or F:G ($P \geq 0.31$). The inclusion of exogenous fibrolytic enzymes did not influence EBW, ADG, DMI or F:G ($P \geq 0.62$). The results of the current study agree with previous literature suggesting that many factors contribute to the effectiveness of exogenous fibrolytic enzymes to improve animal performance. In dairy cows, Yang (2000) reported that milk yield increased when exogenous fibrolytic enzymes were applied to a barley-based concentrate prior to mixing with the TMR, but these same improvements were not observed when exogenous fibrolytic enzymes were mixed with the entire diet. Beauchemin (1995) reported that ADG, DMI and F:G of growing beef steers was dependent on both the inclusion rate of exogenous fibrolytic enzymes and diet composition; beef steers consuming alfalfa-based diets had the greatest improvements in growth performance, dry matter intake and F:G at moderate levels of exogenous fibrolytic enzyme inclusion while steers consuming timothy hay-based diets had the greatest improvements in growth performance, dry matter intake and F:G at high levels of exogenous fibrolytic enzyme inclusion.

As expected, increasing wheat straw inclusion from 5% to 15% decreased EBW, ADG and DMI, and increased F:G ($P < 0.001$) . The differences in performance are likely because of changes in fiber and starch concentrations of the diet, resulting in less energy available for cattle fed diets containing more wheat straw. Lesoing (1981) fed growing beef cattle consuming 0%, 10%, 20%, 30% or 40% wheat straw and showed that ADG decreased and feed:gain increased with increasing wheat straw inclusion. Dry matter, neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations were 4.6%, 3.3% and 2.5% greater for high-straw treatments as corn silage was replaced with wheat straw (Table 1). Likewise, the concentrations of starch in the high-straw diets were 2.6% less than the low-straw treatments.

No wheat straw × exogenous fibrolytic enzyme interactions ($P \geq 0.18$) were observed for PUN, NEFA or GLC. The inclusion of exogenous fibrolytic enzymes did not influence PUN ($P = 0.15$) but did increase GLC and decrease NEFA ($P = 0.04$ and 0.05; respectively). Increased plasma glucose concentration has been observed in other studies when evaluating enzyme supplements, but this occurrence is not consistent. Arriola (2011) reported that plasma glucose increased when lactating dairy cows were supplemented with fibrolytic enzymes when consuming a 33% concentrate diet but not in those consuming a 48% concentrate diet. Holtshausen (2011) reported that insulin concentration increased when dairy cattle consumed a higher level of exogenous fibrolytic enzymes compared to those consuming a lower level. The increase in GLC suggests exogenous fibrolytic enzymes could affect production of gluconeogenic volatile fatty acids The decrease in plasma NEFA could suggest that steers consuming exogenous fibrolytic enzymes were at a higher plane of energy, but this did not translate to an increase in EBW or ADG. Future research should evaluate the interactions between exogenous fibrolytic enzymes, the host and microbial growth.

Wheat straw inclusion did not affect PUN (P = 0.36) or GLC (P = 0.24), but increasing wheat straw inclusion increased NEFA. This was anticipated as wheat straw is less digestible than corn silage because there is less starch and greater ADF, NDF and lignin in wheat straw (NRC, 2016). The lower digestibility of wheat straw would result in steers consuming high-straw diets to have lower energy intake than steers consuming low-straw diets.

Table 1. Diet composition and nutrient analysis.

	Treatments[1]			
	5% Wheat Straw		15% Wheat Straw	
Ingredient, %DM	0 g EFE[1]/MT[2]	750 g EFE/MT	0 g EFE/MT	750 g EFE/MT
Wheat Straw	5	5	15	15
Corn Silage	35	35	25	25
DRC[3]	20	20	20	20
DDGS[4]	20	20	20	20
Oat Hay	15	15	15	15
Supplement[5]	5	5	5	5
Nutrient Analyses, %				
Dry Matter	68.97	69.28	73.89	73.47
Ash	8.85	8.84	9.21	9.21
NDF[6]	43.48	43.58	46.79	46.89
ADF[7]	22.50	22.50	24.99	24.99
Crude Protein	14.55	14.32	14.05	13.81
Starch	27.75	27.94	25.18	25.37
Ca:P	4.50	4.46	4.72	4.56
NEg, Mcal/kg	1.17	1.17	1.11	1.12

[1]Exogenous fibrolytic enzymes
[2]Metric ton (MT)
3Dry rolled corn
[4]Dried distiller's grains with solubles
[5]Supplement contained 0.50% (DM basis) urea and formulated to provide 21.1 g/ton of monensin (Rumensin, Elanco Animal Health; DM basis)
[6]Neutral detergent fiber
[7]Acid detergent fiber

Table 2. Growth and intake of steers consuming forage-based diets at differing levels of wheat straw and exogenous fibrolytic enzyme inclusion.

	5% Wheat Straw		15% Wheat Straw					
	0 g EFE[1]/MT[2]	750 g EFE/MT	0 g EFE/MT	750 g EFE/ MT		*P* - values		
Steers, *n*	18	18	18	19	SEM	[3]WS × EFE	WS	EFE
Initial BW[4], lb.	628	633	628	628	5.6	0.62	0.77	0.62
Final BW, lb.	908	908	858	866	10.9	0.63	<0.001	0.97
ADG[5], lb.	3.34	3.26	2.72	2.84	0.09	0.31	<0.001	0.82
DMI[6], lb/d	19.75	19.60	17.97	18.28	0.37	0.54	<0.001	0.84
F:G[7]	5.91	6.01	6.61	6.44		0.45	<0.001	0.87

[1]Exogenous fibrolytic enzymes
[2]Metric ton
[3]Wheat straw
[4]Body weight
[5]Average daily gain
[6]Dry matter intake
[7]Feed to gain ratio

Table 3. Plasma metabolites of steers consuming forage-based diets at differing levels of wheat straw and exogenous fibrolytic enzyme inclusion.

	5% Wheat Straw		15% Wheat Straw			P- values		
	0 g EFE[1]/MT[2]	750 g EFE/MT	0 g EFE/MT	750 g EFE/MT				
Steers, *n*	18	18	18	19	SEM	WS[3] × EFE	WS	EFE
PUN[4], mmol/ L	9.17	8.95	9.08	8.62	0.24	0.60	0.36	0.15
NEFA[5], μmol/ L	316	305	404	347	17.4	0.18	<0.001	0.05
GLC[6], mmol/ L	4.85	4.93	4.72	4.91	0.06	0.35	0.24	0.04

[1]Exogenous fibrolytic enzymes
[2]Metric ton
[3]Wheat straw
[4]Plasma urea nitrogen
[5]Plasma non-esterified fatty acids
[6]Plasma glucose

Acknowledgements

The authors thank Danisco Animal Nutrition and Health for their financial support and for donating the Bovizyme™ CX; Merck Animal Health for donating the Revalor® -IS; and the staff and students at the NDSU Beef Cattle Research Complex, NDSU Beef Unit, NDSU Central Grasslands Research Extension Center and the NDSU Animal Nutrition Laboratory.

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