Economic Evaluation of Cellulosic Enzymes in Beef Cattle Feeding

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ECONOMIC EVALUATION OF CELLULOSIC ENZYMES

IN BEEF CATTLE FEEDING

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Abstract

The economics of enzyme addition to beef cattle diets was evaluated for past feed and cattle prices (1979 to 1996). Only intermediate levels of enzyme addition (2.5 to 3.5 litres per tonne dry matter of feed) were economical, at only the lowest potential enzyme cost ($ 2 per litre).

Keywords: enzymes, beef, feeding, feedlot, backgrounding

Recent animal science and biotechnology research has renewed interest in using cellulosic enzymes in ruminant diets. Although it was thought that exogenous enzymes could not survive proteolysis in the rumen (Beauchemin, 1995), improvements in fermentation technology and biotechnological development of more improved enzyme preparations (McAllister, 1995) have resulted in isolated but significant improvements in animal performance (Beauchemin, 1995). Several feed companies have recently developed commercial enzyme formulations for direct application to ruminant total mixed rations (TMR=s) at the point of feeding. This paper examines data from cattle feeding trials conducted in Alberta, British Columbia and Washington on the efficacy of recent formulations (Cheng et al, Johnson et al). Preliminary results touted improvements as much as 30 percent increase in liveweight rate of gain for steers on 70 percent silage diets (Cheng et al). This paper examines the economics of enzyme application over a range of beef feeding experiments in Alberta, British Columbia and Washington for feed, feeder and finished cattle prices that have occurred over the last cattle price cycle (1979-1996).

Feeding Trial Data

Details of the feeding experiments are given in Cheng et al and Johnson et al.

The Alberta experiment was conducted at the Agriculture and Agri-Food Canada

Lethbridge Research Centre and consisted of backgrounding 98 Simmental x Charolais steers in individual pens for 121 days. Steers were ranked by weight and randomly assigned to one of four treatment groups, for which the diet (82.5 % barley silage: 12.5 % rolled barley grain as fed) was treated with either: the control (water at 10 L tonne DM^{-1}) or one of three amounts (low, medium and high rate of application) of a 2:1 mixture of enzyme solutions AA@ (cellulase) and AB@ (xylanase) in 10 L total volume tonne DM^{-1}. The enzyme treatment rates were: low: 1.25 L enzyme tonne DM^{-1} ; medium: 3.5 L enzyme tonne DM^{-1}; and high: 5.0 L enzyme tonne DM^{-1}**.** Cattle were weighed at 2 week intervals and feed intake estimated weekly on a pen basis.

The British Columbia experiment was conducted at the Agriculture and Agri-Food Canada Kamloops Research Centre and involved random allocation of 16 heifers and 16 steers (Hereford x Angus) to two treatment groups (8 steers or 8 heifers per pen). A 70% barley-ryegrass silage: 30% steam rolled barley diet was treated with either the control of water (10 L tonne DM^{-1}), or with a medium level of enzyme, i.e., a 2:1 mixture of cellulase AA@ and xylanase AB@ (3.5 L tonne DM^{-1}) in 10 L total volume tonne DM^{-1}**.** Cattle were finished for 51 days. Body weights were recorded every 14 days and feed intake determined weekly. Back fat thickness, rib eye area, marbling score and cutability, and grade score were determined for all carcasses.

The Washington experiment was conducted by the Department of Animal Science at Washington State University in Pullman, Washington and involved finishing of 30 crossbred steers and 30 crossbred heifers for 84 days. Steers or heifers were allocated to pens with one pen per sex per treatment. The treatments included: 1) untreated control, 2) a medium level of enzyme, i.e., 2 parts enzyme A: 1 part enzyme B; 2.76 L per tonne forage DM at 11 L per tonne of forage dilution, 3) a high level of enzyme, i.e., 2 parts enzyme A: 1 part enzyme B; 5.51 L per tonne forage DM at 11 L per tonne of forage dilution, 4) a medium level of enzyme, i.e., 1 part enzyme A: 2 parts enzyme B; 2.76 L per tonne forage DM at 11 L per tonne of forage dilution, and 5) a high level of enzyme, i.e., 1 part enzyme A: 2 parts enzyme B; 5.51 L per tonne forage DM at 11 L per tonne of forage dilution. The diet consisted of alfalfa haylage (85% of the DM) and rolled barley (85% of the DM). Feed intake was monitored daily and cattle were weighed bi-weekly.

Economic Risk Analyses

An economic risk analyses of each of the feeding experiments was conducted based on feed, feeder and finished cattle prices existing during the period of 1979 to 1996, which represents the duration of the most recent cattle cycle. Rsk simulations were constructed for a March beginning feeding period date (the ending feeding dates were dependent on the particular experiment and animal) and involved repeated budgeting of the net returns per head per treatment for different price value sets sampled the from relevant theoretical input price and cost distributions developed from the 1979 to 1996 period. The developed theoretical input price and cost distributions are detailed in Table 1 and were determined using statistical software[1] to find the best-fitting theoretical probability distribution for each of the historical price or cost data series. The risk simulations employed a Monte Carlo sampling procedure (Palisade Corporation) to sample the developed input price and cost variable theoretical probability distributions to obtain a set of sample values used for each budget determination. The simulation then involved repeated budget determinations for each set of derived sample values. Net return per head results of the repeated budgets were used to generate predicted net return per head output probability distributions for each of the treatments in each experiment.

The risk simulations used March as the basis for budgeting the beginning of feeding for each of the experiments to enable the capture in the results of the downtown in cattle prices which began in late 1995 and early 1996 and mark the end of the 1979 to 1996 cattle cycle. Enzyme cost was held constant at $2 per litre, which is the low end of the

[1] The BestFit™ software automatically runs a thorough analysis to find which of up to 25 theoretical continuous probability distributions (e.g. normal, lognormal, logistic, beta, etc.) best fit the data. The software is available from Palisade Corporation, 31 Decker Road, Newfield, NY 14867.

range of current projected enzyme costs ($2 to $4).

Table 1 Historical (1979-1996) Price and Cost Variables and associated

Best-Fitting Theoretical Probability Distributions and Parameters

Variable	Range		$\bar{X}$	Relevant Experiment Budgets	Theoretical Probability Distribution	Relevant Parameter				
	Low	High				:	F	min	most likely	max
March Barley Price $/tonne	54.00	174.93	110.37	Kamloops Lethbridge Washington	Triangular			17.72	96.46	222.00
March Feeder Price $/cwt	68.43	109.70	87.14	Kamloops Lethbridge Washington	Triangular			68.2	77.65	115.00
July Feeder Price $/cwt	70.00	106.18	86.22	Lethbridge	Normal	86.22	10.48			
April Slaughter Price $/cwt	70.87	96.85	82.50	Kamloops	Normal	82.50	6.59			
May Slaughter Price $/cwt	71.99	96.08	81.88	Washington	Normal	81.88	5.65			
Interest Rate %	6.00	11.42	17.75	Kamloops Lethbridge Washington	Triangular	3.77	11.00	20.0		

Source: Canfax Trends Data 1979-1996.

Results

Kamloops Finishing Experiment

With enzyme cost held constant at $2 per litre, overall mean difference between the enzyme treated cattle and control cattle was simulated to be $15 per head for the historical period 1979 to 1996, and ranged from $10 to $19 (table 2). For heifers, the differences averaged $30 per head and ranged from $0.30 to $60. For steers, the differences averaged $0.31 per head and ranged from -$27 to +$27 (table 2). Probability of a positive mean difference from an enzyme treatment versus a no enzyme control treatment was 0.512 for steers and 1.0 for heifers and for steers and heifers combined.

Table 2 Kamloops Feedlot Trial - Simulated net margins and net margin differences ($ per head) for historical period 1979-1996

	Steers			Heifers			Overall Result		
	Control	Enzyme	Diff	Control	Enzyme	Diff	Control	Enzyme	Diff
Prob Net Margin Diff > 0	0.316	0.303	0.51	0.322	0.417	1.00	0.319	0.362	1.00
Mean	-63.64	-63.33	0.31	-57.63	-27.98	29.65	-60.63	-45.65	14.98
Minimum	-445	-420	-27	-418	-417	0.29	-431	-419	10.3
Maximum	352	326	27	335	395	60.4	344	361	19.4
Standard Deviation	133	123	9.9	125	134	9.3	129	129	1.8
Skewness	-0.11	-0.11	0.09	-0.10	-0.10	-0.02	-0.11	-0.10	-0.11

Lethbridge Backgrounding Experiment

With the enzyme cost constant at $ 2 per litre, simulated mean difference in net returns per head, for the period 1979 to 1996, was highest for the medium level 3.5 litre enzyme treatment minus the control treatment at $2.34 (table 3). High end of the range of possible net return differences was $7.59 per head determined for the 5.0 litre enzyme treatment, while the low end of the range of possible net return differences was -$19.10 per head determined for the 1.25 per litre enzyme treatment (table 3). The 3.5 litre enzyme treatment minus the control treatment had the lowest standard deviation net margin difference of $1.34 per head (table 3). The 3.5 per litre enzyme treatment also had the highest probability (0.96) of generating a positive net mean difference above the no enzyme control (table 3).

Table 3 Lethbridge Backgrounding Trial - Simulated net margins and net margin differences ($ per head) for the historical period 1979-1996.

	Control	1.25 L	3.5 L	5.0 L	1.25 L - Control	3.5 L - Control	5.0 L - Control
Prob Net MarginDiff > 0	0.848	0.841	0.854	0.847	0.030	0.960	0.624
Prob Net MarginDiff > 1.0					0.017	0.841	0.476
Prob Net MarginDiff > 2.5					0.007	0.453	0.266
Prob Net MarginDiff > 5.0					0.001	0.024	0.058
Mean	128.73	120.71	131.07	129.58	-8.02	2.34	0.84
Minimum	-250.05	-245.13	-245.77	-253.38	-19.10	-0.37	-8.23
Maximum	454.86	435.76	456.14	462.45	4.92	6.12	7.59
Standard Deviation	125.17	120.91	124.30	126.73	4.26	1.34	2.65
Skewness	-0.13	-0.13	-0.13	-0.13	0.13	0.42	-0.05

Washington Finishing Experiment

Table 4 displays the simulated mean differences (enzyme treatments minus control) in net returns per head for the historical period 1979-1996, assuming a constant enzyme cost of $2 per litre.

Table 4 Washington Feedlot Trial - Simulated net margin differences (enzyme treatment minus control) ($ per head) for historical period 1979-1996 assuming a constant enzyme cost of $2 per litre.

	2A:1B-2.76L	2A:1B-5.51L	1A:2B- 2.76 L	1A:2B-5.51L
Prob Net MarginDiff > 0	0.977	0.007	0.915	0.038
Prob Net MarginDiff > 5	0.838	0.001	0.631	0.003
Mean	9.8	- 15.7	6.6	- 9.3
Minimum	- 7.2	- 30.4	- 10.1	-26.9
Maximum	22.4	1.6	18.7	3.7
Standard Deviation	4.9	6.3	4.8	5.2
Skewness	-0.19	0.22	-0.22	-0.25

Overall (steers and heifers) mean difference in net margin between the no enzyme control treatment and enzyme treatment 2A:1B (at the 2.76 litre per tonne DM application rate) for the period 1979-1996 was simulated to be approximately $10, ranging from a low of -$7 to a high of $22. All of the treatments exhibited positive maximum net difference values, meaning that at some combinations of historical prices and costs that all the treatments improved net income. However, the probability of a positive return using an enzyme treatment over the control is only greater than 0.90 for the enzyme treatments at the 2.76 litre per tonne application rates.

Comparison of the Economic Results from the Feeding Trials

A comparison of the economic results from the feeding trials is given in table 5.

Table 5 Comparison of Mean Net Margin Differences (Control - Treatment) ($ per head) and probabilities of net margin differences being above some target value for the lowest enzyme cost of $ 2 per litre.

Feeding Trial	Enzyme Treatment Levels (L / tonne DM) Dosage Category	2AB 1.25 Low	2AB 2.76 Med	A2B 2.76 Med	2AB 3.5 Med	2AB > 5.0 High
Lethbridge	Mean Net MarginDiff	- $8			$2.3	0.84
	Prob NM diff > $ 0	0.03			0.96	0.62
	Prob NM diff > $1.00	0.02			0.84	0.48
	Prob NM diff > $2.50	0.01			0.45	0.27
	Prob NM diff > $5.00	0.00			0.02	0.06
Kamloops	Mean Net MarginDiff				$15	
	Prob NM diff > $0				1.0	
Washington	Mean Net MarginDiff		$9.8	$6.6		-$27
	Prob NM diff > $0		0.98	0.92		0.04
	Prob NM diff > $5		0.84	0.63		0.00

Conclusions

This study was undertaken to determine the economics of enzyme application to beef cattle diets in terms of prices and costs that exist historically through one cattle cycle. The feeding trials that provided the production information involved various levels of enzyme application to the feed, different animal growth stages (backgrounding versus finishing) and different forages. Budgeting of net returns was on an individual animal basis for the Lethbridge experiment and on a pen basis for the Kamloops and Washington experiments. A more detailed discussion of the results is given in Freeze et al (1996).

Generally, the highest levels of enzyme application (>5.0 litres per tonne DM) were not economical at historical prices due to lower production responses and higher enzyme costs per head. Medium levels of enzyme application (2.76 to 3.5 litres per tonne DM) were economical at the lowest level of potential enzyme cost ($2 per litre), with Kamloops and Washington data showing long run mean returns of approximately $10 to $15 per head. Lethbridge data showed more modest long run mean returns of about $2 per head, with an almost zero probability of a mean net return greater than $5 (table 5). The lowest level of enzyme application (1.25 litres per tonne DM) was not economical due to production responses less than that of the no enzyme control.

Further research is needed to clarify questions that remain. The economic impact of the enzyme treatment on carcass quality (grade discounts) in the Kamloops data was consistent over steers and heifers and points out the need to evaluate carcass effects in enzyme feeding trial experiments. Inconsistent effects re: steers versus heifers suggest more research should be done to look at enzyme-sex interactions.

Lastly, production and economic mean responses were not significant in the Lethbridge experiment, the only experiment where the experimental unit was the individual animal. Although insignificant production responses do not necessarily translate into economic insignificance they did here. The replication involved should give more confidence in the Lethbridge results over those obtained in Kamloops or Washington, and indicates the need for more individual feeding experiments to sort out the output effects of enzyme treatment of feed. However, at a $2 enzyme cost, the medium level of enzyme treatment (3.5 L per tonne DM) in the Lethbridge trial essentially recovered costs (break-even) at combinations of prices and costs that exist through one cattle cycle. This is assuming that application of the enzyme does not involve significant other costs. This would be the case if the enzyme could applied to the grain in the tempering process (water added to grain before feeding) or in the mixing wagon before delivery of the feed to the feed bunk.

The potential market for the cellulosic enzymes in North America is large. Production costs are expected to fall as the requisite genes for cellulosic enzyme synthesis are transferred to plant systems (e.g. Canola) to enable mass production of enzyme, and as genetic engineering boosts activity level of the enzymes. Even at today's costs enzymes represent the foremost new technology available since inophores (essentially medicated feed additives) for the increasing feeding efficiency in beef cattle.

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