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Effects of Sel-Plex on rumen fermentation and purine derivatives of urine in Simmental steers

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ABSTRACT

This study aimed to evaluate the effects of Sel-Plex on rumen fermentation and microbial protein synthesis in the rumen of steers. Eight ruminally cannulated Simmental steers were used in a replicated 4 × 4 Latin square experiment. Treatments were: control (without Sel-Plex), Se-low, Se-medium and Se-high with 7.5, 15 and 22.5 mg Sel-Plex per steer per day, respectively. Ruminal pH, total VFA, acetate and butyrate concentration were not affected by the treatment. The ratio of acetate to propionate was linearly reduced with increasing Sel-Plex dose, due to increased propionate production. Ruminal microbial protein synthesis was linearly and quadratically increased with increasing Sel-Plex dose. The results indicate that Sel-Plex potentially improves rumen fermentation. The optimum dose was 15 mg/d under the present experimental conditions.

KEY WORDS: organic selenium, rumen , microbial protein synthesis, beef cattle

INTRODUCTION

Schwarz and Foltz (1957) proved that selenium is an ingredient of Factor 3 which can prevent liver necrosis in mice. Subsequently, the effects of selenium on animals were extensively studied by nutritionists, showing that it is an essential element. It is a component of GSH-px, a free-radical scavenger that protects the cell membrane from oxidative damage. Most studies have investigated the effect of inorganic selenium on rumen fermentation and production performance (Gunter et al., 2003; Hemingway, 2003); few have addressed the effect of organic selenium on rumen fermentation and digestion. Therefore, the aim of this work

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was to study the effects of Sel-Plex on ruminal pH and fermentation as well as on ruminal microbial protein synthesis in beef cattle.

MATERIAL AND METHODS

Animals and expeirmental design

Eight ruminally cannulated Chinese Simmental steers at an average age of 2.5 years and 430±20 kg body weight, were assigned to a replicated 4×4 Latin square. Treatments were: control (without Sel-Plex), Se-low, Se-medium and Se-high with 7.5, 15 and 22.5 mg Sel-Plex per steer per day, respectively. Sel-Plex (Se, 1 g/kg) was supplied by Alltech, Inc. Steers were housed in individual pens (3×3 m) and fed twice daily at 07.00 and 19.00 h. Diets consisted of 60% maize straw and 40% concentrate (Table 1). Feed intake was determined before the experiment and in the experimental period was restricted to a maximum of 90% of *ad libitum* intake. Experimental periods were 21 days with 11 d of adaptation and 10 d of sampling.

Table 1. Ingredient and chemical composition of diet, g/kg dry matter

Ingredients		Chemicalcomposition	
Maize straw	600	NE_{mf}[2],MJ/kgDM	63.0
Maize grain, ground	208	Crudeprotein	101.1
Wheat bran	40	NDF	565.1
Soyabean meal	66	ADF	355.9
Cottonseed cake	48	Ca	15.6
Rapeseed meal	20	P	8.2
Calcium carbonate	5		
Salt	4		
Dicalcium phosphate	3.5		
Mineral and vitamin mix[1]	5.5		

[1] contained, ppm: Co 42, Cu 3500, Fe 20,000, Mn 12,000, Zn 12,000, I 1200, Se 600, IU/g: vit. A 3000, vit. D 500, vit. E 15

[2] NE_{mf} was estimated using the Chinese Beef Nutrition Requirement (Feng, 2000)

Sample collections and determination

Rumen fluid was collected at 0, 3, 6, and 9 h after the 7 a.m. feeding during d 19 and 20 of the experimental period. pH was immediately measured potentiometrically. VFA were separated and quantified by gas chromatography (GC102AF, Shanghai Specialties Ltd., China) using a 2-m (φ 4-mm) fused PEG2000, Chromsob W AW DMCS column (Goetsch and Galyean, 1983). Ammonia was determined using the method described by Yang (1996). Ruminal degradation kinetics of the maize straw

(DM and NDF) were measured using the nylon bag technique on d 12 to 14 of the experimental period (Ørskov and McDonald, 1970; McDonald, 1981). NDF were determined using the methods described by Van Soest et al. (1991), DM according to AOAC (1984). Urine was collected and recorded from d 11 to 21 of the experiment and the pH brought to below 3 by adding 10% H_2SO_4. At the end of the collection, 20 ml of urine samples were diluted to 100 ml with distilled water and then divided into 2 subsamples. Allantoin and uric acid in urine were determined using a UV-2100 spectrophotometer and IEEA procedures (1997). Ruminal microbial N synthesis was calculated according to Chen and Gomes (1992).

Statistical analysis

The data were analysed using the mixed model procedure (Proc Mixed; SAS, 1996) to account for the effects of square, period within square, animal within square and treatment. Linear and quadratic orthogonal contrasts were tested using the CONTRAST statement of SAS.

RESULTS

Ruminal pH and total VFA concentrations did not differ between the control and Sel-Plex treatments and did not increase with increasing Sel-Plex supplementation (Table 2). On the other hand, propionate (as % of total VFA) increased linearly. Consequently, the ratio of acetate to propionate was reduced linearly ($P<0.01$). The ammonia N content was reduced either linearly or quadratically ($P<0.01$) with increasing Sel-Plex supplementation.

Table 2. Effects of Sel-Plex supplementation on ruminal pH and fermentation

Item	Treatments				SE	Contrast, P <	
	control	Se-low	Se-med	Se-high		linear	quadratic
pH	6.72	6.66	6.59	6.60	0.03	ns	ns
Total VFA, mM	70.43	74.37	75.12	73.98	0.97	ns	ns
Mol/100 mol							
acetate, A	69.76	68.07	67.29	67.55	0.76	ns	ns
propionate, P	22.82[b]	24.49[a]	25.07[a]	24.76[a]	0.33	0.01	ns
butyrate	7.43	7.45	7.63	7.69	0.12	ns	ns
A:P	3.05[a]	2.78[b]	2.68[b]	2.73[b]	0.11	0.01	ns
Ammonia N, mg/100 ml	9.68[a]	8.43[b]	8.11[c]	8.57[b]	0.17	0.01	0.01

[a,b,c] means in the same row with a different superscript are significantly different at $P<0.05$

Ruminal soluble, potential degradable fractions and ED of DM were linearly increased, but the degradation rate decreased linearly with increasing Se

supplementation (Table 3). A quadratic response of ruminal digestion kinetics to the dose of Se supplementation was also detected. However, only a linear response of the soluble fraction, and quadratic response of ED to the dose of Se supplementation were detected in the maize straw NDF digestion kinetics.

Table 3. *In situ* ruminal digestion kinetics and effective degradability (ED) of maize straw

Item	Treatments				SE	Contrast, P <	
	control	Se-low	Se-med	Se-high		linear	quadratic
DM							
a	0.116^{c}	0.200^{b}	0.280^{a}	0.126^{c}	0.015	0.01	0.01
b	0.691^{b}	0.712^{b}	0.719^{b}	0.871^{a}	0.021	0.01	0.05
c	0.018^{a}	0.013^{b}	0.009^{b}	0.008^{b}	0.001	0.01	0.05
ED	0.403^{c}	0.450^{ab}	0.464^{a}	0.438^{b}	0.006	0.01	0.01
NDF							
a	0.031	0.036	0.061	0.059	0.006	0.04	ns
b	0.894	0.874	0.861	0.933	0.025	ns	ns
c	0.011	0.011	0.011	0.007	0.003	ns	ns
ED	0.293^{c}	0.330^{b}	0.380^{a}	0.329^{b}	0.009	0.01	0.01

^{a,b,c} means in the same row with a different superscript are significantly different at P<0.05

Daily urinary excretion of uric acid was not affected by the treatment, but urinary excretion of allantoin as well as total PD was quadratically affected (P<0.01) by Se supplementation (Table 4). Consequently, the estimated intestinal flow of microbial N (g/d) was quadratically increased (P<0.01) with increasing Se supplementation.

Table 4. Effects of Sel-Plex on purine derivatives excreted in urine

Item	Treatments				SE	Contrast, P <	
	control	Se-low	Se-med	Se-high		linear	quadratic
Allantoin, mmol/day	83.30^{d}	157.07^{b}	173.76^{a}	139.86^{c}	2.40	0.01	0.01
Uric acid, mmol/day	7.45	8.31	8.84	8.56	0.37	ns	ns
Total PD, mmol/day	90.75^{d}	165.38^{b}	182.60^{a}	148.42^{c}	3.41	0.01	0.01
Absorption, mmol/day	48.73^{d}	123.36^{b}	140.58^{a}	106.40^{c}	2.63	0.01	0.01
Microbial N, g/day	47.07^{d}	110.90^{b}	125.64^{a}	96.40^{c}	2.25	0.01	0.01

^{a,b,c,d} means in the same row with a different superscript are significantly different at P<0.05

DISCUSSION

Supplementation of the steer diet with Sel-Plex altered the rumen fermentation pattern from acetate to propionate as shown by an apparent reduction in the ratio

of acetate to propionate with increasing Se doses. Ruminal pH (range from 6.60 to 6.72) in the present study was in the optimum range for cellulolytic bacteria activity (Russell and Wilson, 1996). Rumen VFA concentration reflects the equilibrium between absorption and production of VFA rather than a direct relation with rumen digestion. In *in vitro* experiments, acetate and butyrate concentrations decreased significantly by supplementation with 0.2 mg Se (Na_2SeO_3) per kg DM, propionate increased significantly, the ratio of acetate and propionate decreased significantly, total VFA showed no significant difference (Wang and Dong, 1996; Lu et al., 1999). Total VFA, acetate and propionate and the ratio of acetate and propionate decreased slightly and the digestibility of NDF was not significantly affected by supplementation with 0.2 mg Se (Na_2SeO_3 and Na_2SeO_4) per kg DM in sheep (Serra et al., 1994). Proteolytic activity of bacteria increased due to Sel-Plex supplemention at 15 mg per day, and consequently NDF degradability of maize straw, CP degradability of soyabean meal and propionate increased.

It is possible that reduction of ammonia N concentration was due to increased consumption of ammonia N by enhanced growth of ruminal microbial populations, especially the fibre-degrading populations, with Se supplementation or increased ammonia absorption from the rumen. Cellulolytic bacteria derive their N exclusively from ammonia (Russell et al., 1992). Ab sorbed purines are almost completely converted into uric acid during passage across the intestinal mucosa before reaching the liver. Uric acid can then be converted into allantoin. Allantoin and uric acid are referred to as 'purine derivatives' (PD) (Chen et al., 1996). Allantoin, total PD and increased intestinal flow of microbial N indicated that Sel-Plex promoted the utilization of ruminal ammonia N by rumen bacteria, and microbial protein synthesis.

CONCLUSIONS

Supplemntation of Sel-Plex in the diet of steers altered the rumen fermentation pattern to more propionate production and microbial production in the rumen. The optimum dose of Sel-Plex in the present experimental conditions was 15 mg/d.

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