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Effects of various supplemental starch and protein levels on ruminal fermentation and liquid passage of beef steers fed tallgrass-prairie hay

Abstract
The effect of supplements containing various proportions of degradable intake protein (DIP) and starch on ruminal digestion characteristics of forage-fed beef steers was evaluated. Fluid passage rates, ruminal ammonia (N H), 3 and total volatile fatty acid (VFA) concentrations increased as the amount of supplemental DIP increased. Starch infused at .3% of BW increased molar proportion s of propionate and butyrate and decreased acetate, compared to feeding DIP alone. However, proportions of branched-chain VFA increased with DIP at all levels of starch infusion. Total digestible organic matter intake (TDOMI) was increased with each addition of DIP; however, infusing starch within a DIP level decreased TDOMI. Providing supplemental DIP is more important for improving the use of low-quality, tallgrass-prairie hay than is ruminally available starch.

Keywords
Cattlemen's Day, 1997; Kansas Agricultural Experiment Station contribution; no. 97-309-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 783; Beef; Beef steers; Protein; Starch; Supplements; Ruminal fermentation

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EFFECTS OF VARIOUS SUPPLEMENTAL STARCH AND PROTEIN LEVELS ON RUMINAL FERMENTATION AND LIQUID PASSAGE OF BEEF STEERS FED TALLGRASS-PRAIRIE HAY

K. C. Olson, R. C. Cochran, T. J. Jones, E. S. Vanzant[1], and E. C. Titgemeyer

Summary

The effect of supplements containing various proportions of degradable intake protein (DIP) and starch on ruminal digestion characteristics of forage-fed beef steers was evaluated. Fluid passage rates, ruminal ammonia (NH_3), and total volatile fatty acid (VFA) concentrations increased as the amount of supplemental DIP increased. Starch infused at .3% of BW increased molar proportions of propionate and butyrate and decreased acetate, compared to feeding DIP alone. However, proportions of branched-chain VFA increased with DIP at all levels of starch infusion. Total digestible organic matter intake (TDOMI) was increased with each addition of DIP; however, infusing starch within a DIP level decreased TDOMI. Providing supplemental DIP is more important for improving the use of low-quality, tallgrass-prairie hay than is ruminally available starch.

(Key Words: Beef Steers, Protein, Starch, Supplements, Ruminal Fermentation.)

Introduction

Intake and digestion of low-protein forages by beef cattle are known to increase when supplemental degradable intake protein (DIP) is fed. Precise feeding recommendations for DIP need to be established, because protein-based feedstuffs are expensive. Furthermore, it is unclear how other supplement components, like starch, affect animal response to DIP supplementation. Studies investigating the effect of supplements containing various proportions of DIP and starch on ruminal digestion characteristics are needed to define desirable supplement compositions. This study was designed to examine the interactive effects of supplemental DIP and starch on ruminal fermentation and liquid passage rate of steers consuming low-quality hay.

Experimental Procedures

Thirteen beef steers (average initial body weight = 570 lb) were used in a 13-treatment, four-period, Latin square. Treatments were arranged as a 3 x 4 factorial plus an unsupplemented control and consisted of four DIP levels (casein infused at .03, .06, .09, and .12% of BW) superimposed on three starch levels (none or corn starch grits infused at .15 and .3% of BW). All steers had ad libitum access to tallgrass-prairie hay (5% CP). Forage refusals were measured, and new forage was offered once daily. Supplements were infused intraruminally immediately before forage was fed. Following an adequate adaptation period, digestibility was determined via total fecal collection. Subsequently, ruminal VFA, NH_3, and fluid passage rates were evaluated by collecting multiple samples of ruminal fluid throughout a given day.

Results and Discussion

Production responses by beef cattle are driven, to a large degree, by the total amount of digestible organic matter (digestible forage organic matter + digestible supplement organic matter; TDOMI) that is consumed. Supplementation programs that increase TDOMI can be said to augment total energy supply to the animal. Steers receiving no supplement in our study had lower TDOMI than supplemented

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steers (Table 1). In general, TDOMI was increased when DIP was provided but was decreased when starch was added within a given level of DIP supplementation. We interpret this result to mean that DIP is more critical to achieving optimal use of low-protein forages than is ruminally degradable starch.

Effects of starch and DIP supplements on ruminal fermentation and rate of fluid passage were consistent with changes in TDOMI. Average levels of ruminal NH_3 were low for all treatments (range = trace to 1.5 mM), likely because of the low protein level in the basal forage and efficient use by ruminal microbes. Ruminal NH_3 increased as supplemental DIP increased, regardless of starch level. Steers receiving only DIP had greater ruminal NH_3 than steers receiving starch at .15 or .3% of BW, probably because of the greater capability of starch-digesting bacteria to compete for NH_3 compared with fiber-digesting bacteria.

Total volatile fatty acid (VFA) concentrations are correlated with ruminal diet digestibility. Unsupplemented steers had lower total VFA than supplemented steers. Total VFA concentration increased with supplemental DIP but was not affected by starch infusion.

Proportions of individual ruminal VFA are useful indicators of the type of fermentation predominating. Supplemented steers had greater proportions of isobutyrate, valerate, and isovalerate than unsupplemented steers, which likely was due to the provision of precursors for these VFA in the supplemental DIP. Steers receiving only DIP had higher acetate and lower propionate and butyrate than steers fed DIP plus starch at .3% BW. Greater proportions of acetate in steers given only DIP indicated increased fermentation of structural carbohydrates from the forage. Conversely, increased propionate and butyrate in steers fed the highest level of starch suggested that ruminal microbes were less reliant on forage fiber as an energy source.

Frequently, increased rate of nutrient passage from the rumen is associated with higher feed intake. Ruminal liquid passage rate in our study became more rapid as the amount of supplemental DIP increased but was not altered by starch supplementation.

This study supports the contention that DIP is the primary factor limiting the effective use of low-quality, tallgrass-prairie forage by beef cattle. In general, total VFA concentration, rate of ruminal liquid passage, and TDOMI were greatest when DIP fell between 10 and 12.5 % of TDOMI. Infusion of ruminally degradable starch altered patterns in VFA and NH_3 concentration and decreased TDOMI.

Table 1. Effect of Supplemental Degradable Intake Protein and Starch Levels on Total Digestible Organic Matter Intake, Ruminal Fermentation, and Liquid Passage Rate

Starch Level (% BW)	Protein Level (% BW)	TDOMI (% BW)	DIP Intake (% of TDOMI)	NH_3 (mM)	Passage Rate (%/h)	Total VFA (mM)	Acetate (%)	Propionate (%)	Butyrate (%)	Isobutyrate (%)	Valerate (%)	Isovalerate (%)
0	0	.9	4.9	0	5.7	55.0	77.1	14.4	7.1	.5	.4	.5
0	.03	1.1	7.4	.3	7.7	70.4	79.2	12.0	7.1	.6	.5	.6
0	.06	1.3	9.0	.4	9.3	65.9	78.3	12.4	7.1	.7	.7	.8
0	.09	1.4	10.3	.6	7.6	74.5	74.1	16.5	6.8	.8	.9	.9
0	.12	1.6	11.2	1.5	10.6	75.2	78.0	11.6	7.2	1.0	1.0	1.2
.15	.03	1.0	7.2	.1	7.7	69.7	77.1	13.6	7.4	.7	.5	.7
.15	.06	1.2	9.0	.3	7.4	71.8	76.4	14.1	7.2	.7	.8	.8
.15	.09	1.5	9.4	.6	9.7	77.6	76.3	13.7	7.3	.8	.9	.9
.15	.12	1.4	12.6	1.1	10.2	77.9	76.0	12.5	8.1	1.0	1.1	1.3
.30	.03	1.0	7.7	.1	7.4	65.2	70.6	19.7	7.4	.7	.8	.8
.30	.06	1.1	9.4	.2	8.3	69.1	75.0	14.5	8.0	.7	.7	1.1
.30	.09	1.3	10.3	.5	7.5	68.4	71.5	17.0	8.5	.8	1.1	1.0
.30	.12	1.4	11.8	.9	9.6	76.2	72.6	15.8	8.2	.9	1.2	1.2
	SE	.1	.4	.1	1.4	5.4	1.9	1.8	.4	.1	.1	.1
Contrast[1,2,3]												
1	-	.001	.001	.001	.027	.002	.338	.976	.228	.001	.002	.001
2	L	.001	.001	.001	.015	.006	.543	.802	.933	.001	.001	.001
	Q	.285	.013	.024	.754	.344	.959	.816	.711	.544	.913	.413
3	L	.001	.001	.001	.006	.001	.552	.460	.096	.001	.001	.001
	Q	.095	.678	.096	.929	.156	.979	.780	.321	.387	.989	.481
4	L	.001	.001	.001	.040	.005	.130	.973	.003	.001	.001	.001
	Q	.615	.023	.294	.859	.623	.272	.395	.350	.881	.672	.159
5	-	.032	.808	.046	.955	.406	.421	.728	.082	.440	.510	.514
6	-	.001	.264	.008	.485	.612	.001	.003	.001	.948	.066	.097

[1]Probability of a greater F-test
[2]L = linear effect, Q = quadratic effect
[3]1 = No supplement vs. supplement, 2 = DIP only, 3 = DIP + .15% BW starch, 4 = DIP + .3% BW starch, 5 = DIP only vs. DIP + .15% BW starch, 6 = DIP only vs. DIP + .3% BW starch