# IMPROVING THE UTILIZATION OF SOYBEAN HULLS BY CATTLE WITH DIGESTIVE ENZYME AND DIETARY BUFFER SUPPLEMENTATION

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## Summary

Four ruminally cannulated Holstein steers (749 lb) were used in a 4 × 4 Latin square experiment to evaluate the benefits of supplementing digestive enzymes and dietary buffers to a soybean hull-based diet fed to steers once daily at 15.4 lb/day (as fed basis). Treatments were arranged as a 2 × 2 factorial with factors being two levels (0 and 3 grams/day) of digestive enzymes and two levels (0 and 93 grams/day) of dietary buffers. Buffers and enzymes were thoroughly mixed with the soybean hull-based diet to provide a completely mixed ration. Digestive enzyme or buffer supplementation increased ($P \leq 0.06$) diet digestibilities of dry matter, organic matter, neutral detergent fiber, and acid detergent fiber. Addition of buffer also increased ($P \leq 0.06$) digestibilities of glucose, mannose, arabinose, xylose and galactose, whereas enzyme supplementation increased ($P=0.03$) xylose digestibilities and tended to increase ($P=0.10$) arabinose digestibilities. The addition of enzymes and buffer to the soybean hull-based diet did not alter passage of liquid or solids from the rumen and therefore cannot account for any of the responses in digestion. Also, ruminal pH was not altered when steers were supplemented with digestive enzyme and(or) buffer. The lack of response in pH to buffer was surprising, because the observed effect of buffer on fiber digestibilities would have been expected to be a result of a moderation of the ruminal pH. Results from this experiment demonstrated that both digestive enzyme and buffer supplementation improved the digestibility of soybean hull-based diet, and responses were greatest when both additives were supplemented together.

## Introduction

Soybean hulls contain large amounts of potentially digestible fiber for cattle. However, their digestion may be less than expected when fed as a primary ingredient in forage-free diets. Research at Kansas State University has demonstrated that addition of alfalfa to soybean hull-based diets may improve digestibilities. However, these improvements were not due to a slower passage of soybean hulls through the gastrointestinal tract. Therefore, we hypothesized that the addition of roughage to soybean hull-based diets may have stimulated rumination and maintained a more favorable pH within the rumen for activity of microbes and digestive enzymes. This study evaluated the benefits of supplementing digestive enzymes and dietary buffers to diets containing soybean hulls as the primary ingredient.

## Experimental Procedures

Four ruminally cannulated Holstein steers (749 lb initial body weight) were housed in individual tie-stalls and had free access to fresh water. The soybean hull-based diet (Table 1) was fed once daily at 15.4 lb/day (as fed basis). Dietary intakes were approximately 1.8% of the average initial body weight. The experimental design was a 4 × 4 Latin square. Treatments were arranged as a 2 × 2 factorial with factors being two levels (0 and 3 grams/day) of digestive enzymes and two levels (0 and 93 grams/day) of dietary buffers. The multi-enzyme complex (SAFIZYM FP; Lesaffre Development) was from the fungus *Trichoderma reseei* and included the enzyme activities, xylanase, beta-glucanase, galactomannase, and mannase. The buffer consisted of 0.5% of the diet dry matter as magnesium oxide and 1% as sodium bicarbonate. Buffers and enzymes were thoroughly mixed with the soybean hull-based diet to provide a completely mixed ration. Periods were 14 days, which allowed 8 days for adaptation to treatments, 5 days (days 9-13) for fecal collections (fecal bags) to measure digestibilities and passage rates, and 1 day for collection of ruminal fluid to measure ruminal pH. Ruminal passage rates of liquids and solids were determined by feeding pulse doses of liquid (chromium EDTA) and solid (ytterbium chloride) digesta markers and by measuring their concentrations in fecal samples taken once daily. Ruminal pH was measured from samples of ruminal fluid taken at 0, 3, 6, and 12 hours after feeding.

## Results and Discussion

Diet digestibilities and ruminal passage rates are presented in Table 2. Feeding only digestive enzyme or buffer separately increased ($P \leq 0.06$) diet digestibilities of dry matter, organic matter, neutral detergent fiber, and acid detergent fiber. However, numerically these improvements were small. Addition of both digestive enzyme and buffer to the soybean hull-based diet tended to act synergistically (interaction; $P \leq 0.15$) and increased digestibilities of dry matter, organic matter, and neutral detergent fiber by 3.5%, and digestibilities of acid detergent fiber by 4.1% (Table 2). Acid detergent fiber is a measure of cellulose and lignin, whereas neutral detergent fiber also includes the hemicellulose fraction. Slightly greater improvements in the digestibilities of acid detergent fiber (4.1% increase) versus neutral detergent fiber (3.5% increase) suggest that the addition of the enzyme and buffer impacted the cellulose fraction of soybean hulls the most, although the digestibilities of individual sugars does not support this conclusion. Digestibilities of glucose, mannose, arabinose, xylose, and galactose increased ($P \leq 0.06$) in response to the addition of buffer to the soybean hull-based diet. Addition of the enzyme mixture increased ($P=0.03$) xylose digestibilities and tended to increase ($P=0.10$) arabinose digestibilities. However, numerically these improvements were small and reflect those for dry matter, organic matter, neutral detergent fiber, and acid detergent fiber. Supplementation with both enzyme and buffer tended to act synergistically (interaction; $P \leq 0.21$) and increased digestibilities of glucose and xylose by 5.2%. There was also a tendency (interaction; $P=0.15$) for the digestibilities of mannose to increase in response to the addition of both enzyme and buffer. Cellulose consists of chains of glucose molecules, whereas the major component of hemicellulose is xylose. Because improvements in digestibility were similar for both glucose and xylose, it does not appear that a specific cell wall structure was targeted by the addition of enzyme and buffer.

Previous research results demonstrated that addition of roughage to soybean hull-based diets increased digestibilities and ruminal passage rates. Addition of dietary buffers typically increases water intake, and therefore increases ruminal passage rates. However, the addition of enzymes and buffer to the soybean hull-based diet in this experiment did not alter passage of liquid or solids from the rumen (Table 2).

Thus, changes in passage rate cannot account for any of the responses in digestion.

Differences in ruminal pH were not observed when steers were supplemented with digestive enzyme, buffer or a combination of both (Figure 1). For all treatments, ruminal pH decreased from approximately 6.5 at feeding to approximately 5.7 at 3 hours after feeding. The lack of change in pH in response to buffer addition was surprising, because improvements in fiber digestibilities due to the addition of buffer would have been expected to be a result of a moderation of the ruminal pH after feeding. Previous research has demonstrated that fiber digestion may be inhibited at ruminal pH below 6.0. However, it is possible that the effects of ruminal buffering with the addition of magnesium oxide and sodium bicarbonate is relatively short-lived and that decreases in ruminal pH may have been inhibited only during the first few hours after feeding and before the 3-hour sampling period. A tendency for greater improvements ($P \leq 0.15$) in diet digestibilities when both enzyme and buffer were added (Table 2) suggests that the beneficial effects of enzyme addition to the soybean hull-based diets may be dependent on ruminal buffering.

Our data indicate that both the addition of digestive enzyme and buffer improved the digestibility of a soybean hull-based diet. However, the response was greatest when buffer and enzymes were combined.

**Table 1. Composition of the Soybean Hull-Based Diet**

| Item | % of Dry Matter |
|---|---|
| Ingredient | |
| Soybean hulls | 95.5 |
| Cane molasses | 3.0 |
| Calcium phosphate | 0.5 |
| Trace mineralized salt[a] | 0.5 |
| Urea | 0.5 |
| Nutrient | |
| Organic matter | 92.5 |
| Neutral detergent fiber | 59.9 |
| Acid detergent fiber | 43.6 |
| Crude protein | 13.9 |
| Glucose | 33.9 |
| Xylose | 8.2 |
| Mannose | 5.3 |
| Arabinose | 4.4 |
| Galactose | 2.6 |

[a]Composition (g/100 g): NaCl (95 to 99), Mn (>0.24), Cu (>0.032), Zn (>0.032), I (>0.007), and Co (>0.004).

**Table 2. Effects of Digestive Enzyme and Dietary Buffer Supplementation on Digestibilities and Passage Rates**

| Item | Treatment[a] | | | | | *P*-value[b] | | |
|---|---|---|---|---|---|---|---|---|
| | Control | Enzyme | Buffer | Enzyme + Buffer | SEM | E | B | E×B |
| Digestibility, % | | | | | | | | |
| Dry matter | 74.0 | 74.4 | 74.6 | 76.6 | 1.3 | 0.04 | 0.02 | 0.15 |
| Organic matter | 75.9 | 76.2 | 76.5 | 78.6 | 1.4 | 0.05 | 0.02 | 0.11 |
| Neutral detergent fiber | 77.2 | 77.6 | 77.7 | 79.9 | 1.8 | 0.04 | 0.03 | 0.10 |
| Acid detergent fiber | 74.7 | 74.9 | 75.4 | 77.8 | 2.1 | 0.06 | 0.02 | 0.09 |
| Glucose | 75.4 | 75.3 | 77.1 | 79.3 | 2.8 | 0.22 | 0.01 | 0.21 |
| Mannose | 97.4 | 97.4 | 97.6 | 97.8 | 0.18 | 0.21 | 0.01 | 0.15 |
| Arabinose | 90.0 | 90.4 | 90.5 | 91.5 | 0.77 | 0.10 | 0.06 | 0.44 |
| Xylose | 77.2 | 77.9 | 78.2 | 81.2 | 2.2 | 0.03 | 0.02 | 0.14 |
| Galactose | 91.4 | 91.6 | 92.3 | 92.2 | 0.49 | 0.83 | 0.06 | 0.66 |
| Ruminal passage, %/hour | | | | | | | | |
| Liquid | 4.8 | 5.1 | 4.9 | 4.7 | 0.32 | 0.90 | 0.40 | 0.23 |
| Solid | 3.4 | 3.7 | 4.0 | 3.5 | 0.46 | 0.73 | 0.59 | 0.16 |

[a]Control = soybean hull-based diet; Enzyme = soybean hull-based diet plus enzyme addition; Buffer = soybean hull-based diet plus buffer addition; Enzyme + Buffer = soybean hull-based diet plus enzyme and buffer addition.

[b]E = effect of enzyme; B = effect of buffer; E×B = effect of an interaction between enzyme and buffer.

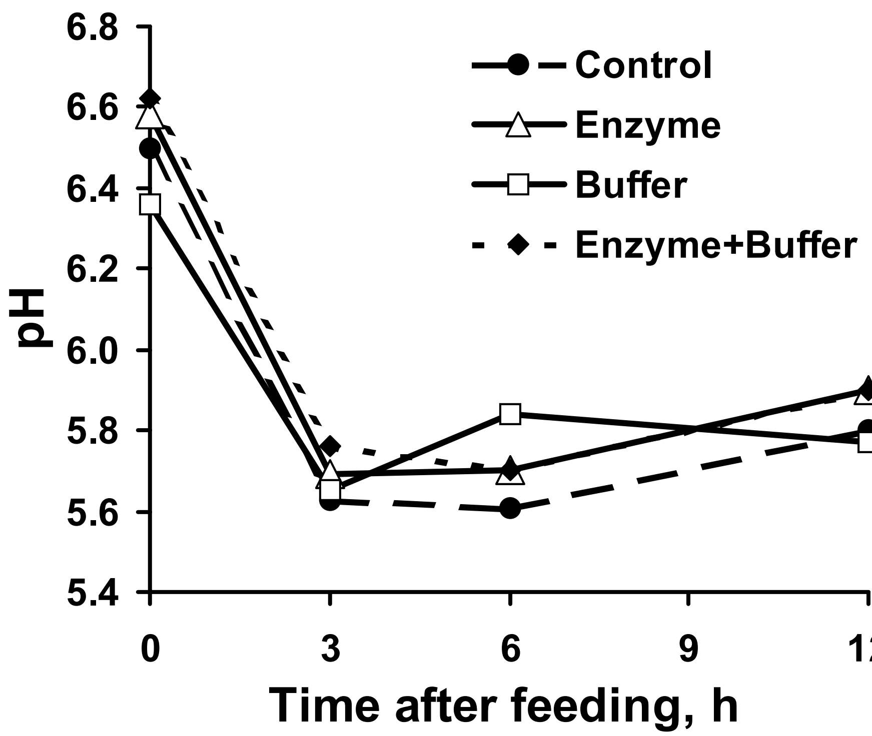


**Figure 1. Effects of Digestive Enzyme and Dietary Buffer Supplementation on Ruminal pH.**