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Individual Sweet Bran Components in High-Forage Rations Fed to Holstein Steers Contribute to Changes in Nutrient Digestibility

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Abstract

Sweet Bran (SB), a wet corn gluten feed product (Cargill Corn Milling, Blair, NE), is widely used in cattle diets. Sweet Bran consists of a proprietary blend of corn bran, corn germ meal, and corn steep liquor, all of which are byproducts of the corn wet milling process. This study evaluated the impact of individual SB components on digestibility, ruminal fermentation, and feeding behavior of Holstein steers fed high-forage diets. Twelve steers with rumen and duodenal cannulas were assigned to one of four dietary treatments: no SB components (control), corn germ meal (germ), bran (bran), or steep liquor (steep). Diets containing SB components led to greater dry matter intake compared to steers fed the control diet ($P < 0.01$). The steep diet also enhanced the digestibility of dry matter, protein, and starch ($P < 0.01$, $P = 0.08$, and $P = 0.03$, respectively). Germ and bran, which were similar, improved neutral detergent fiber digestibility ($P < 0.01$) compared to the control diet. Steep notably increased ammonia concentration ($P < 0.01$) and achieved the highest butyrate levels ($P < 0.01$), indicating more vigorous fermentation. In terms of feeding behavior, the steep diet resulted in more frequent, shorter, and faster feeding sessions ($P < 0.01$), whereas the germ, bran, and control diets were associated with slower intake rates. Diets containing SB components, particularly steep, enhanced nutrient digestibility and fermentation in Holstein steers compared to control.

Introduction

Sweet Bran (SB; Cargill Corn Milling, Blair, NE) is a wet corn gluten feed used in cattle diets. It consists of a mixture of three byproducts of the corn wet milling process: solvent-extracted germ meal, bran, and steep liquor. It is used to partially replace corn grain and soybean meal in cattle diets, and is an excellent source of energy and ruminally degradable protein. However, each of its components has a different nutrient profile. This research was done to compare and determine the digestibility, ruminal fermentation profile, and feed intake behavior of Holstein steers fed high-forage diets containing individual components of SB.

Experimental Procedures

This study involved 12 Holstein steers that had cannulas in both their rumen and duodenum. They were housed at the Kansas State University Intake Facility and

randomly assigned to one of four diets in a 4 × 4 Latin square design, balanced to avoid carryover effects and blocked by weight. The four diets (Table 1) were: 1) without any Sweet Bran components (control), 2) with corn germ meal (germ), 3) with corn bran (bran), and 4) with corn steep liquor (steep). The study lasted four periods, each 23 days long. The first 18 days were for the steers to adjust to their diets, and samples were collected from days 19 to 23. The diets were mixed daily in the morning and fed twice a day at 9 a.m. and 3 p.m. The Roughage Intake Control system (Hokofarm Group, The Netherlands) monitored dry matter intake (DMI) and feeding behavior.

Titanium dioxide (TiO_2) was used as a marker to track digesta flow, and it was dosed twice daily (10 g/dose) into the rumen from days 7 through 21. Ruminal, duodenal, and fecal samples were taken every 2 hours over a 24-hour period from days 19 to 21. Ruminal fluid was analyzed for pH and then acidified 1:3 with 25% m-phosphoric acid (weight/volume) for later analysis of ammonia nitrogen ($N\text{-}NH_3$) and volatile fatty acids (VFA). Ammonia nitrogen levels were measured colorimetrically with a spectrophotometer, and VFA concentrations were determined by gas chromatography. Duodenal contents and fecal samples were combined for each steer within each period, and TiO_2 concentrations in these composites were measured colorimetrically to calculate apparent digestibility.

Data were analyzed using the MIXED model procedure of the Statistical Analysis System (SAS version SAS Studio; SAS Inst. Inc., Cary, NC). One steer was excluded from the analysis because it consumed alternative treatment diets. Fixed effects included treatment and period, and animal was utilized as a random effect. Ammonia, VFA, pH, and feeding behavior were analyzed using hour as repeated measures and animal within sequence as subject. Statistical significance was declared at $P < 0.05$, and tendency for significance at $P < 0.10$.

Results and Discussion

For DMI (Table 2), cattle fed the control had less feed intake compared to other treatments ($P < 0.01$), indicating that including corn byproducts, especially steep, might enhance digestibility, leading to greater intake. Dry matter digestibility of the diet containing steep was greater than that of other treatments for both ruminal ($P < 0.01$) and total tract digestion ($P = 0.08$), and protein ($P < 0.01$) compared to other treatments, suggesting it is beneficial for protein utilization. Additionally, steep had higher total tract digestibility of starch ($P = 0.03$), suggesting it may offer an advantage in energy provision from starch. Germ and bran exhibited higher neutral detergent fiber digestibility than other treatments ($P < 0.01$), with an advantage in energy from fiber, and similar overall nutrient digestibility, while the control had the lowest digestibility percentages. The pattern of ruminal digestibility generally matched total tract digestibility, except for starch, where the control had numerically higher ruminal digestibility but not higher total tract digestibility.

The diets with SB components decreased ruminal pH (Table 3), indicating greater fermentation activity ($P < 0.01$). The steep diet notably increased $N\text{-}NH_3$ concentration by three to six times that of other treatments ($P < 0.01$), reflecting its high protein content and extensive ruminal degradation. It also led to the highest butyrate levels ($P < 0.01$), which likely was derived from the conversion of lactate within steep liquor to butyrate by lactic acid consuming bacteria. Though not statistically different, the highest total VFA concentrations were observed when cattle were fed the diet

containing steep, suggesting more intense fermentation than other diets. Acetate levels were consistent across all diets, while steep had slightly higher propionate levels ($P > 0.10$).

Regarding feeding behavior (Table 4), steers on the steep diet had the most frequent bunk visits, with the shortest duration per visit, and the fastest intake rate ($P < 0.01$). In contrast, steers on the control diet had the fewest visits and the slowest intake rate. When consuming the germ diet, steers had the longest total meal duration, while on the bran diet, they fell between germ and steep in most metrics. On the control diet, steers exhibited the least feeding activity, while the germ diet promoted prolonged eating.

Implications

Adding corn steep liquor to the diet increased ruminal fermentation and diet digestion compared to other components of wet corn gluten feed.

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Table 1. Composition of high-forage diets containing individual components of Sweet Bran fed to Holstein steers

	Treatments[1]			
Percent on dry matter basis	**Control**	**Germ**	**Bran**	**Steep**
Ingredients				
Corn silage	70.00	35.00	35.00	35.00
Alfalfa hay	15.00	15.00	15.00	15.00
Corn, fine ground	13.06	13.84	13.07	12.43
Urea	1.00	---	0.76	---
Vitamin and mineral supplement	0.94	1.16	1.17	2.56
Solvent-extracted germ meal	---	35.00	---	---
Corn bran	---	---	35.00	---
Corn steep liquor	---	---	---	35.00
Analyzed nutrients				
Crude protein	12.07	13.57	13.51	17.03
Neutral detergent fiber	32.99	37.04	43.19	21.82
Starch	32.80	29.00	25.00	24.20

[1]Germ = corn solvent-extracted germ meal; Bran = corn bran; Steep = corn steep liquor.

Table 2. Apparent digestibility of nutrients in the rumen and the total tract of Holstein steers fed individual components of Sweet Bran

	Treatments[1]					
Item	Control	Germ	Bran	Steep	SEM[2]	*P*-value
Dry matter intake, lb/day	19.4[b]	24.6[a]	24.8[a]	26.4[a]	1.5	<0.01
Ruminal digestibility, %						
Dry matter	83.2	84.4	84.3	86.4	1.1	0.08
Protein	73.6[b]	72.0[b]	75.1[b]	80.1[a]	1.5	<0.01
Neutral detergent fiber	81.1[b]	86.9[a]	87.4[a]	82.8[b]	1.4	<0.01
Starch	95.4	94.7	93.9	94.9	0.7	0.44
Total tract digestibility, %						
Dry matter	89.6[c]	90.9[b]	90.0[bc]	93.2[a]	0.6	<0.01
Protein	87.7[c]	88.3[bc]	89.3[b]	93.0[a]	0.6	<0.01
Neutral detergent fiber	84.3[c]	88.7[a]	87.5[ab]	87.0[b]	0.7	<0.01
Starch	99.4[b]	99.4[b]	99.3[b]	99.7[a]	0.1	0.03

[1]Germ = corn solvent-extracted germ meal; Bran = corn bran; Steep = corn steep liquor.
[2]Standard error of the mean.
[a,b,c]Values in a row with a common superscript letter are not different ($P > 0.05$).

Table 3. Ruminal fermentation parameters for Holstein steers fed individual components of Sweet Bran

	Treatments[1]					
Item	Control	Germ	Bran	Steep	SEM[2]	*P*-value
pH	6.4[a]	6.2[b]	6.2[b]	6.2[b]	0.1	<0.01
Ammonia-nitrogen, mM	9.2[b]	5.0[c]	8.7[d]	29.3[a]	1.3	<0.01
Acetate, mM	60.3	58.2	61.2	59.5	1.5	0.49
Propionate, mM	18.7	20.3	20.4	21.7	0.8	0.12
Butyrate, mM	11.3[b]	11.7[b]	11.1[b]	14.3[a]	0.6	<0.01
Total volatile fatty acids, mM	93.3	93.2	95.2	100.5	2.8	0.21

[1]Germ = corn solvent-extracted germ meal; Bran = corn bran; Steep = corn steep liquor.
[2]Standard error of the mean.
[a,b,c]Values within a row with a common superscript letter are not different ($P > 0.05$).

Table 4. Feed intake behavior of Holstein steers fed individual components of Sweet Bran

	Treatments[1]					
Item	Control	Germ	Bran	Steep	SEM[2]	*P*-value
Number of visits to bunk/day	23.4[c]	26.2[bc]	29.1[ab]	30.5[a]	1.4	<0.01
Meal duration, minutes/day	96.7[c]	119.5[a]	110.3[ab]	100.8[bc]	4.6	<0.01
Visit duration, minutes	5.1[a]	5.1[a]	4.6[a]	3.6[b]	0.3	<0.01
Intake rate, oz/minute	7.4[b]	7.4[b]	8.0[b]	9.6[a]	0.3	<0.01

[1]Germ = corn solvent-extracted germ meal; Bran = corn bran; Steep = corn steep liquor.
[2]Standard error of the mean.
[a,b,c]Values within a row with a common superscript letter are not different ($P > 0.05$).