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# Influence of Restricted Intake and Reduced Dietary Starch on Colonic pH and *E. coli* Prevalence

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O157:H7 was recovered from the composite fecal sample; pens were classified as medium prevalence if the organism was recovered from the device, but not from the composite feces; pens were classified as low prevalence if the organism was not recovered from the device or the composite feces. This classification scheme correlated well (Spearman's  $r = 0.76$ ,  $P < 0.0001$ ) with the pen-prevalence determined by culturing the feces from individual cattle. Pens classified as high prevalence had significantly higher rankings in pen-prevalence than pens classified as medium prevalence

( $P = 0.05$ ) or low prevalence ( $P = 0.0006$ ), and pens classified as medium prevalence had significantly higher rankings in pen-prevalence than pens classified as low prevalence ( $P = 0.005$ ).

The premise of the pen-test was to culture a few devices from which many cattle in a pen could have contributed organisms. Culture of the pen-test devices alone or in parallel with culture of a composite fecal sample may be a diagnostically efficient strategy to characterize *E. coli* O157:H7 fecal shedding in feedlot pens. This diagnostic strategy may be useful as a research tool or as a

monitoring tool in the development of animal production food safety programs.

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## Influence of Restricted Intake and Reduced Dietary Starch on Colonic pH and *E. coli* Prevalence

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A finishing diet low in starch increased fecal pH, lowered VFA, and reduced numbers of acid-resistant *E. coli* shed in the feces.

### Summary

*Ninety feedlot steers were used to test the effects of reducing dietary starch and intake on colonic pH, VFA, total and acid-resistant coliform and E. coli populations, and E. coli O157:H7 shedding. When corn bran and wet corn gluten feed (WCGF), or high moisture corn and WCGF were substituted for dry rolled corn, colonic pH increased while VFA concentration decreased. The corn bran and WCGF diet reduced acid-resistant E. coli shedding. Restricting intake increased colonic pH and decreased VFA con-*

*centration, but did not affect acid-resistant E. coli shedding. Prevalence of E. coli O157:H7 was not affected by diet or intake.*

### Introduction

Enterohemorrhagic *Escherichia coli* O157:H7 is a bacterium found commonly in the intestinal tract of livestock that can cause severe illness and death in humans. More than 100 outbreaks of *E. coli* O157:H7 have been reported since 1982, 52% of which have been linked to foods derived from cattle.

Besides its ubiquitous distribution in livestock, other noteworthy characteristics of *E. coli* O157:H7 are its low infective dose for humans and its acid resistance. Because it can thrive under low pH conditions, undigested feed that is fermented in the colon may facilitate growth of *E. coli* O157:H7 and ultimately increase the numbers of the organism being shed in the feces.

High grain finishing diets may result in large amounts of undigested starch reaching the colon. Because of this, it has been suggested that feeding hay instead of grain would decrease the amount of starch reaching the colon,

increase colonic pH and decrease the numbers of acid-resistant *E. coli* being shed in the feces. In 1998, it was reported that switching cattle from a grain-based diet to hay four days prior to slaughter reduced the prevalence of both generic and acid resistant *E. coli*. A similar study conducted at the University of Nebraska confirmed these results. When steers consuming dry-rolled corn, high-moisture corn, or wet corn gluten feed were switched to alfalfa hay for five days, acid-resistant *E. coli* populations in the feces were reduced by 99% (2000 Nebraska Beef Report, pp. 39-41).

Feeding hay at the end of the feeding period may not be a feasible management practice for cattle feeders. However, if reducing the amount of fermentation in the colon is the key to reducing the numbers of acid-resistant *E. coli* being shed in the feces, more practical approaches may be available. High moisture corn, wet corn gluten feed (WCGF) and corn bran are feedstuffs used commonly in Nebraska feedlots, and each would be expected to result in less undigested starch reaching the colon. Therefore, the objectives of this trial were to determine the effect of

**Table 1. Composition of diets.**

Ingredient, %DM	Treatment		
	High	Med	Low
Dry rolled corn	81.55	—	—
High moisture corn	—	43.75	—
Corn bran	—	—	43.75
Wet corn gluten feed	—	43.75	43.75
Alfalfa hay	7.50	7.50	7.50
Molasses	3.00	—	—
Supplement	7.95	5.00	5.00

**Table 2. Effect of diet on colonic digesta samples.**

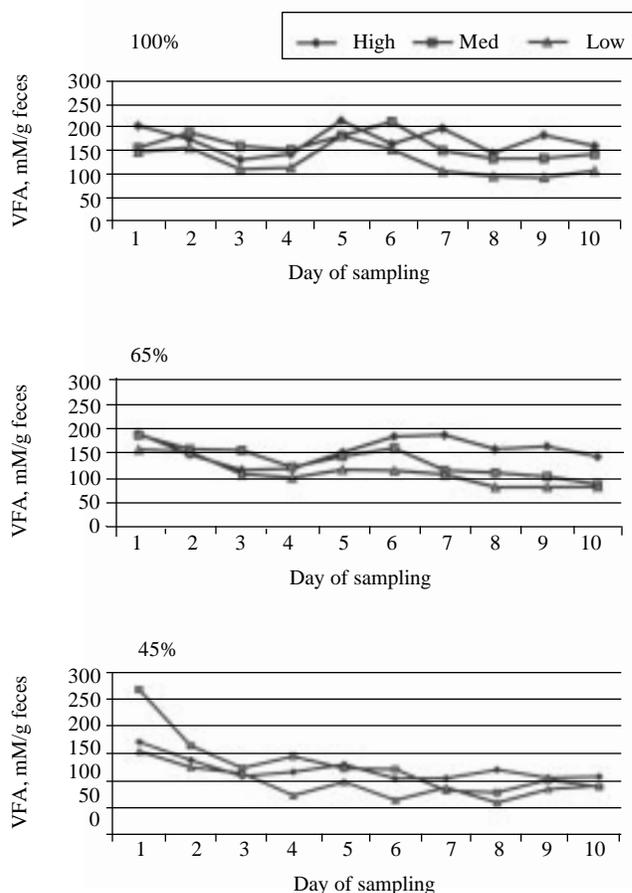
Item	Dietary treatment <sup>a</sup>		
	High	Med	Low
Colonic pH	6.90 <sup>c</sup>	7.25 <sup>d</sup>	7.52 <sup>e</sup>
VFA, mM/g feces	188.01 <sup>f,g</sup>	193.95 <sup>f</sup>	150.43 <sup>g</sup>
Total coliform, log <sub>10</sub> <sup>b</sup>	5.52	4.78	5.43
Acid resistant coliform, log <sub>10</sub> <sup>b</sup>	4.28 <sup>c</sup>	2.98 <sup>d</sup>	2.64 <sup>d</sup>
Total <i>E. coli</i> , log <sub>10</sub> <sup>b</sup>	6.81 <sup>c</sup>	5.71 <sup>d</sup>	6.35 <sup>c</sup>
Acid resistant <i>E. coli</i> , log <sub>10</sub> <sup>b</sup>	4.69 <sup>f</sup>	4.06 <sup>g</sup>	3.86 <sup>g</sup>

<sup>a</sup>High = dry rolled corn, Med = high moisture corn and WCGF, Low = corn bran and WCGF.

<sup>b</sup>Bacterial numbers shown in log<sub>10</sub> colony forming units / g feces.

<sup>c,d,e</sup> Means within a row differ ( $P < .01$ ).

<sup>f,g</sup> Means within a row differ ( $P < .05$ ).



**Figure 1. Effect of day on colonic VFA concentration within intake level. DRC = dry-rolled corn, HMC = high-moisture corn and wet corn gluten feed, and Bran = corn bran and wet corn gluten feed. 100% = ad libitum, 65% and 45% = intake restricted to 65% and 45% of ad libitum, respectively.**

replacing dry-rolled corn with either high-moisture corn and WCGF or corn bran and WCGF on colonic pH and volatile fatty acid concentration, as well as coliform bacteria and *E. coli* being shed in feces. Additionally, we wished to determine the effects of limiting intake of each of these diets. Treatment diets were fed at the end of the finishing phase, with the objective being to reduce shedding of *E. coli* prior to arrival at the packing plant without hampering performance.

## Procedure

Ninety crossbred steers (BW = 1198 lb) were used to test the effects of finishing diet and level of intake on colonic pH and VFA content, as well as coliform bacteria and *E. coli* shedding. The project was designed as a 3 x 3 factorial, with three diets offered at three levels of intake. Calves were randomly assigned to treatment and allotted to one of 18 pens (5 head/pen; 2 pens/treatment). Treatment diets (Table 1) were formulated to supply varying amounts of unfermented starch reaching the colon, and were based on dry-rolled corn (High), high-moisture corn and wet corn gluten feed (Med), or a combination of corn bran and wet corn gluten feed (Low). Diets were offered free choice (100%), or restricted to either 65% or 45% of full consumption for 10 days. Cattle were penned together within diet type for 14 days prior to initiation of the trial to establish ad libitum levels of intake. Fecal samples were collected from the rectum of each individual on ten consecutive days, and analyzed for pH, acetate, butyrate, isobutyrate, propionate, isovalerate and total VFA concentration. Total coliform bacteria, total *E. coli*, and acid-resistant coliforms and *E. coli* were quantified. The presence of *E. coli* O157:H7 was also determined.

## Results

Analysis of fecal samples collected on day 1 (Table 2) represent the effect of ad libitum consumption of the treatment diets. Cattle consuming diets containing

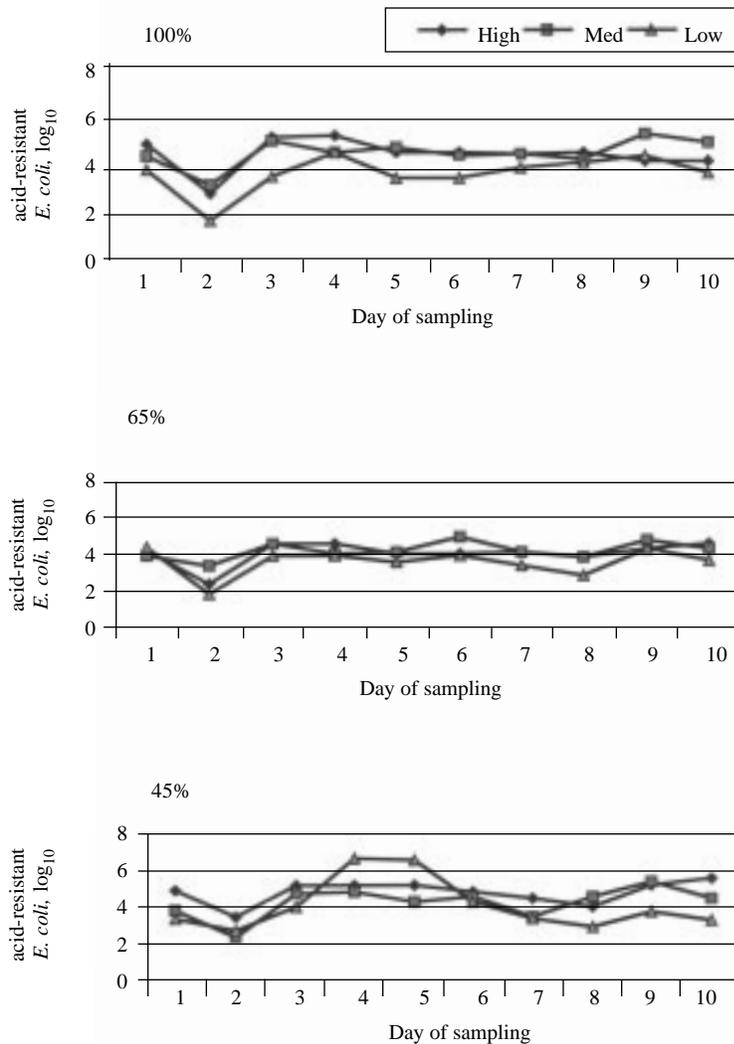
(Continued on next page)

WCGF had higher ( $P < .01$ ) colonic pH values than those on a DRC-based finishing ration. Replacing HMC with corn bran further raised ( $P < .01$ ) colonic pH. Volatile fatty acid concentration of colonic digesta did not differ ( $P > .05$ ) between the DRC and HMC-based diets. The corn bran diet did reduce ( $P < .05$ ) the amount of VFA in the colon.

The total number of coliform bacteria isolated from rectal grab samples collected on day 1 did not differ ( $P > .05$ ) between diets. Acid-resistant coliforms were reduced ( $P < .01$ ) by the inclusion of WCGF. The total number of *E. coli* cultured was lower ( $P < .01$ ) for cattle consuming the HMC diet compared to the other treatments, and the corn bran treatment tended ( $P = .06$ ) to be lower than DRC. The number of acid-resistant *E. coli* being shed in the feces was lower ( $P < .05$ ) in samples collected from calves consuming diets containing WCGF.

Once intake restrictions were imposed, level of intake significantly ( $P < .01$ ) influenced colonic pH. Cattle on ad libitum intake had an average colonic pH of 7.29. That increased to 7.35 and 7.46 for 65% and 45% restriction, respectively. Because of the inclusion of limestone in the diets, and its potential to act as a buffer in the colon, colonic VFA concentration may be a better indicator of microbial activity in the hind gut, rather than pH. Restricting intake decreased ( $P < .01$ ) the amount of VFA from 150, to 131, and 110 mMol/g, for 100%, 65, and 45% intake, respectively. Intake level did not ( $P = .83$ ) affect the numbers of acid-resistant *E. coli* being shed in feces.

The number of calves shedding *E. coli* O157:H7 ranged from 0% to 18% over the 10-day sampling period, and prevalence was not affected by diet. Level of intake also had no significant impact on O157:H7, though numerical differences were evident. Across days and diets, 12% of ad libitum, 14% of 65% intake, and 5% of 45% intake calves were positive for O157:H7. In order for treatments to yield statistical differences



**Figure 2.** Effect of day on acid-resistant *E. coli* numbers cultured from colonic digesta. DRC = dry-rolled corn, HMC = high-moisture corn and wet corn gluten feed, and Bran = corn bran and wet corn gluten feed. 100% = ad libitum, 65% and 45% = intake restricted to 65% and 45% of ad libitum, respectively.

in the presence or absence of *E. coli* O157:H7, it may be necessary to have larger sample sizes than the numbers used in this study.

Replacing dry-rolled corn with high-moisture corn and WCGF, or corn bran and WCGF raised colonic pH and reduced VFA concentrations in feedlot steers. Restricting intake to 65% and 45% of ad libitum had a similar effect. A WCGF and corn bran-based diet tended to reduce numbers of acid-

resistant *E. coli* shed in the feces. Prevalence of *E. coli* O157:H7 in feces was not affected by diet or level of intake.

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