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Influence of Diet on Total and Acid Resistant *E. coli* and Colonic pH

Tony Scott
University of Nebraska-Lincoln

Casey Wilson
University of Nebraska-Lincoln

Doreen Bailey
University of Nebraska-Lincoln, dbailey2@unl.edu

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Todd Milton
University of Nebraska-Lincoln

See next page for additional authors

Authors
Tony Scott, Casey Wilson, Doreen Bailey, Terry J. Klopfenstein, Todd Milton, Rodney A. Moxley, David R. Smith, Jeff Gray, and Laura Hungerford

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Rod Moxley
Dave Smith
Jeff Gray
Laura Hungerford[1]

Manipulation of finishing diets does not reduce shedding of acid-resistant *Escherichia coli* in feces; however, short duration hay feeding reduces acid-resistant *E. coli* shedding in the feces.

Summary

Nine steers were fed finishing diets in a replicated 3x3 Latin square design to determine if dietary manipulation would alter total and acid resistant E. coli *populations. Manipulating diet by limit-feeding of finishing diets did not affect total or acid-resistant* E. coli *populations. Altering dietary ingredients did not affect total* E. coli *populations; however, steers fed diets containing dry-rolled or high-moisture corn had lower acid-resistant* E. coli *populations. Following completion of the Latin Square, all animals were fed alfalfa hay ad libitum for five days. Switching steers to alfalfa hay lowered both total and acid-resistant* E. coli *populations.*

Introduction

The bacterium *Escherichia coli* is a normal inhabitant of the intestinal tracts of human beings and animals. However, some strains of *E. coli* — for example, serotype O157:H7 — are capable of causing disease in humans. In cattle, *E. coli* O157:H7 is carried in the gastrointestinal tract and is shed in the feces while the animal shows no signs of disease. The organism is thought to enter the food chain through fecal contamination of the hide during slaughter. Two important features of *E. coli* O157:H7 are its low infective dose and acid resistance. The low infective dose for humans, coupled with the fact that complete prevention of microbial contamination at slaughter is not feasible, has lead to the development of the concept that food-borne illness might best be prevented by reducing pathogen prevalence in livestock, a concept also known as pre-harvest food safety.

Recently, short-duration hay feeding was suggested as a viable pre-harvest food safety technique (Diez-Gonzalez, et al., 1998, Science, 281:1578). When animals that had been consuming grain were fed hay for four days, the prevalence of both generic and acid-resistant *E. coli* was reduced. High grain diets allow undigested starch to accumulate in the colon. Accumulated starch is subsequently fermented resulting in volatile fatty acid production, an acidic pH, and facilitated growth of acid-resistant *E. coli*. The resulting hypothesis is that reducing the starch load in the colon will significantly reduce the numbers of *E. coli* O157:H7.

Regardless of the potential benefits of hay feeding, it is not a practical approach for cattle feeders. However, if the amount of starch being fermented in the colon is the key to reducing the prevalence of *E. coli*, there may be alternative means to achieve the same results. Wet corn gluten feed and high-moisture corn are two common dietary ingredients that offer opportunities to achieve similar results as observed with hay feeding. Wet corn gluten feed contains little or no starch and is 80% digestible in the rumen. Therefore, feeding wet corn gluten feed should reduce the starch load in the colon since material bypassing digestion in the rumen would be fibrous corn bran as opposed to starch. High-moisture corn is more extensively degraded in the rumen than dry-rolled corn. Therefore, comparatively less starch bypasses digestion in the rumen when feeding high-moisture corn. The net effect of replacing dry-rolled corn with wet corn gluten feed or high-moisture corn would be reduced starch load in the colon.

Therefore, our hypothesis for this study was by manipulating the finishing diet, the amount of starch being fermented in the colon would decrease, thereby increasing colonic pH and decreasing the number of acid-resistant *E. coli*. Also, it was hypothesized that limit-feeding of finishing diets may offer an alternative means of reducing acid-resistant *E. coli*. Limit-feeding of finishing diets should result in less fermentation in the colon (increased colonic pH) because of more complete digestion in the rumen due to slower rate of passage, increased retention time and increased extent of digestion.

Procedure

Experiment 1

Nine steers were fed finishing diets in a replicated 3 x 3 Latin square design. Treatments were finishing diets (Table 1) based on dry-rolled corn (DRC), high-moisture corn (HMC), or wet corn gluten feed (WCGF). Diets were formulated to contain a minimum of 12.5% CP, .7% Ca, .35% P, .6% K, and included 25 g/ton Rumensin and 10 g/ton Tylan.

Each period was 21 days in duration. During days 1-9 of each period, steers were fed at 1.8% of body weight (DM basis). Intake for each subsequent period was adjusted based on weights taken at the end of each 21-day period. Steers were allowed to consume feed ad libitum during days 10-21 of each period. Samples of colonic digesta were obtained on days 9, 20 and 21 and analyzed for volatile fatty acid concentration (analyses not completed; therefore, data not shown), pH and numbers of total and acid-resistant *E. coli*.

(Continued on next page)

Experiment 2

Upon completion of the final period of the 3 x 3 Latin Square, the nine steers were fed alfalfa hay ad libitum, allowing three steers each previously being fed dry-rolled corn, wet corn gluten feed, or high-moisture corn to be observed after short duration hay feeding. Samples of colonic digesta were obtained on two consecutive days following five days of hay feeding and analyzed for volatile fatty acid concentration (analyses not completed; therefore, data not shown), pH, and numbers of total and acid-resistant *E. coli*.

Results

Experiment 1

The effects of diet on DMI, most probable number (MPN) of total and acid-resistant *E. coli*, and colonic pH are shown in Table 2. During the period when steers were being limit-fed, neither total nor acid-resistant *E. coli* counts were statistically different among the three treatments; however, colonic pH was higher ($P < .10$) in steers fed WCGF than in steers fed DRC or HMC. There was no treatment effect on DMI when steers were switched to ad libitum feeding. Total *E. coli* numbers were similar among treatments. Steers consuming DRC or HMC had significantly lower ($P < .10$) acid-resistant *E. coli* numbers than steers consuming WCGF. Colonic pH was higher in steers fed WCGF or HMC ($P < .10$) than in steers fed DRC.

Our interpretation is that acid-resistant *E. coli* numbers can not be reduced through either limit-feeding or this type of dietary manipulation. However, feeding WCGF did increase colonic pH in steers during both the limit-feeding period and the ad libitum feeding period. Wet corn gluten feed is very low in starch concentration, but it does not appear that lowering the amount of starch reaching the colon will reduce acid-resistant *E. coli* numbers. Likewise, even though HMC is more extensively degraded in the rumen and colonic pH increased during ad libitum feeding compared to DRC, there was no reduction in

Table 1. Composition of finishing diets.

	Treatment[a]		
Ingredient (% of DM)	DRC	HMC	WCGF
Dry-rolled corn	84.707	33.773	40.832
High-moisture corn	——	50.866	——
Wet corn gluten feed	——	——	45.000
Alfalfa hay	7.500	7.500	7.500
Molasses	5.000	5.000	5.000
Limestone	1.338	1.337	1.304
Urea	.952	1.019	——
Salt	.300	.300	.300
Dicalcium phosphate	.107	.108	——
Potassium chloride	.032	.033	——
Trace mineral	.020	.020	.020
Rumensin premix	.016	.016	.016
Vitamin premix	.015	.015	.015
Tylan premix	.013	.013	.013

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.

Table 2. Effect of diet on DMI and MPN of total and acid-resistant *E. coli*.

	Treatment[a]			
Item	DRC	HMC	WCGF	SEM
Limit-fed period[b]				
Total *E. coli*, $\log_{10}$[c]	7.87	8.54	8.50	.28
Acid-resistant *E. coli*, $\log_{10}$[d]	2.61	4.52	4.24	.77
Colonic pH	6.42[e]	6.61[e]	6.85[f]	.12
Ad libitum period[g]				
DMI, lb/day	18.69	18.03	18.88	.62
Total *E. coli*, $\log_{10}$[c]	8.25	8.45	8.46	.21
Acid-resistant *E. coli*, $\log_{10}$[d]	3.04[e]	3.24[e]	3.71[f]	.47
Colonic pH	6.21[e]	6.55[f]	6.68[f]	.14

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.
[b]Limit-fed period = days 1-9.
[c]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[d]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.
[ef]Means within a row with unlike superscripts differ ($P < .10$).
[g]Ad libitum period = days 10-21.

Table 3. Effect of hay feeding on MPN of total and acid-resistant *E. coli*.

	Treatment[a]			
Item	DRC	HMC	WCGF	SEM
Total *E. coli*, $\log_{10}$[b]	7.13	6.89	6.89	.34
Acid-resistant *E. coli*, $\log_{10}$[c]	1.70	1.00	1.33	.29
Colonic pH	8.00	7.86	7.96	.06

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.
[b]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[c]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.

Table 4. Effect of feeding alfalfa hay versus a finishing diet on MPN of total and acid-resistant *E. coli*.

	Treatment[a]		
Item	ALF	FIN	SEM
Total *E. coli*, $\log_{10}$[b]	6.97[c]	7.95[d]	.20
Acid-resistant *E. coli*, $\log_{10}$[e]	1.34[c]	3.99[d]	.33
Colonic pH	7.94[c]	6.52[d]	.14

[a]ALF = alfalfa hay; FIN = finishing diet.
[b]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[cd]Means within a row with unlike superscripts differ ($P < .01$).
[e]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.

acid-resistant *E. coli* counts. Similarly, limit-feeding of the finishing diets did not alter acid-resistant *E. coli* numbers in comparison to ad libitum feeding. Potentially, one could limit intake more and possibly reduce acid-resistant *E. coli*; however, the reduced intake would impact daily gain and potentially carcass merit.

Experiment 2

The effect of switching steers to alfalfa hay for five days is shown in Table 3. Total *E. coli* counts were similar among treatments; however, counts were reduced from previously observed counts in Period 3 by .5, 1.27, and 1.16 $\log_{10}$ units for DRC, HMC, and WCGF, respectively. Similarly, there were no differences in acid-resistant *E. coli* counts among the treatments; however, counts were reduced from those previously observed in Period 3 by 2.35, 2.58, and 3.01 $\log_{10}$ units for DRC, HMC, and WCGF, respectively. These numbers indicate irrespective of diet, acid-resistant *E. coli* numbers were reduced when steers were fed alfalfa hay ad libitum for a period of five days.

Since there were no significant differences among DRC, HMC, or WCGF finishing diets when switched to alfalfa hay feeding, data were pooled to illustrate the effect of feeding alfalfa hay versus feeding finishing diets on the MPN of total and acid-resistant *E. coli* and colonic pH (Table 4). Switching steers to alfalfa hay lowered ($P < .01$) both total and acid-resistant *E. coli*. Total *E. coli* numbers were lowered by about 1 $\log_{10}$ unit while acid-resistant *E. coli* numbers were lowered by about 2.5 $\log_{10}$ units. Colonic pH was increased ($P < .01$) by over 1 pH unit in response to hay feeding. These data indicate short-duration hay feeding reduced acid-resistant *E. coli* populations in the feces by over 99%.

Dietary manipulation of finishing diets either by substituting ingredients or limit-feeding successfully increased colonic pH, indicating substrate changes at the level of the colon; however, increased colonic pH was not associated with reduced populations of acid-resistant *E. coli*. Feeding alfalfa hay both increased colonic pH and decreased acid-resistant *E. coli*. This study confirms Diez-Gonzalez (1998) report that feeding hay for a short duration can reduce acid-resistant *E. coli* populations.

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[1]Tony Scott, Casey Wilson, research technicians, Animal Science, Lincoln; Doreen Bailey, research technician, Veterinary and Biomedical Sciences, Lincoln; Terry Klopfenstein, Professor, Todd Milton, Assistant Professor, Animal Science, Lincoln. Rod Moxley, Professor, Dave Smith, Jeff Gray, Assistant Professors, Veterinary and Biomedical Sciences, Lincoln; Laura Hungerford, Associate Professor, Great Plains Veterinary Educational Center, Clay Center.