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Abstract
Escherichia coli O157 is an important food-borne pathogen for which the gastrointestinal tract of cattle is the major reservoir. Fecal shedding of E. coli O157 in cattle reflects the ability of the organism to persist in or colonize the gastrointestinal tract. Evidence suggests that the site of persistence or colonization is in the hindgut and not the rumen. Although the reasons are not known, it is likely that the ecosystem of the hindgut is more hospitable than the rumen. Therefore, we hypothesize that dietary factors that promote supply of substrates (starch, fiber, protein, or lipids) to the hindgut will have a significant effect on the ability of E. coli O157 to survive and colonize, and influence shedding in feces. Our objective was to use processed grains to alter hindgut fermentation in ways detrimental to the survival, growth, and colonization of E. coli O157. Grains that are less extensively digested within the rumen produce more starch for the hindgut, increasing fermentation activity and acid production in the hindgut. Steam-flaking of grains has been shown to enhance ruminal starch digestion compared to dry-rolling, effectively reducing the amount of starch reaching the hindgut. The objective of this study was to evaluate the effects of grain type (sorghum or wheat) and grain processing (dry-rolled or steam-flaked) in finishing diets on prevalence of E. coli O157 in cattle.

Keywords
Cattlemen's Day, 2007; Kansas Agricultural Experiment Station contribution; no. 07-179-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 978; Beef; Cattle; E. coli O157; Processed grains

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GRAIN PROCESSING REDUCES *E. COLI* O157 IN FEEDLOT CATTLE

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Introduction

Escherichia coli O157 is an important food-borne pathogen for which the gastrointestinal tract of cattle is the major reservoir. Fecal shedding of *E. coli* O157 in cattle reflects the ability of the organism to persist in or colonize the gastrointestinal tract. Evidence suggests that the site of persistence or colonization is in the hindgut and not the rumen. Although the reasons are not known, it is likely that the ecosystem of the hindgut is more hospitable than the rumen. Therefore, we hypothesize that dietary factors that promote supply of substrates (starch, fiber, protein, or lipids) to the hindgut will have a significant effect on the ability of *E. coli* O157 to survive and colonize, and influence shedding in feces.

Our objective was to use processed grains to alter hindgut fermentation in ways detrimental to the survival, growth, and colonization of *E. coli* O157. Grains that are less extensively digested within the rumen produce more starch for the hindgut, increasing fermentation activity and acid production in the hindgut. Steam-flaking of grains has been shown to enhance ruminal starch digestion compared to dry-rolling, effectively reducing the amount of starch reaching the hindgut. The objective of this study was to evaluate the effects of grain type (sorghum or wheat) and grain processing (dry-rolled or steam-flaked) in finishing diets on prevalence of *E. coli* O157 in cattle.

Experimental Procedures

Heifers (n = 347) were screened for the presence of *E. coli* O157. Heifers positive for fecal shedding of *E. coli* O157 were retested within a week, and 40 heifers (initial body weight = 630 lbs) were selected for use in the study. Heifers were assigned to one of four treatments consisting of a 2 × 2 factorial arrangement with factor 1 being grain type (sorghum- or wheat-based diets) and factor 2 being the method of grain processing (steam-flaking or dry-rolling). A series of transition diets were used to adapt animals to high-concentrate finishing diets consisting of 81.4% (dry-matter basis) dry-rolled or steam-flaked sorghum, or 52.0% (dry-matter basis) dry-rolled or steam-flaked wheat (Table 1). Steam-flaked corn was added to wheat diets to achieve a similar concentrate to forage ratio among all diets. Each transition diet was fed for four days to achieve the final diet on day 16 of the study. Once daily, heifers were fed amounts sufficient to result in only traces of feed remaining on the following day. Animals were housed in one of two barns containing 20 individual pens.

Fecal and rectal swab samples were collected from each heifer three times a week for a month. Detection of *E. coli* O157 was by

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selective enrichment, immunomagnetic separation, and plating on selective agar. Biochemical and antigenic tests were also used for further confirmation. Fecal pH was measured in samples once a week.

Results and Discussion

Sorghum and wheat grains were chosen for this study because their ruminal digestibilities differ substantially, resulting in different amounts of starch reaching the hindgut. Steam-flaked or dry-rolled wheat diets in our study contained only 52.0% wheat, because wheat has one of the fastest rates of ruminal starch digestion with increased propensity to induce metabolic disorders. Grain processing impacted (P = 0.026) dry matter intake, but grain type did not (P>0.10; Figure 1). One study demonstrated intake differences of diets containing different grain processing methods are likely a combination of differences in metabolizable energy and ruminal degradation of starch, which yielded differences in ruminal acid concentrations.

Fecal pH was measured on days 9, 16, 23 and 30 as a potential indicator of hindgut fermentation activity. Grain processing had no effect on fecal pH (Figure 1); however, grain type × sampling day interaction (P = 0.01) affected fecal pH. On day 9 of the study when animals were fed the third transition diet, fecal pH was lower (P = 0.01) in cattle fed sorghum diets (6.38) compared to cattle fed wheat diets (6.56), but this difference was not apparent on any other sampling day. A previous study had reported that increased availability of substrate in the hindgut increases the accumulation of organic acids (VFA) and reduces pH. Short-chain fatty acids (acetic, propionic, butyric) have been shown to suppress and inhibit growth of *E. coli* O157 at pH values of 6.0 and 5.5, respectively. In our study, differences in fecal pH were not consistently detected among dietary treatments. It is possible that fecal pH may not truly reflect the pH of the cecum or colon.

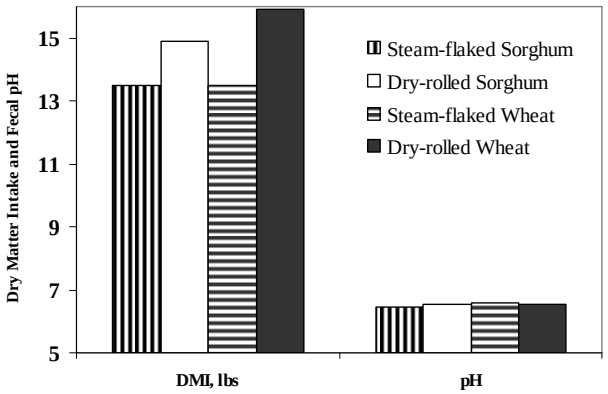

Figure 1. Average Dry Matter Intake and Fecal pH in Heifers Fed Steam-flaked Sorghum, Dry-rolled Sorghum, Steam-flaked Wheat or Dry-rolled Wheat Diets.

Mean prevalence of *E. coli* O157 in all heifers across all sampling days was 50.0%. Analysis of prevalence data began on day 9, when animals were on the third transition diet. Mean prevalence of *E. coli* O157 from day 9 in heifers fed the steam-flaked sorghum, dry-rolled sorghum, steam-flaked wheat, and dry-rolled wheat diets were 73%, 30%, 58%, and 29%, respectively. Grain type did not impact prevalence of *E. coli* O157, but grain processing method did (P<0.001). Mean prevalence in heifers fed dry-rolled grain diets (29.5%) was lower than prevalence in heifers fed steam-flaked grain diets (64.7%; Figure 2). Previous studies have shown that cattle diets containing grains with lower ruminal-starch degradation are associated with lower prevalence of *E. coli* O157. Dry-rolled grains are known to have lower ruminal-starch degradation compared to steam-flaked grains, thus presenting more starch to the hindgut and possibly increasing fecal starch. Previous dietary intervention strategies for *E. coli* O157 resulted in lower fecal pH and lower prevalence of the organism in cattle fed corn as compared to cattle fed barley. Because barley is more digestible than corn in the rumen, corn diets would present more starch to the hindgut and increase organic acid production, thus reduc-

ing pH and potentially reducing survivability of *E. coli* O157.

Implications

Grains processed by dry rolling, which are known to increase the amount of starch reaching the hindgut and enhance fermentation, may be useful in reducing *E. coli* O157 in cattle when fed prior to slaughter.

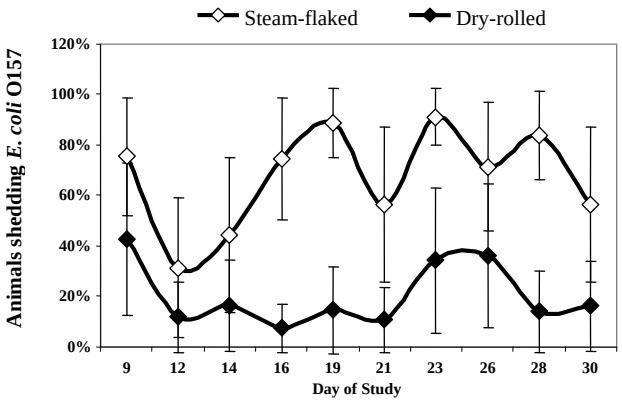

Figure 2. Least Squares Means and Standard Errors (bars) for Prevalence of *E. coli* O157 in Heifers Fed Diets with Dry-rolled or Steam-flaked Grains.

Table 1. Ingredient Composition of Experimental Diets (% dry matter basis) and Days Diets were Fed

Diet	Transition 1	Transition 2	Transition 3	Transition 4	Final Diet
Days fed	0-3	4-7	8-11	12-15	16-30
Sorghum diets					
Sorghum[1]	48.4	56.6	64.9	73.1	81.4
Alfalfa hay	40.0	31.8	23.5	15.3	7.0
Corn steep liquor	5.5	5.5	5.5	5.5	5.5
Soybean meal	1.8	1.8	1.8	1.8	1.8
Premix[2]	4.3	4.3	4.3	4.3	4.3
Wheat diets					
Wheat[1]	31.4	36.5	41.7	46.8	52.0
Steam-flaked corn	18.8	21.9	25.0	28.1	31.2
Alfalfa hay	40.0	31.8	23.5	15.3	7.0
Corn steep liquor	5.5	5.5	5.5	5.5	5.5
Premix[2]	4.3	4.3	4.3	4.3	4.3

[1]Steam-flaked or dry-rolled as appropriate for treatments.
[2]Formulated to provide 0.7% calcium, 0.7% potassium, 0.3% salt, 0.1 mg / kg cobalt, 10 mg / kg copper, 0.5 mg/kg iodine, 60 mg/kg manganese, 0.3 mg/kg selenium, 60 mg/kg zinc, 0.05 g/ton melengestrol acetate, 30 g/ton monensin, and 9 g/ton tylosin in the final diet (dry-matter basis).