Dietary Interactions and Interventions Affecting *Escherichia coli* O157 Colonization and Shedding in Cattle*

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**Abstract**

*Escherichia coli* O157 is an important foodborne pathogen affecting human health and the beef cattle industry. Contamination of carcasses at slaughter is correlated to the prevalence of *E. coli* O157 in cattle feces. Many associations have been made between dietary factors and *E. coli* O157 prevalence in cattle feces. Preharvest interventions, such as diet management, could reduce the fecal prevalence and diminish the impact of this adulterant. Dietary influences, including grain type and processing method, forage quality, and distillers grains have all been associated with *E. coli* O157 prevalence. In addition, several plant compounds, including phenolic acids and essential oils, have been proposed as in-feed intervention strategies. The specific mechanisms responsible for increased or decreased *E. coli* O157 shedding or survival are not known but are often attributed to changes in hindgut ecology induced by diet types. Some interventions may have a direct bacterial effect. Frequently, results of studies are conflicting or not repeatable, which speaks to the complexity of the hindgut ecosystem, variation in animal feed utilization, and variation within feed products. Still, understanding specific mechanisms, driven by diet influences, responsible for *E. coli* O157 shedding will aid in the development and implementation of better and practical preharvest intervention strategies.

**Introduction**

According to the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) estimates, more than 33 million pounds of beef products were recalled during 2007, and more than 7 million pounds were recalled in 2008 for possible *Escherichia coli* O157:H7 contamination (http://www.fsis.usda.gov/FSIS_Recalls/). These dramatic numbers indicate potential health implications for humans and economic repercussions for the beef industry. *E. coli* O157, a Shiga toxin–producing serotype of *E. coli*, is an important foodborne pathogen associated with enteritis in thousands of people in the United States every year. In more severe cases, infection can lead to hemolytic uremic syndrome, and possibly death (Rangel et al., 2005). Calves are likely colonized early in life (Gannon et al., 2002), and the organism is generally considered part of the normal gastrointestinal flora of cattle and not associated with disease. Presence of *E. coli* O157 in cattle feedlots appears fairly ubiquitous (Sargeant et al., 2003); however, several variables, including season, geographic location, and diet, have been associated with increased prevalence (Herriott et al., 1998; Bach et al., 2002; Dewell et al., 2005; Chase-Topping et al., 2008; Renter et al., 2008). Although many associations have been made, reasons why specific factors influence *E. coli* O157 presence in cattle remain largely unknown.

Because of its location in the gut, *E. coli* O157 colonization and survival are likely affected by gastrointestinal conditions, including pH, concentration of volatile fatty acids (VFA), presence of competing organisms, and, possibly, other unknown factors. Diet, which impacts the gastrointestinal conditions, is frequently associated with *E. coli* O157 prevalence (Dargatz et al., 1997; Herriott et al., 1998; Callaway et al., 2003b; Fox et al., 2007; Jacob et al., 2008a). Often, results of studies

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evaluating associations between diets or diet components and E. coli O157 prevalence are conflicting or not repeatable, which speaks to the complexity of hindgut ecology and mechanisms responsible for increased or decreased colonization and fecal shedding. Still, feeds and feeding management have been proposed as possible preharvest intervention strategies (Callaway et al., 2003a; Loneragan and Brashears, 2005; LeJeune and Wetzel, 2007). The primary objective of this review is to highlight dietary components or practices that have been associated with E. coli O157 prevalence in ruminants, primarily cattle, and provide insight into factors that may be beneficial in developing intervention strategies. Although feed additives currently in use or being developed, including ionophores, probiotics, and sodium chloride, have been associated with E. coli O157 prevalence, they are not included in this review.

**Grain Type and Processing**

Cattle are typically fed high-energy grain diets to increase weight gain and efficiency of feed conversion; grain type in diets has been linked to E. coli O157 prevalence. Barley grain has been positively associated with E. coli O157 shedding in both observational and experimental studies (Dargatz et al., 1997; Buchko et al., 2000; Berg et al., 2004). Specifically, Berg et al. (2004) reported that cattle shed a higher concentration of E. coli O157 and had higher fecal pH when fed a barley grain diet compared with cattle fed a corn-based diet. Interestingly, concentrations of generic E. coli populations were higher in corn-fed cattle (6.2 log CFU/g) than in barley-fed cattle (5.6 log CFU/g), similar to the grain and forage effect reported by Diez-Gonzalez et al. (1998). Although hypothesized to be a change in hindgut ecology, the specific mechanism responsible for increased E. coli O157 shedding in barley-fed cattle is not known. Barley, which has lower starch content than other traditional cereal grains (Huntington, 1997), is more rapidly and completely digested in the rumen (Ørskov, 1986; Theurer, 1986) and results in less undigested starch for secondary fermentation in the large intestine. Therefore, cattle fed barley grain-based diets have an increased pH and decreased VFA concentrations in the hindgut. A study to evaluate the survival of inoculated E. coli O157 in fecal samples from cattle fed either barley or corn diets found few differences in the pathogen survival; however, pH and VFA concentrations were generally similar between the two diets before E. coli O157 disappeared (Bach et al., 2005b).

In addition to the hypothesized rationale of increased hindgut starch concentration in corn-fed cattle, one study evaluated effects of supplementing canola oil in barley- and corn-based diets because the total oil content between the two grain types is likely different and may impact hindgut conditions (Bach et al., 2005a). Fats or oils could have a direct impact on E. coli O157 because fatty acids, particularly unsaturated fatty acids, have antibacterial activity (Galbraith and Miller, 1973). Fecal shedding of inoculated E. coli O157 was not different between diets in this study, and although fecal pH was lower and VFA concentrations were higher in corn-fed than in barley-fed cattle, there was no effect on shedding, fecal pH, or VFA concentration with supplementation of canola oil (Bach et al., 2005a).

An association between E. coli O157 prevalence and diets containing cottonseed has also been inconsistent. Cottonseed, which has high oil content, could affect the hindgut ecosystem. Garber et al. (1995) reported a negative association between feeding whole cottonseed to heifers and fecal shedding of E. coli O157 in a case-control study; Hancock et al. (1994) reported similar findings. Others have shown no relationship between the two factors (Dargatz et al., 1997; Herriott et al., 1998; Buchko et al., 2000). Several other positive associations between feed types like corn silage (Herriott et al., 1998) and E. coli O157 shedding in cattle have been reported sporadically, but again, these observations are limited (e.g., Dargatz et al., 1997).

The processing method used to prepare cereal grains for cattle diets also affects substrate availability in the hindgut. Processing grains with heat, moisture, or mechanical treatment will increase starch degradation in the rumen, which in turn influences starch availability and fermentation in the lower gastrointestinal tract (Huntington, 1997). Fox et al. (2007) reported that grain-processing method affected E. coli O157 prevalence in cattle. In that study, heifers fed steam-flaked grains (more completely digested in the rumen) had higher E. coli O157 prevalence than heifers fed dry-rolled grain diets (less completely digested in the rumen) on most sampling days. They hypothesized that dry-rolled grains provided more substrate (starch) to the hindgut, reducing pH and creating an inhospitable environment for E. coli O157. The authors measured fecal pH as an indicator for fermentation activity in the hindgut and found no significant difference between cattle fed the two types of processed grains (Fox et al., 2007). Depenbusch et al. (2008) also showed a trend of higher E. coli O157 prevalence in cattle fed steam-flaked grain diets compared with cattle fed dry-rolled grain diets for 30 days. In one of the two experiments, positive E. coli O157 samples were associated with greater fecal starch concentration; however, neither fecal starch nor fecal pH was associated with E. coli O157-positive samples in a second experiment (Depenbusch et al., 2008). An increased fecal starch concentration does not support the hypothesis that increased substrate negatively affects E. coli O157. In an observational study of cattle in Midwestern feedlots, Dewell et al. (2005) found no significant effect of grain processing on E. coli O157 prevalence in cattle.

In an Australian study, steam-flaked sorghum or rolled barley resulted in increased fecal generic E. coli concentrations compared with diets with whole sorghum or barley (Gilbert et al., 2005). The whole grains were associated with higher fecal starch concentrations and higher fecal pH. Because fecal pH and starch concentration are not consistently associated with E. coli O157 (Gilbert et al., 2005; Depenbusch et al., 2008), neither is likely entirely responsible for the association of steam-flaked grains with higher E. coli O157 prevalence. Still, it does appear that different processing methods (steam-flaking and dry-rolling) may affect E. coli prevalence and concentrations.

**Forage Quality**

Similar to the difference reported between grain type and processing, differences in E. coli O157 prevalence have been reported in ruminants fed diets with different forage qualities. Kudva et al. (1995) reported that switching experimentally inoculated sheep from an alfalfa pellet diet to a low-quality forage diets increased E. coli O157 shedding. In another study, E. coli O157 was inoculated in fecal samples from cattle fed
straw, low-digestible grass silage, and highly digestible grass silage plus maize silage, and the survival was analyzed (Franz et al., 2005). The authors reported a faster rate of decline in concentrations of E. coli O157 in low-quality forages, associated with higher pH and fiber content, which contradicts the work of Kudva et al. (1995). Perhaps these differences could be explained by phenolic acids found in the different forage types (described later).

**Forage and Grain Diets**

Studies evaluating effects of forage and grain diets on the fecal shedding of E. coli O157 in ruminants are perhaps the most numerous and conflicting (Table 1). Experimental inoculation studies of both sheep and cattle have shown that animals fed forage diets shed E. coli O157 in the feces for a longer duration than animals consuming grain-based diets (Kudva et al., 1997; Hovde et al., 1999; Van Baale et al., 2004). However, not all studies have found significant differences in E. coli O157 prevalence between these feed types (Tkalcic et al., 2000; Fegan et al., 2004). Additionally, a study evaluating survival of inoculated E. coli O157 in manure samples from cattle fed hay- or silage-based diets had conflicting results, which were related to the duration the donor animals were on feed (Wells et al., 2005).

Generally, the rationale for a positive association is an increased ruminal and/or hindgut pH and decreased VFA concentrations associated with the forage diet, which contribute to a more hospitable environment for E. coli O157 survival and colonization. Van Baale et al. (2004) found an increased fecal and ruminal pH in calves fed forage diets, which complemented their E. coli O157 shedding results. This rationale is logical considering that when ruminants are fed grain diets, starch can be fermented in the rumen or pass through before secondary fermentation occurs in the cecum and colon, lowering pH and increasing VFA concentrations (Huntington, 1997). Russell et al. (2000) reported that grain feeding had a greater effect on fermentation and bacterial populations in the hindgut than in the rumen.

Interestingly, Diez-Gonzalez et al. (1998) reported significantly higher total E. coli concentrations in feces of cattle fed concentrate diets compared with feces from cattle fed forage diets. As expected, lower pH and higher VFA concentrations were observed in cattle fed grain than in cattle fed forage diets (Diez-Gonzalez et al., 1998). Similar findings with generic E. coli have been reported by others (Krause et al., 2003; Gilbert et al., 2005). The association between these generic E. coli and E. coli O157 populations is not known. However, Diez-Gonzalez et al. (1998) reported that increased concentrations of acid-resistant E. coli were observed in cattle fed diets with grain than in cattle fed a diet with no grain. It has been suggested that E. coli O157 survival is favored in low pH and high VFA concentration conditions (Russell et al., 2000). Acid resistance has been shown to occur in E. coli O157 incubated in...

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**Table 1. Effects of Feeding Grain- or Forage-Based Diets on Escherichia coli O157 and Generic E. coli Shedding or Survival in Ruminant Feces**

<table>
<thead>
<tr>
<th>Diet</th>
<th>Organism</th>
<th>Study design</th>
<th>Results</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% grass vs. 50% corn and 50% alfalfa</td>
<td>E. coli O157</td>
<td>Sheep: experimental inoculation</td>
<td>Increased length of shedding in forage-fed</td>
<td>Kudva et al., 1997</td>
</tr>
<tr>
<td>62% barley + 19% corn, 90% alfalfa, and 100% hay</td>
<td>E. coli O157</td>
<td>Cattle: experimental inoculation</td>
<td>Increased length of shedding in hay-fed</td>
<td>Hovde et al., 1999</td>
</tr>
<tr>
<td>1.9 kg Bermuda grass + 3.8 kg concentrate mix vs. 3.8 kg Bermuda grass + 1.9 kg concentrate mix</td>
<td>E. coli O157</td>
<td>Cattle: experimental inoculation</td>
<td>No difference in fecal shedding</td>
<td>Tkalcic et al., 2000</td>
</tr>
<tr>
<td>90% grain + 10% silage vs. 50% alfalfa hay + 50% grass hay</td>
<td>E. coli O157</td>
<td>Cattle: experimental inoculation</td>
<td>No difference in fecal shedding</td>
<td>Grauke et al., 2003</td>
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<tr>
<td>Grass-fed vs. lot-fed</td>
<td>E. coli O157</td>
<td>Cattle: observation of natural prevalence</td>
<td>No difference in prevalence or concentration</td>
<td>Fegan et al., 2004</td>
</tr>
<tr>
<td>85% forage + 15% grain vs. 15% forage + 85% grain</td>
<td>E. coli O157</td>
<td>Cattle: experimental inoculation</td>
<td>Increased length of shedding in forage-fed</td>
<td>Van Baale et al., 2004</td>
</tr>
<tr>
<td>100% hay vs. 88% corn silage + 9% cracked corn</td>
<td>E. coli O157</td>
<td>Cattle: inoculation of feces</td>
<td>Death rate dependent on animal time on feed</td>
<td>Wells et al., 2005</td>
</tr>
<tr>
<td>No grain, 60% rolled corn, 80% rolled corn</td>
<td>Generic E. coli</td>
<td>Cattle: observation of natural E. coli population</td>
<td>Higher concentration in grain-fed</td>
<td>Diez-Gonzalez et al., 1998</td>
</tr>
<tr>
<td>100% forage (grass) vs. 70% rolled sorghum +30% grass</td>
<td>Generic E. coli</td>
<td>Cattle: observation of natural E. coli population</td>
<td>Higher concentration in grain-fed</td>
<td>Krause et al., 2003</td>
</tr>
<tr>
<td>Roughage (±50% molasses) vs. 80% grain</td>
<td>Generic E. coli</td>
<td>Cattle: observation of natural E. coli population</td>
<td>Higher concentration in grain-fed</td>
<td>Gilbert et al., 2005</td>
</tr>
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</table>
Distillers Grains

Because of increased availability due to increased ethanol production, distillers grains, an ethanol fermentation co-product usually derived from corn, are included in cattle diets as a protein and energy source (Klopfenstein et al., 2008). After the starch from corn is fermented to ethanol, the remaining nutrients (protein, fiber, and fat) are concentrated approximately threefold and fed to cattle in a wet or dehydrated form (Klopfenstein et al., 2008). Other cereal grains can be fermented in a similar manner. Several studies have demonstrated an association between feeding ethanol coproducts (distillers or brewers grains) and E. coli O157 prevalence in cattle. In 2003, Syngre et al., investigating management factors associated with E. coli O157 shedding, initially reported an association in Scottish cattle fed distillers grains. This observation was also seen in U.S. feedlots with brewers grains, a coproduct of the brewing industry (Dewell et al., 2005). Differences in the probability of detecting E. coli O157 in the terminal rectum of cattle fed varying levels of distillers grains were reported in a vaccine trial; however, the relationship was not linear (Peterson et al., 2007). In a study aimed at evaluating the effect of feeding distillers grains on E. coli O157 shedding, cattle fed dried distillers grains with solubles (DDGS) at 25% of the final diet had a twofold higher prevalence of the organism than cattle not fed DDGS (Jacob et al., 2008a). Likewise, a challenge model using calves orally inoculated with E. coli O157 and fed one of two diets, with or without 25% DDGS, found that calves fed distillers grains shed higher concentrations of E. coli O157 at the end of the study and had a higher concentration in gut contents at necropsy than calves in the control group (Jacob et al., 2008b). Persistence of the organism was also different in experimentally inoculated manure slurries from cattle fed varying levels of wet distillers grains with solubles (WDGS) (Varel et al., 2008). In that study, E. coli O157 concentrations were greater for a longer duration in cattle fed 20% and 40% WDGS than in manure slurries from cattle fed 0% WDGS. Although the potential association between dietary distillers grains and E. coli O157 prevalence and/or persistence in cattle has been well described, statistically significant associations have not always been found (Jacob et al., 2009). Regardless, there is no published data to suggest that distillers grains decrease the E. coli O157 prevalence or concentration in cattle.

The mechanism responsible for the trend of increased E. coli O157 when feeding distillers grains in cattle is not known. Similar to other dietary components, two general mechanisms have been proposed: (1) distillers grains alter the hindgut ecology of cattle, making a more suitable environment for E. coli O157, or (2) a component of distillers grains stimulates the growth of E. coli O157 (Jacob et al., 2008a). It is not unexpected that hindgut ecology changes when cattle are fed distillers grains. Klopfenstein et al. (2008) described the high ruminal escape property of protein in dried distillers grains diets, which could provide more protein in the hindgut and result in increased degradation and ammonia concentration. Also, the starch content of corn has been removed in distillers grains, which allows for less secondary fermentation compared with corn-based diets. In addition, distillers grains have previously been shown to alter rumen microbial populations (Fron et al., 1996). There is some evidence from in vitro ruminal fluid fermentations that E. coli O157 growth was actually stimulated compared with control fermentations; however, this was not observed in fecal fermentations, which may be expected if the site of action is the lower gut (Jacob et al., 2008a). Clearly, more research is needed before this association can be explained. Physiological factors beyond those altered by feeding distillers grains likely contribute to the discrepancy between some studies, and the increasing use of distillers grains is not solely responsible for E. coli O157 prevalence in cattle.

Dietary Interventions

Seaweed products

There are a few reports on the ability of a commercially available brown seaweed product derived from Ascophyllum nodosum (Tasco-14™; Acadian, Dartmouth, Nova Scotia, Canada) to reduce E. coli O157 shedding in cattle. This product has been shown to improve carcass characteristics in slaughtered cattle (Braden et al., 2007). Using two pens of cattle in a commercial feedlot, Braden et al. (2004) found that feeding 2% Tasco-14 reduced prevalence of E. coli O157 on hides and in fecal samples at slaughter when compared with the control group. The same product was used in a study with calves experimentally inoculated with E. coli O157:H7 (Bach et al., 2007). PENS of inoculated calves were fed a control diet or the seaweed at different levels (10 or 20 g/kg diet) for 7 or 14 days. Over the sampling period, mean E. coli O157:H7 concentrations and the frequency of obtaining a positive sample were lower from animals fed Tasco-14 at 10 and 20 g/kg for 14 and 7 days, respectively, compared with animals fed the control treatment (no Tasco-14) or Tasco-14 at 20 g/kg for 14 days. The mechanism for a decrease in fecal E. coli O157 shedding in cattle administered Tasco-14 is not known but is hypothesized to be a direct microbial effect (Braden et al., 2004). This was supported by the work of Bach et al. (2007), who found no changes in VFA concentrations or pH in fecal samples from the four treatments. This seaweed product may have potential as a preharvest intervention strategy.

Phenolics/essential oils

Plants commonly synthesize phenolic compounds for defense against microorganisms and predators. The antimicrobial nature of these compounds is believed to be enzyme inhibition by oxidized compounds or interactions with proteins that have not been described (Cowan, 1999). There is some evidence to suggest that phenolic compounds can be inhibitory to E. coli O157. Survival of E. coli O157 inoculated into cattle fecal samples decreased, particularly when higher
concentrations (0.5%) of trans-cinnamic and para-coumaric acids were applied to the samples (Wells et al., 2005). Only one of these compounds, trans-cinnamic acid, affected fecal pH (Wells et al., 2005), so it is not known whether inhibition was pH mediated or the result of a direct microbial effect. Tannins, a more complex phenolic compound observed in hydrolyzable and condensed types (Cowan, 1999), have also been evaluated for efficacy as an inhibitory substance for E. coli O157. In-vitro incubations showed that both tannin types decreased the growth rate of E. coli O157 in pure culture and were bactericidal, more so with the hydrolyzable type, to E. coli O157 (Min et al., 2007). In addition, the hydrolyzable tannin was shown to reduce fecal E. coli concentration in an in-vivo experiment with cattle fed hay diets (Min et al., 2007).

It has been known for some time that essential oils, which are also phenolic compounds, obtained from plants have antibacterial properties that can inhibit foodborne pathogens in pure culture (Dabbah et al., 1970; Burt and Reinders, 2003; Burt, 2004). Often, these oils are more effective against Gram-positive organisms (Dabbah et al., 1970; Fisher and Phillips, 2006), although application of some plant oils has been shown to reduce coliform counts in stored manure (Varel and Miller, 2001). Although the specific mechanism of action is compound dependent, the ability of oils to disrupt membranes and ion concentrations generates their antibacterial properties (Cowan, 1999; Burt, 2004). Nannapaneni et al. (2008) demonstrated the susceptibility of E. coli O157:H7 isolates to two of seven orange essential oils by agar-disk diffusion. Recently, in-vitro ruminal fluid fermentations with varying concentrations of orange peel or dried orange pulp, which contain essential oils, were shown to decrease inoculated E. coli O157:H7 (Callaway et al., 2008). The concentration of citrus oil reaching the lower gut, the colonization site for E. coli O157, is unknown. However, because the organism can also be in the rumen (Laven et al., 2003) feeding orange pulp products may be a useful in-feed intervention strategy. Feeding citrus products, primarily dried pulp, to cattle as a source of energy is common in citrus-producing regions like Florida (Wing, 2003). Further work is needed to assess in-vivo efficacy of these products; however, if proven to work they are potentially useful, particularly in diets of beef and dairy cattle in regions where the coproducts are available.

Mechanisms and Implications

It is generally accepted that most cattle shedding E. coli O157 do so at a concentration of <10^3 CFU/g feces; however, there appears to be extreme individual animal variation, with some shedding the organism at much higher levels (e.g., >10^5 CFU/g feces; Low et al., 2005; Chase-Topping et al., 2007). These animal variations, particularly when animals shed a large concentration of E. coli O157, likely contribute to overall group prevalence (Matthews et al., 2006) but have not always been linked to diet and are not well understood. Other factors, including season, have frequently been associated with E. coli O157 prevalence. These factors show that the biological relationship between E. coli O157 and the ruminant reservoir is likely more complex than diet influences alone. However, because feed components continue to be associated with prevalence, understanding these interactions may allow us to exploit the mechanisms for potential preharvest intervention. It is difficult to assess the specific effect of different diet components on E. coli O157 growth and colonization in-vivo. The true prevalence of E. coli O157 independent of any diet influence in cattle is not known so differences attributed to one component increasing the shedding cannot easily be distinguished from another component decreasing shedding.

The difference in prevalence observed between different diets is often attributed to changes in hindgut ecology, primarily pH and VFA concentrations, although in the case of phenolic and seaweed interventions, it may be direct microbial effects. The pH and VFA concentrations throughout the rumen and intestine are directly related to feed composition; however, studies evaluating dietary influences on E. coli O157 rarely report these values. Even when reported, results are not always consistent and provide only a generalized hypothesis. One reason for the inconsistencies in pH and VFA concentration data may be the inherent differences in component utilization between animals. Ørskov (1986) reports a difference in starch fermentation of 35% between two sheep fed an identical corn diet. Another reason for inconsistencies is the variability in nutrient composition between feed products including slilage where the starch content is influenced by inclusion level and plant maturity (Huntington, 1997). Finally, dietary influences are sometimes reported using generic E. coli populations as a model for E. coli O157. There are inconsistencies in the response of E. coli O157 and more generic E. coli populations to pH and dietary influences. When used as a model, these results are difficult to interpret and suggest that E. coli may not always be equivalent for assessing an E. coli O157 response to diet influences (Grauke et al., 2003).

One proposed mechanism for E. coli O157 inhibition in the hindgut is an increase in secondary starch fermentation (Fox et al., 2007). Starch content can vary by grain type and processing method, but passage rate and consumption also contribute to the amount of starch initially fermented in the rumen (Huntington, 1997). Generally, a large percentage of starch (80–95%) is fermented in the rumen, and a considerable portion of the remaining starch undergoes digestion in the small intestine (Huntington, 1997). Still, starch that escapes the rumen and small intestine can undergo secondary fermentation in the large intestine, similar to ruminal fermentation, and result in changes in pH and VFA concentrations (Ørskov et al., 1970). The effect of starch or glucose infused both ruminally and/or abomasally into steers was shown to lower cecal and fecal pH compared with controls; however, total anaerobic and aerobic counts were higher (Van Kessel et al., 2002). There was no statistically significant difference in total E. coli counts. Diets with higher starch contents generally decrease the concentration of acetate while increasing propionate and butyric acid concentrations (Ørskov et al., 1970). Still, more specific effects of these specific short-chain fatty acids are not well described. In pure culture, propionate was shown to reduce viability of E. coli O157 at 37°C (McWilliam Leitch and Stewart, 2002). Antimicrobial activity toward E. coli O157 in this study was actually greater for lactate, another organic acid derived from glucose. Sensitivity of E. coli O157 to lactate has been described elsewhere (Jordan et al., 1999). In addition, Krause et al. (2003) showed that lactic acid bacteria showed results similar to E. coli, increasing in concentration in grain-fed cattle. The effect of these results, specifically as they relate to E. coli O157, is not known; however, lactic acid bacteria have been shown to have anti-E. coli O157 effects (Brashears et al., 2003).
Few studies relate dietary fiber content to *E. coli* O157 shedding in cattle, and fiber content is often not measured in fecal samples. However, dietary fiber is known to alter physiology and stimulate growth of bacteria in the human colon (Cummings and Stephen, 1980). Possibly, increased fiber content stimulates increased mucus production in the hindgut. Higher fiber concentration than animals with a higher dietary acid detergent fiber percentage (10–35%). In both studies, increasing fecal pH values were seen with higher fiber content samples. Higher fiber content may be confounded by other dietary influences such as starch because of diet composition. The association between *E. coli* O157 and distillers grains, with concentrated fiber components and decreased starch content, is just one example of this complexity. Feeding high lipid content may also alter the hindgut ecosystem and affect *E. coli* O157, however, studies assessing various oils (canola and cottonseed) have generally shown no association. The lipid content in distillers grains is also concentrated, but again, these results are likely confounded by other factors (starch, fiber, etc.). Interestingly, essential oils, including those from citrus products, have some direct antimicrobial property, have shown some efficacy, and may be a useful intervention strategy.

In conclusion, to better understand effects of diet on *E. coli* O157 colonization and shedding in cattle, more specific work to confirm and identify differences beyond pH and VFA concentrations is needed. Many inconsistencies regarding dietary influences on *E. coli* O157 are reported in the literature; however, variability in nutrient composition, animal utilization, and processing methods influence these physiological conditions and make repeatable results challenging. Difficult, work to distinguish between confounding factors such as fiber and starch may add clarity to any potential mechanism associated with increased *E. coli* O157 colonization. In addition, the organism–host relationship is likely far more complex than dietary influences alone, and the response to dietary changes of other microbial populations, possibly other foodborne pathogens, is not known. Still, if simple mechanisms can be exploited or existing or new compounds with direct anti-*E. coli* O157 activity can be developed, practical preharvest intervention strategies to reduce the economic and human health burden of this organism can be implemented.

**Disclosure Statement**

No competing financial interests exist.

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