CHAPTER 16

Escherichia coli O157:H7 and *Listeria monocytogenes* Shedding in Beef and Dairy Cattle

Introduction

THE CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC) has identified *Escherichia coli* O157:H7 and *Listeria monocytogenes* as two major foodborne pathogens (CDC, 2014). Consumption of ground beef is the most frequently implicated cause of *E.coli* O157:H7 foodborne illnesses in humans, and food products from cattle have been linked to approximately 75 percent of these outbreaks (USDA-APHIS, 1997; Vugia et al., 2007). Cattle are a major reservoir of *E. coli* O157:H7 in the mucosal surface of the rectum (Naylor et al., 2003; Gyles, 2007; Hussein, 2007) and in feces (Callaway et al., 2003; Berg et al., 2004; Jacob et al., 2008a,b). In fact studies have shown that up to 30 percent of cattle are carriers of E. coli O157:H7 (Callaway et al., 2006; Reinstein et al., 2007; Stanford et al. 2005).

Many factors affect shedding of these pathogens in ruminants including feed, water, age of animal, and season (Caro et al., 1990; Bach et al., 2002; Renter and Sargeant, 2002; Ho et al., 2007). Manure containing *E.coli* O157:H7 from cattle housing facilities can contaminate water supplies, be used as irrigation water for crops, or transmitted through other animals (Hill et al., 2006; LeJeune et al., 2001; Sargeant et al., 2003; Thurston-Enriquez et al., 2005). Although diet is considered to be an important factor that may contribute to fecal shedding of these pathogens, the relative impact of grain, grain co-products, and forage is unclear. Initial research by Diez-Gonzalez et al. (1998) showed that an abrupt shift from grain to hay-based rations significantly reduced generic *E.coli* populations. However, several subsequent research studies that have shown variable results (Hancock et al., 2000; Hovde et al., 1999; Keen et al., 1999).

Listeria monocytogenes are also present in feces of cattle (Pell, 1997; Pauly et al., 1999). Several *Listeria* spp. (*L. innocua*, *L. monocytogenes*, and *L. welshimeri*) were identified to be present in 9 to 35 percent of fecal samples from healthy beef feedlot cattle (Siragusa et al., 1993). Skovgaard and Morgen (1988) showed that *Listeria* spp. were present in fecal and silage samples collected from 7 dairy farms, and Ryster et al. (1997) isolated *L. monocytogenes* from 2 percent of 129 silage samples and 35 of hay silage samples. These results indicate that silage samples may be a potential risk factor for transmission of *L. monocytogenes* to cattle. However, there is a lack of clear evidence showing a direct relationship between diet composition and pathogen shedding in beef and dairy cattle.

Because of the concerns about potential contamination of meat and milk with *E.coli* O157:H7 and *L. monocytogenes*, and the potential role that diet composition may contribute to the risk of contamination, it is important to review the results from research studies involving feeding DDGS to beef and dairy cattle to determine if it is a risk factor.

Does DDGS Increase Shedding of *E. coli* O157:H7?

Various types of bacteria are present everywhere in the environment and they are present in corn co-products. However, the proportion of grain and forage, and crude protein levels in cattle diets may be a more important factor (Biswas et al., 2016).

An initial report suggested that feeding DDGS increased the shedding of *E. coli* O157:H7 in cow-calf operations in Scotland (Synge et al., 2003). In a subsequent study, other researchers found that feeding brewer's grains to cattle also increased *E. coli* O157 shedding, and increased the likelihood of shedding by more than 6-fold (Dewell et al., 2005). In 2007, there was a dramatic increase in interest in identifying and understanding the possible reasons for the increase in E. coli O157:H7 contamination in ground beef in the United States. Because of the exponential increase in distiller's grains production and use in cattle diets during this same time period, there were some suspicions that feeding distiller's grains were contributing to this problem. As a result, researchers began conducting studies to determine if there was a relationship between feeding distiller's grains with solubles and the increased incidence of *E. coli* O157:H7 in beef. A series of controversial studies conducted by researchers at Kansas State University (Jacob et al., 2008a,b,c), showed low prevalence and inconsistent responses to *E. coli* O157:H7 shedding in feedlot cattle fed DDGS diets. Despite these inconsistent results, these researchers concluded that feeding distiller's grains increased fecal *E. coli* O157:H7 shedding in beef feedlot cattle.

However, subsequent studies conducted by researchers at the University of Nebraska (Peterson et al., 2007) showed that feeding up to 50 percent (dry matter basis) wet distiller's grains diets did result in *E. coli* O157:H7 shedding occurred, but the level of shedding was no different than cattle fed diets containing no DDGS. These results were not in agreement with those reported by Jacob et al. (2008a,b,c).

Furthermore, Nagaraja et al. (2008) collected manure samples from 700 cattle fed either control and DDGS diets for 150 days and showed that the overall prevalence of *E. coli* O157:H7 shedding was low (5.1 percent) and feeding DDGS had no effect on increasing *E. coli* O157:H7 shedding. Furthermore, in contrast to earlier studies, Jacob et al. (2009) showed no differences in the fecal shedding of *Escherichia coli* O157:H7 and *Salmonella* spp. in cattle fed dry-rolled corn or DDGS.

Callaway et al. (2010) conducted a study to evaluate changes in rumen and fecal bacterial population in beef feedlot cattle fed diets where DDGS replaced 0, 25, or 50 percent of the grain supplement and showed that bacterial populations were different when feeding DDGS, which may have been related to lower rumen pH. Biswas et al. (2016) showed that feeding a high forage and high protein diet resulted in the greatest *E. coli* O157:H7 shedding in dairy cattle, compared with the low forage and high protein diet which resulted in the least shedding. These results indicate that diet composition and crude protein content can influence *E. coli* O157:H7 shedding in dairy cattle, but including DDGS in the ration had no effect.

Currently, there is no scientific evidence suggesting that the levels of DDGS being fed is a cause for *E. coli* O157:H7 contamination in ground beef. Furthermore, if there is a possible connection between feeding of distiller's grains and E. coli shedding, the mechanism has not been elucidated. *In vitro* studies have not detected any effects of distiller's grains on *E. coli* O157:H7 populations in mixed ruminal and fecal fluid fermentations (Callaway et al., 2008). It is important to recognize that bacterial contamination (including *E. coli* O157:H7) in the meat supply can occur during many segments of the food chain, and is not restricted to feed or feed ingredients.

Does DDGS Increase Shedding of *L. monocytogenes*?

No studies have been conducted to determine the effect of diet composition or feeding DDGS on fecal shedding of *Listeria* by cattle. Fenlon et al. (1996) showed that about 30 percent of cattle in one herd shed *L. monocytogenes* after being fed silage. Ho et al. (2007) determined that 38 percent of silage samples evaluated contained *L. moncytogenes*, and 94 percent of the cows fed silage excreted *L. moncytogenes* in their feces at least once during the study. Biswas et al. (2016) showed that dairy cows excreted *Listeria* when fed alfalfa hay that was contaminated with *Listeria*, which represented the greatest portion of the diet. These researchers showed that feeding a high forage or low protein diet resulted in the greatest *Listeria* shedding compared with feeding low forage or high protein diets. However, the DDGS source used in this study contained no detectable levels of *E. coli* or *Listeria* spp.

Conclusions

Food-borne pathogenic bacteria continue to be a significant threat to human health in many countries around the world, despite the implementation of food safety regulations. Although post-harvest sanitation strategies have reduced *E. coli* O157:H7 and *Listeria* monotogenes presence in meat and milk products, implementation of pre-harvest intervention strategies can further reduce the risk of food borne pathogens in food animals before they enter the food chain. Some feedstuffs appear to alter shedding levels of *E. coli* O157:H7, but these effects have not always been consistent. Fasting and feeding poor quality forages have been shown to increase shedding of *E. coli* O157:H7 in cattle, but abruptly switching cattle from a high grain diet to a high-quality hay-based diet has been shown to reduce *E. coli* O157:H7 populations. More research is needed to identify the mechanism (e.g., competitive exclusion, physical removal, forage quality, tannins, lignin, other phenolics) by which feeding forage impacts the microbial populations of the ruminant intestinal tract, including the ecology of *E. coli* and *E. coli* O157:H7 populations, in order to implement practical dietary modifications. Furthermore, very little is known about the effects of diet composition and the use of various feed ingredients in *Listeria* shedding in dairy and beef cattle.

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