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Vaccine impacts E. coli O157 in feedlot cattle

Abstract

Many human foodborne illnesses are caused by pathogens commonly harbored by food animals. Escherichia coli O157 is one of these pathogens commonly isolated from beef cattle feces and can enter the food chain at harvest. In addition to the human health concerns, this pathogen has important economic implications. Costly recalls of beef products and loss of consumer confidence associated with outbreaks of foodborne illness can affect profitability on many levels of production. In the past 10 years, E. coli O157 has cost the beef industry an estimated $2.67 billion. A portion of this expense is allocated to government and industry research. Methods to intervene and reduce the opportunity of these pathogens to enter the food chain have been tested and implemented both pre- and postharvest. The focus of this experiment was to evaluate the effectiveness of a novel vaccine technology to reduce E. coli O157 shedding in feeder cattle prior to harvest. A relatively new vaccine technology developed by Epitopix (Wilmar, MN) targets pathogenic bacteria based on their inherent requirement for iron. Vaccines developed with this technology target siderophore receptor and porin proteins (SRP) of specific bacteria and disrupt their iron transport systems, which ultimately causes death of the organisms. Preliminary experiments have shown that SRP vaccines reduce fecal shedding of Salmonella Newport and E. coli O157 in experimentally infected mice. In two experiments involving experimentally infected cattle, an SRP vaccine for E. coli O157 reduced fecal shedding of the experimental strain of E. coli O157. Given the success of this vaccine in cattle challenged with E. coli O157, the objective of the current experiment was to test the efficacy of the E.coli O157 SRP vaccine in feedlot cattle naturally infected with E. coli O157.

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

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VACCINE IMPACTS *E. COLI* O157 IN FEEDLOT CATTLE

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Introduction

Many human foodborne illnesses are caused by pathogens commonly harbored by food animals. *Escherichia coli* O157 is one of these pathogens commonly isolated from beef cattle feces and can enter the food chain at harvest. In addition to the human health concerns, this pathogen has important economic implications. Costly recalls of beef products and loss of consumer confidence associated with outbreaks of foodborne illness can affect profitability on many levels of production. In the past 10 years, *E. coli* O157 has cost the beef industry an estimated $2.67 billion. A portion of this expense is allocated to government and industry research. Methods to intervene and reduce the opportunity of these pathogens to enter the food chain have been tested and implemented both pre- and post-harvest. The focus of this experiment was to evaluate the effectiveness of a novel vaccine technology to reduce *E. coli* O157 shedding in feeder cattle prior to harvest.

A relatively new vaccine technology developed by Epitopix (Wilmar, MN) targets pathogenic bacteria based on their inherent requirement for iron. Vaccines developed with this technology target siderophore receptor and porin proteins (SRP) of specific bacteria and disrupt their iron transport systems, which ultimately causes death of the organisms. Preliminary experiments have shown that SRP vaccines reduce fecal shedding of *Salmonella* Newport and *E. coli* O157 in experimentally infected mice. In two experiments involving experimentally infected cattle, an SRP vaccine for *E. coli* O157 reduced fecal shedding of the experimental strain of *E. coli* O157. Given the success of this vaccine in cattle challenged with *E. coli* O157, the objective of the current experiment was to test the efficacy of the *E. coli* O157 SRP vaccine in feedlot cattle naturally infected with *E. coli* O157.

Experimental Procedures

A population consisting of approximately 600 feedlot heifers was screened for the presence of *E. coli* O157 in the feces. Cattle positive for fecal shedding of *E. coli* O157 were re-sampled to confirm shedding. At re-sampling, an additional procedure was included to identify animals that were shedding the organism at abnormally high levels (super-shedders). Sixty cattle were selected from the original population for use in this study. Fifty of these 60 animals were fecal positive for *E. coli* O157 on two occasions and the remaining 10 animals were fecal positive on one occasion. Cattle were stratified based on results of fecal shedding of *E. coli* O157 in screening samples and randomly allotted, within strata,

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to one of three treatment groups (20 animals/treatment): 1) control, 2) vaccinated on day 0 and 21 with 2 cc with SRP *E. coli* vaccine, or 3) vaccinated on day 0 and 21 with 3 cc of SRP *E. coli* O157 vaccine. Cattle were housed in one of three barns containing 20 individual feeding pens. Animals were allocated to pens in treatment blocks within each barn to eliminate sharing of waterers across treatments and reduce animal-to-animal contact across treatments. Waterers were cleaned three times weekly to reduce the potential of these as a transmission vector. Cattle were fed a standard feedlot receiving diet (Table 1) once daily.

Table 1. Ingredient Composition and Nutrient Content of the Experimental Diet

Ingredients:	Percent of Diet (DM basis)
Steam-flaked corn	50.3%
Alfalfa hay	40.0%
Corn steep liquor	4.0%
Premix	5.7%
Nutrients:	
NEm	0.83 Mcal/lb
NEg	0.55 Mcal/lb
CP	14.5%
Ca	0.70%
P	0.33%
Ca:P	2.1:1

Fecal samples and rectoanal mucosal swab samples were collected two or three times a week for 8 weeks to monitor shedding of *E. coli* O157. Precautions were taken to reduce the potential for sample contamination chute side. Detection of *E. coli* O157 was by selective enrichment, immunomagnetic separation, and plating on selective agar. Biochemical and antigenic tests were also used for further confirmation. Procedures to identify super-shedders were also performed on fecal samples. Briefly, pre-enriched samples were streaked onto selective agar in triplicate and if two or three of these plates had confirmed *E. coli* O157 colonies present, the animal of sample origin was considered a super-shedder.

Results and Discussion

Overall, average *E. coli* O157 prevalence across all sampling days in the feedlot heifers was 9.3% as detected by rectoanal mucosal swab (RAMS) culture, 10.9% as detected by fecal culture, and 15.8% as detected by either RAMS or fecal culture. A previous study performed one year earlier with similar type cattle in the same facility with similar procedures found an average prevalence of 50%. Because prevalence was lower than expected, data were analyzed as repeated measures on animals over weeks instead of sampling days to increase prevalence, and barn was included as a random effect. Overall prevalence of *E. coli* O157 in cattle receiving placebo, 2 ml vaccine, and 3 ml vaccine was 33.7%, 29.1%, and 17.7% (Figure 1). Treatment also reduced the number of days that animals were found positive for *E. coli* O157, with a significant difference in pair-wise comparison of placebo vs 3 ml vaccine treatments (P = 0.08; Figure 2).

Modeling efforts by other researchers revealed that 80% of natural transmission of *E. coli* O157 in a cattle population is attributed to 20% of infections in which animals are shedding the organism at abnormally high levels. Reducing the number of animals shedding at high levels would be an important outcome of pre-harvest intervention strategies. In the current experiment, the number of animals identified as super-shedders on one or more sampling days was reduced by vaccine treatment (P = 0.08; Figure 3). Again, pair-wise com-

parison of placebo and 3 ml vaccine treatments revealed that the vaccine was efficacious in reducing the percentage of *E. coli* super-shedders in feeder cattle. These differences may give insight into proper dosage of the vaccine for efficacy in naturally infected cattle.

Implications

The *E. coli* O157 SRP vaccine reduced prevalence and the number of days that cattle shed *E. coli* O157 and there is evidence that the vaccine decreases the number of cattle shedding high levels of the organism.

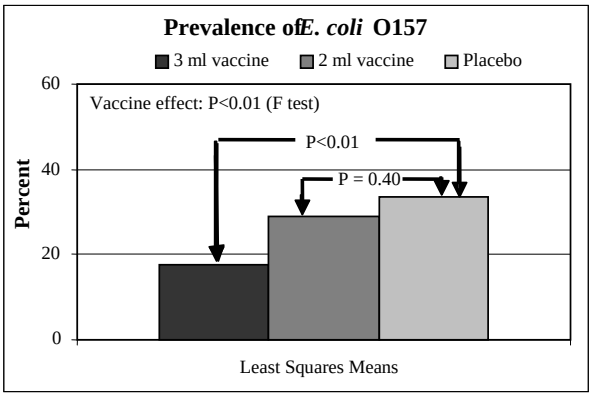

Figure 1. Percent of Animals Testing Postitive for *E. coli* O157 on Sampling Weeks by Treatment Group.

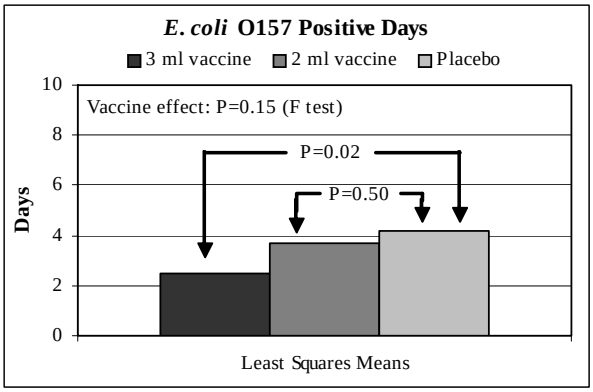

Figure 2. Least Squares Means of the Number of Days Animals were Found Positive for *E. coli* O157 by Treatment. Data were analyzed with a general linear model.

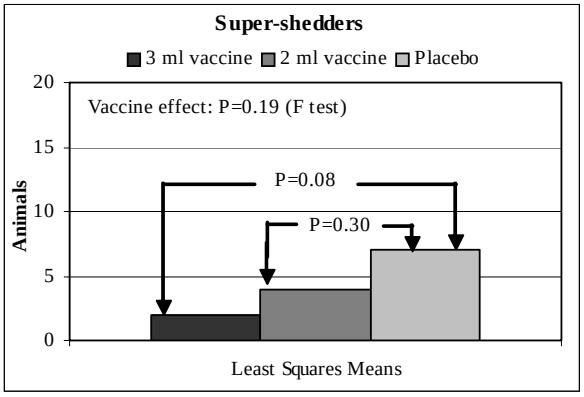

Figure 3. Least Squares Means by Treatment of the Number of Animals Detected as Super-shedders on One or More Sampling Days. Data were analyzed with a general linear model.