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Research and Extension

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A Commercially Available SRP Vaccine Reduces Prevalence of *E. coli* O157:H7 in Feces of Beef Cattle Under Commercial Feedlot Conditions

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Introduction

Of all food safety challenges facing the beef industry, *Escherichia coli* O157:H7 has consistently presented the greatest economic remonstrance to meat packers and retailers. Cattle naturally shed *E. coli* O157:H7 in their feces, and it is a source of carcass contamination at harvest. If contaminated trim enters the food supply and is subsequently prepared incorrectly, it can lead to the human condition known as hemorrhagic colitis. In children or elderly people, an *E. coli* O157:H7 infection may lead to a more serious form known as hemolytic uremic syndrome, which is potentially lethal. Although the majority of previous research has been dedicated to reduction in contamination post-harvest, recent focus has shifted to pre-harvest mitigation of *E. coli* O157:H7. Post-harvest procedures are effective, so there is less room for improvement than in pre-harvest mitigation. Also, reducing the *E. coli* O157 burden entering the plant may improve the efficacy of post-harvest tools and ultimately reduce human illness.

Most previous research efforts have been focused on controlling *E. coli* within the abbatoir. Over the last 10 years, the National Cattlemen's Beef Association has estimated *E. coli* O157 to cost the industry $2.67 billion. The *E. coli* O157 siderophore-receptor and porin-based (SRP) vaccine has been shown to reduce fecal shedding of *E. coli* in cattle in laboratory conditions as well as field conditions. In 2007, the vaccine received conditional licensure from the USDA. The objective of this study was to determine the efficacy of the SRP vaccine by (1) quantifying the prevalence of *E. coli* O157:H7 in vaccinated cattle under field conditions and (2) monitoring anti-SRP antibody titer levels immediately prior to harvest.

Experimental Procedures

Beef cattle from 10 commercial feedlots located in Nebraska and Colorado were used in the field trial, with a total of 200,000 animals enrolled in the study. Feedlots were randomly assigned to 1 of 2 treatments: (1) all incoming cattle were injected with 2 ml of SRP *E. coli* O157:H7 vaccine (Pfizer Animal Health, New York, NY) subcutaneously at arrival and again at time of re-implant (approximately 100 days prior to harvest) or (2) all incoming cattle were used as controls and did not receive the vaccine. Feedlots were assigned letters (A–J), and samples were labeled with the appropriate feedyard letter code, sample number, and sampling date to blind laboratory personnel to treatment assignment.

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Cattle were housed in pens with pipe-and-cable fences, concrete feed bunks, and automatic waterers. Approximately 80 to 120 cattle were housed in each pen, depending on bunk space availability. Cattle did not co-mingle during the study. Cattle were fed a similar ration at all feedyards, consisting of a mixture of high-energy grains, roughage, and supplement.

Upon arrival, cattle were unloaded into an arrival pen and allowed to rest for 24 hours prior to processing. The next morning, cattle were processed, subjected to normal processing procedures (vaccination, deworming, and administration of a steroid implant), and administered the 2-ml dose of SRP *E. coli* O157 vaccine. Per label, the vaccine was administered subcutaneously in the neck. As part of the 2-dose regimen, cattle received a second 2-ml dose of the SRP vaccine at time of re-implant, which varied from 1 to 3 months after initial vaccination (approximately 80 to 100 days before harvest).

Pen floor fecal samples were taken from feedyards at 4 sampling intervals over the course of the summer (May, June, July, and August) of 2010. Within each feedyard, 5 pens of market-ready cattle were selected for sampling each week; cattle within these pens were shipped to the abbatoir the following week. Samples from 20 fresh fecal pats were collected using a clean spoon, cup, and lid. A 0.35-oz fecal sample was collected, and the sample cup was labeled and sealed in a plastic bag. The sealed bags containing the sealed sample cups were stored on ice in coolers. After sampling, coolers shipped overnight to the Epitopix laboratory in Willmar, MN, for microbiological analysis.

Coinciding with the fecal sample collection, pre-harvest blood samples were taken from cattle entering the packing plant. Samples were collected on 3 occasions throughout the summer (June, July, and August). For each sampling month, 1 lot of 5 animals representing each feedyard was sampled. Samples were shipped frozen on dry ice to Epitopix laboratory for anti-SRP antibody determination using enzyme-linked immunosorbant assay.

Pen-level prevalence of *E. coli* O157:H7 was converted to odds ratios, and these values were log transformed for statistical analysis. This statistical design entailed a repeated measure on the feedyard. Outcomes of interest were modeled using categorical linear regression techniques. Pen-level binomial response variables were analyzed using the LOGIT format of PROC GLIMMIX in SAS (SAS Inc., Cary, NC).

For fecal samples, 2 statistical models were found to be relevant in this trial. The first model took into account the random effect of feedyard, which incorporates interdependency between animals within a pen, as well as the interdependence of pens within the feedyard. This model revealed an interaction between feedyards and sampling month, so a second model was created to force this interaction into the model as a random variable. For the second model to converge, the random effect of feedyard was removed. From these models, least squared means were computed to determine statistical significance. Means were considered different using a protected F-test with $\alpha = 0.10$.

Results and Discussion

A significant vaccine status × sampling time interaction occurred for prevalence of *E. coli* O157:H7 in the feces of cattle (*P* = 0.0004). After accounting for this interaction, prevalence of *E. coli* O157:H7 was lower in the feces of vaccinated cattle (12.83%) when compared with feces of control cattle (20.25%; *P* = 0.07; Figure 1). This model demonstrates a reduction in *E. coli* O157 shedding with the use of 2 sequential doses of SRP vaccine. Prevalence was also lower in May than in June, July and August (Figure 2).

Anti-SRP antibody titer level was higher in vaccinates (0.622) versus controls (0.075; *P* < 0.001; Figure 3). Titers were also compared within the vaccinate cohort by days on feed since last vaccination. Cattle were placed into 1 of 3 bins based on the length of time since receiving the second vaccination. There was no difference in sample:positive ratios among the 3 groups.

Because vaccinated cattle demonstrated elevated titers when sampled at the packing plant immediately prior to harvest, the vaccine is effective at inducing a prolonged immune response throughout the feeding period. There was no difference in titer response with increasing days on feed following the final vaccination (Figure 4). Regardless of how many days prior to harvest calves were vaccinated, a measurable anti-SRP antibody response was evident at the time of slaughter. Results of this study suggest that a simple ELISA blood test at harvest could be used as a tool for vaccination compliance.

Implications

Vaccination of feedlot cattle with SRP *E. coli* vaccine may be an effective tool to reduce the prevalence of *E. coli* O157:H7 in feedlot cattle upon arrival at the packing plant, reducing the risk of foodborne illness from beef products.
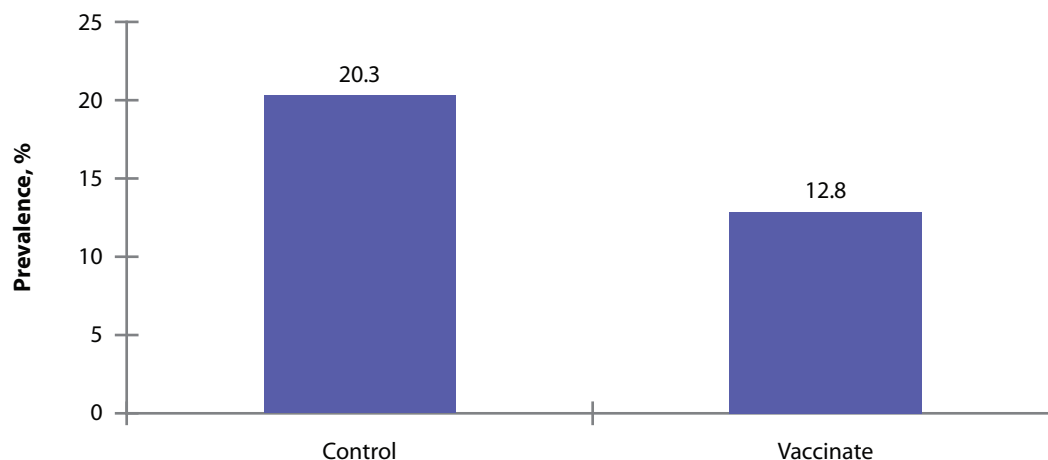

Figure 1. Effect of SRP technology on *E. coli* O157:H7 prevalence in feeder cattle (vaccinates vs. control, *P* = 0.07).
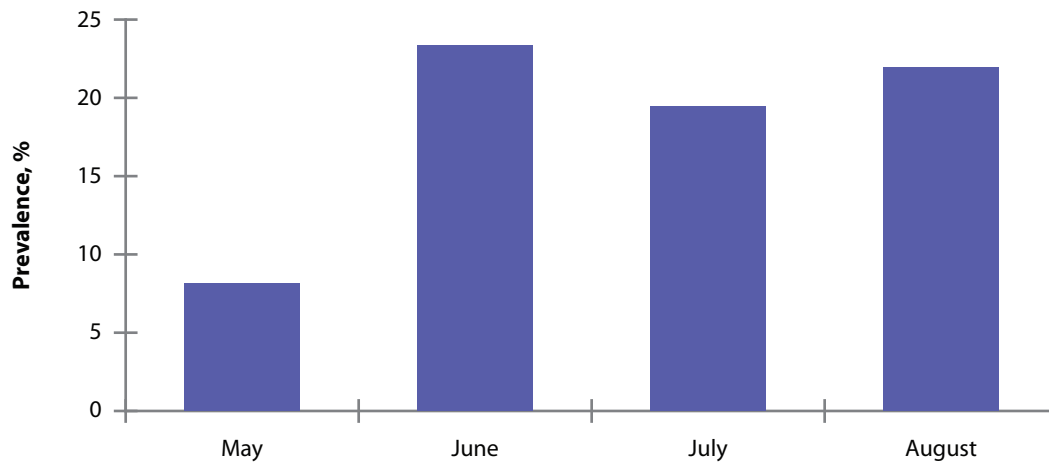
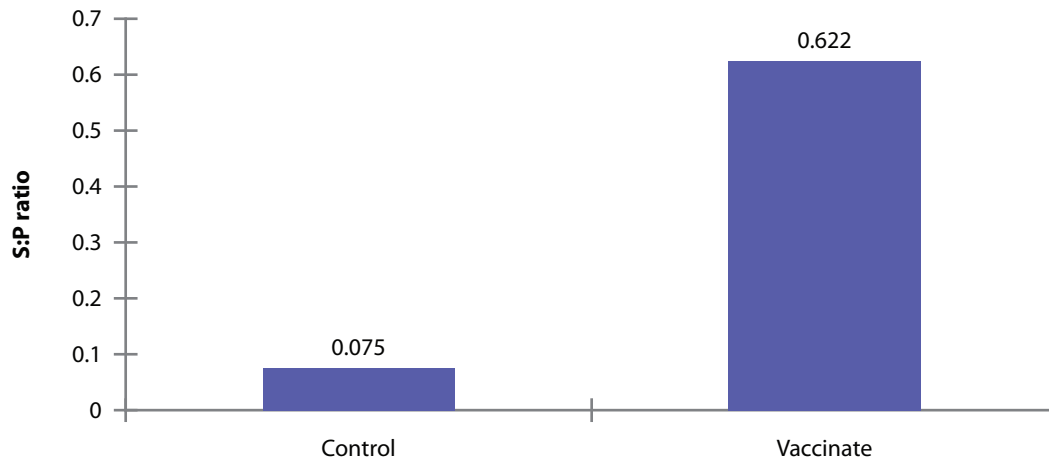**Figure 2. Prevalence of *E. coli* O157:H7 in feeder cattle during summer months (effect of month, *P* = 0.04).**

Figure 3. Effect of SRP vaccination on serum anti-*E. coli* O157:H7 sample:positive (S:P) ratio in feeder cattle (vaccinates vs. controls, *P* < 0.01).
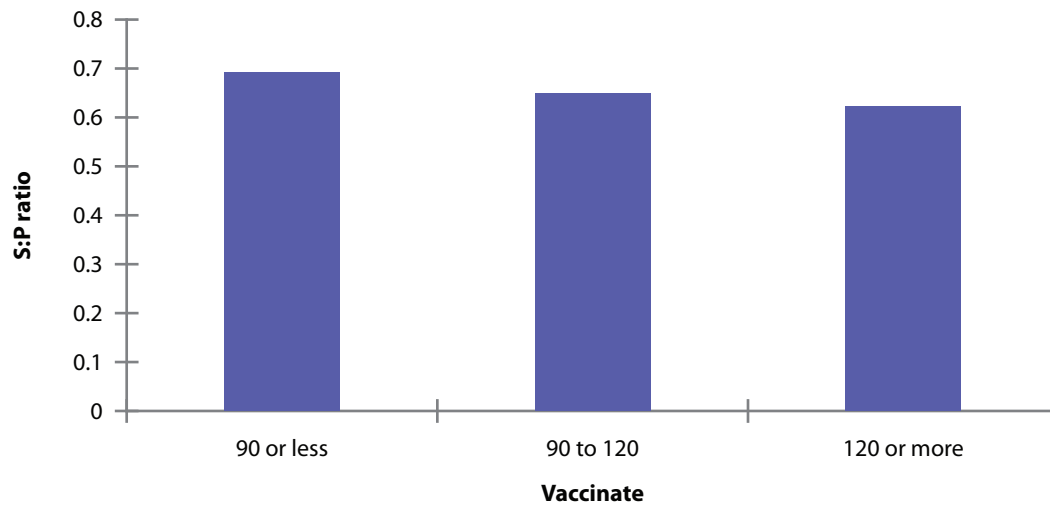
Figure 4. Sample:positive (S:P) ratio of vaccinates relative to days on feed since last vaccination (effect of days on feed, $P = 0.31$).