

## Project Summary

### **Orange Pulp and Peel as Feedstuffs to Reduce *E. coli* O157:H7 and *Salmonella* Populations in Ruminants**

#### **Principal Investigators:**

Todd Callaway<sup>1</sup>, Tom Edrington<sup>1</sup>, Steven Ricke<sup>2</sup>, and Phil Crandall<sup>2</sup>

<sup>1</sup>USDA ARS, and <sup>2</sup>University of Arkansas

**Study Completed  
2010**



*Funded by The Beef Checkoff*

# Orange Pulp and Peel as Feedstuffs to Reduce *E. coli* O157:H7 and *Salmonella* Populations in Ruminants

## Executive Summary

### Background

Foodborne pathogenic bacteria such as *E. coli* O157:H7 and *Salmonella* are threats to the safety of beef, and are publically perceived as “hamburger diseases”. These pathogens are found in the gut of cattle where they can live undetected in both beef and dairy cattle. Each year, EHEC and *Salmonella* spp. infections cause more than 1.6 million illnesses at a cost to the U.S. economy of more than \$15.6 billion. Foodborne pathogenic bacteria can be introduced into the abattoir in the feces of cattle or attached to their hide, providing a direct route into the food chain.

Because of the economic, public health and market share impact of these pathogens, several intervention strategies have been implemented in cattle processing plants to decrease bacterial contamination on carcasses. However, these are not perfect. Therefore pre-harvest intervention strategies that reduce pathogens in the live animal have been devised and investigated. Not only do pre-harvest pathogen reduction strategies reduce pathogen load entering the processing plant, but they also reduce the pathogen burden in the environment which has led to several high profile human outbreaks that were linked to cattle manure (e.g., lettuce outbreak in California).

Fresh citrus peel and dried orange pulp are by-products from citrus juice production that have a relatively high nutritive value (high TDN). Orange peel and pulp is available at low prices in citrus-producing regions and is often incorporated into least cost ration formulations for beef and dairy cattle. Orange peel and pulp and other citrus fruits contain essential oils (e.g., limonene) that are toxic to bacteria and exhibit antioxidant effects in host animals. Because of the natural antimicrobial effects of orange peel/pulp, it has been proposed for use as a low-cost feed ingredient that could be used to decrease foodborne pathogenic bacteria populations in cattle. Previously, we demonstrated that orange peel and pulp reduced populations of *E. coli* O157:H7 and *Salmonella* in mixed ruminal fluid fermentations in test tube conditions and reduced.

### Objectives

This study was designed to determine if feeding dried orange peel pellets to sheep (as a model ruminant) killed *Salmonella* and *E. coli* O157:H7 in the gastrointestinal tract.

### Methods

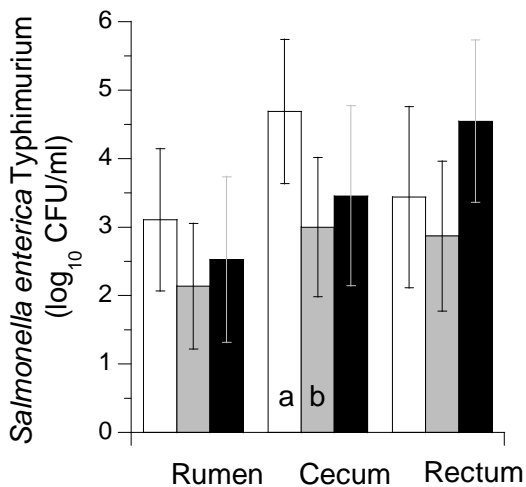
Barbado sheep (n = 48; 50 kg BW) were purchased and transported to College Station, TX. Sheep in the first study (n = 24) were fed a commercial sheep ration that was supplemented with 0%, 10% or 20% pelleted orange peel for 7 d. Following this adaptation period, sheep were artificially inoculated with 10<sup>8</sup> CFU *Salmonella* Typhimurium by oral dosing.

Sheep in the second study (n = 24) were fed a commercial sheep ration that was supplemented with 0%, 5% or 10% pelleted orange peel for 7 d. Following this adaptation period, sheep were artificially inoculated with  $10^8$  CFU *E. coli* O157:H7 by oral dosing.

In both studies fecal shedding of *Salmonella* was measured daily for 5 d before animals were humanely sacrificed. Digesta samples were collected from the rumen, cecum and rectum of the sheep. Samples were diluted and plated on agar plates supplemented with antibiotics to detect the inoculated strains of *Salmonella* and *E. coli* O157:H7.

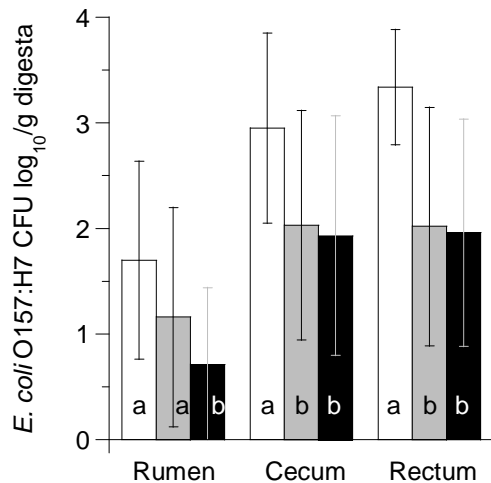
### Important Results

Sheep did not consume orange peel at levels >10% of their diet, likely due to palatability concerns, so effects of feeding the 20% Orange peel to sheep in the first study were not detected. However, feeding 10% orange peel in the ration reduced ruminal, cecal and rectal populations of *Salmonella* Typhimurium approximately 1, 2 and 0.5  $\log_{10}$  CFU ( $P < 0.08$ ,  $< 0.06$ ,  $< 0.10$ ), respectively (Figure 1).



**Figure 1.** Intestinal populations (CFU/g feces,  $\log_{10}$ ) of *Salmonella* Typhimurium in sheep fed 0, 10 or 20% dried orange peel. White bars represent 0% OP, grey bars 10% OP, and black bars 20% dried orange peel feeding.

In the second study, orange peel dosing levels were reduced to 5% and 10% to ensure intake of the OP. Intake of OP was 100% in both orange peel groups. Ruminal populations of inoculated *E. coli* O157:H7 were reduced linearly by increasing levels of OP, but the difference only reached significance ( $P < 0.05$ ) in sheep fed 10% OP (Figure 4). Feeding 5% and 10% OP reduced ( $P < 0.05$ ) *E. coli* O157:H7 populations in both the cecum and rectum compared to control sheep (Figure 2).



**Figure 2.** Intestinal populations (CFU/g feces, log<sub>10</sub>) of *E. coli* O157:H7 in sheep fed 0, 10 or 20% dried orange peel. White bars represent 0% OP, grey bars 5% OP, and black bars 10% dried orange peel feeding.

Collectively, our results indicate that orange peel and pulp can be used to reduce foodborne pathogens in live animals. Further research is needed to determine the most efficacious feeding and treatment regimen to maximize the pathogen reducing effect. This information can be applied to the United States Beef industry directly as a pathogen reduction strategy that can be utilized today, ensuring the safety and wholesomeness of our beef supply.

### Impact on the Beef Industry

Feeding orange peel and pulp in cattle rations reduced *E. coli* O157:H7 and *Salmonella* throughout the gastrointestinal tract of sheep used as a model ruminant. *Salmonella* and *E. coli* O157:H7 are pathogenic foodborne bacteria that have been significant impactors on the perception of the wholesomeness and safety of beef. By finding ways to reduce the levels of these critical pathogens in cattle, then we can improve beef safety and reduce the environmental impact of these pathogens in the waste stream. The use of a “green” by-product from juice production to reduce pathogens in cattle is potentially impactful, both from a practical and a public relations standpoint.

## Lay Summary

Orange juice production results in the waste products orange peel and orange pulp. These by-product feedstuffs have a high nutritive value for cattle and are often included in cattle rations as a least-cost ration ingredient. These by-products includes essential oils which exhibit antibacterial properties against cattle-associated pathogenic foodborne bacteria, such as *Salmonella* and *E. coli* O157:H7. The present study indicates that feeding orange peel or dried orange pulp to sheep (as a model of cattle) reduced *Salmonella* and *E. coli* O157:H7 populations in the rumen, rectum and cecum at least 10-fold. Feeding of orange pulp at levels up to 10% of the ration were most effective in controlling populations of *Salmonella* and *E. coli* O157:H7 in the sheep. Orange pulp feeding also reduced survival of *Salmonella* and *E. coli* O157:H7 in cattle feces in test tube fermentations. Collectively our results indicate that feeding this commonly available feedstuff can reduce pathogen populations in food animals. This is an antipathogen strategy that can be implemented in various farms along the beef production continuum, and included in dairy rations prior to their entry to the beef supply. The availability of a green feedstuff that is economically feasible and results in an improvement in human food safety is an exciting development for the beef industry.

---

***For more information contact:***

National Cattlemen's Beef Association  
9110 East Nichols Avenue  
Centennial, Colorado 80112-3450  
(303) 694-0305