

# Overview of Pre-Harvest Safety Interventions

## Introduction

Since 1993, the beef industry has spent more than \$28 million on beef safety research, outreach and education through The Beef Checkoff. Including private industry efforts, collectively, the industry spends more than \$350 million annually on improving beef safety. Much of the research has focused on addressing foodborne pathogens at the harvest and processing level. However, researchers, industry participants and producers have also identified the need to expand the industry's tool chest and focus more research efforts on pre-harvest safety interventions.

The goal of these efforts is to increase the efficacy of post-harvest safety technologies, and to apply another layer of safety by reducing pathogen loads on cattle presented for slaughter.

## Background

The immediate goal of researching and developing pre-harvest safety interventions is not necessarily to achieve a 100 percent reduction in pathogen shedding. While, ultimately, doing so would reap huge benefits in food safety, it's not realistic. Rather, the goal is to reduce pathogen loads on cattle presented for slaughter, so in-plant safety systems are not overwhelmed. In most instances, post-harvest interventions are extremely effective and the additive effect of pre-harvest interventions to decrease pathogen loads on hides would increase the efficacy of the entire safety system.

Most of the experiments evaluating pre-harvest safety interventions have focused on the feedlot level as it is a production stage more intensely managed and is also the stage in beef production immediately before harvest. Additionally, most research in pre-harvest beef safety has also focused on *E. coli* O157:H7 as it is the pathogen that has most impacted beef safety. Research is expanding to include other pathogens such as *Salmonella*, *Listeria monocytogenes* and *Campylobacter jejuni* and emerging issues such as the development of antibiotic-resistant bacteria.

According to researchers, it is possible to broadly organize options for pre-harvest control of *E. coli* O157 and other foodborne pathogens into two categories:

1. Modifications of existing management strategies, such as changing a feed ration or cleaning water troughs more frequently
2. Targeted intervention strategies or technologies, such as an *E. coli* O157 vaccine or feed additives

Because *E. coli* and *Salmonella*, as well as other foodborne pathogens, are often ubiquitous and have a unique ability to adapt, research to date has failed to identify specific management practices that have consistently reduced pathogen prevalence. That's why research in the pre-harvest sector continues to be a top priority and is ongoing. Targeted technologies, including *E. coli* vaccines and other control strategies, are not yet broadly available on a commercial basis as many are still being researched, validated or approved by the appropriate regulatory agencies, but several of these technologies have demonstrated promising results.

As a result, these technologies continue to be a key area of research. It is important for farmers and ranchers to understand how they might eventually be used in beef production systems. While the majority of pre-harvest interventions examined to date have focused on the feedlot sector, as this field of research continues to expand, interventions may be introduced that could be applied at the cow-calf or dairy level.

## Production Best Practices

Basic principles that many producers are familiar with as the foundation of good animal-health management have been advocated as a first step to address foodborne pathogens in beef products that might impact human health. While no clear reduction in pathogen shedding has been demonstrated by research when applying these practices, they can still serve as a foundation for future efforts and align closely to principles outlined in the industry Beef Quality Assurance (BQA) program.

Basic principles of production best practices include:

- Clean feed
- Clean water
- Appropriately drained and maintained environment
- Biosecurity

These principles can also be applied to the lairage areas of processing facilities. The condition of lairage areas should be managed to minimize contamination of hides from holding pens.

## Management Strategy Modifications

In addition to the production best practices described previously, researchers have been examining modifications to existing management practices to determine how they might reduce pathogen levels in cattle. The most notable area of research has been ration modification focusing on type of feed, frequency of feeding and feed quality, which have all been hypothesized to impact bacterial shedding rates in cattle.

### Ration Modification

There has been conflicting data collected on the impact of changing feedlot rations prior to harvest and its impact on reducing pathogen shedding. The goal of this practice would be to modify cattle's intestinal environment, making it less hospitable to *E. coli* O157:H7; however, with no clear benefits and potentially negative repercussions on cattle performance, this deserves more research before being recommended as a potential strategy.

## Targeted Interventions

What follows is a list of novel, targeted interventions that researchers are currently evaluating. While a few of these interventions are available for use as a means to reduce *E. coli* O157:H7, the majority are still experimental in nature. This document is meant to be for informational purposes only and was written to better familiarize beef producers with tools that researchers are currently evaluating for their ability to improve beef safety.

### Chlorine

As a disinfectant for livestock watering troughs, chlorine may be used, however if levels are not maintained throughout the day and/or organic matter such as manure gets in the trough, the effect is minimal. Further work is needed to determine if this is an effective intervention at the commercial level.

### Electrolyzed Water or Water Ozonation

These treatments may not be practical in commercial settings as they require specialized equipment, but based on their use in disinfecting municipal water supplies, may have some application within the livestock industry.

### Direct-Fed Microbials

This category includes probiotics, which contain bacteria or microorganisms that are beneficial to the host animal and reduce harmful pathogens through competitive exclusion. Most of the research in this area has focused on a specific *Lactobacillus*-based direct-fed microbial. Research has demonstrated a reduction in *E. coli* O157:H7 prevalence in cattle and a subsequent reduction of hide contamination. Hundreds of strains of *Lactobacillus* exist and a comprehensive research project evaluating 650 strains found that only five showed promise in reducing *E. coli* O157:H7. Of particular importance was the fact that some actually demonstrated the potential to increase pathogen shedding, versus decrease shedding.

### Seaweed Extract

An extract has been identified from a specific variety of seaweed (*Actophyllum nodosum*), which is a known source of cytokinin that has been shown to have antioxidant effects. Research has evaluated the supplementation of this extract in feedlot rations prior to harvest. Efficacy in reducing *E. coli* O157:H7 shedding has been variable in research trials.

## Orange Peel and Pulp

These by-products of the citrus juice industry are being utilized in some feedlot and dairy rations as a low-cost ingredient. Orange peel and pulp and other citrus fruits contain essential oils that are toxic to bacteria and exhibit an antioxidant effect in host animals. An experimental trial using sheep showed that feeding orange peel for seven days reduced *Salmonella* populations in the animals.

## Ractopamine

This is a beta-agonist commercially available as a medicated feed additive and is approved for use in feedlot cattle as a means of increasing lean-meat yield. Some experimental work has been conducted to determine its impact on decreasing *E. coli* O157:H7 and *Salmonella* but the mechanism for such a result is currently unknown.

## Antibiotic Feed Additives

Including commercially available additives in the feed such as ionophores, neomycin sulphate, tetracycline and oxytetracycline has been proposed as a possible means of decreasing pathogen shedding; however, results have been inconclusive. Neomycin sulfate has shown significant promise in reducing *E. coli* O157 in multiple feedlot studies; however, a label change would be required before it could be used to control *E. coli* O157 in cattle. Additionally, concerns about antibiotic use in livestock and antimicrobial resistance may hinder future research in this area. Potential benefits for human health would have to be balanced with concerns about antimicrobial resistance when evaluating antibiotic feed additives as a pre-harvest intervention.

## Competitive Exclusions

Other strains of *E. coli* produce antimicrobial proteins that can inhibit *E. coli* O157:H7. By feeding these other strains to feedlot cattle, researchers have proposed it may lessen fecal shedding. This research is still very experimental in nature and its benefits have not been clearly defined.

## Cattle-Hide Washing

Washing cattle prior to harvest removes visible manure, and can potentially reduce the likelihood of contamination occurring at harvest when the hide is removed.

## Bacteriophages

Viruses that kill bacteria have been approved for use in post-harvest interventions. More recently the U.S. Department of Agriculture (USDA) Food Safety Inspection Service (FSIS) has allowed their use on cattle in holding pens immediately before slaughter with the goal of reducing hide contamination. While this method has shown promise, it also requires application equipment to apply the spray compound to the cattle.

## Sodium chlorate

This compound has been researched as an additive to feed and water and significant reductions in the shedding of *E. coli* O157 as well as *Salmonella* have been seen. This product is awaiting FDA approval for this use and currently may not be used in cattle going to slaughter for human food.

## *E. coli* Vaccines

Currently two vaccines are being investigated that are designed to reduce fecal shedding of *E. coli* O157:H7 in cattle. One of the vaccines acts against *E. coli* O157:H7 by disrupting the bacteria's iron transport system and is conditionally licensed in the United States. The other vaccine is a bacterial extract and is fully licensed in Canada. The vaccine manufacturer is seeking conditional licensing in the United States. While the vaccines employ different technologies, both have been shown in experimental studies to reduce fecal shedding in commercial environments. The use of vaccines as intervention tools has significant potential as their use is a management practice producers are familiar with and can incorporate more easily into existing management programs. As researchers determine the most effective dose and time of administration and these products work through the regulatory approval process, one important point to consider will be how to encourage adoption of these interventions as well as other promising technologies among farmers and ranchers when no discernible benefit to animal health is seen.

## *Salmonella* Vaccine

A conditionally licensed *Salmonella* Newport bacterial extract vaccine is also available in the United States and is undergoing further validation studies to secure a full license for use as a means of reducing *Salmonella* Newport in cattle populations.

For all interventions, the feasibility of use in current production systems must be considered. This would include the time commitment to animal handling needed for delivery/application of the intervention as well as the use of specialized equipment.

## Conclusion

Because of the complex nature of beef-production environments, knowledge gaps exist in how both management strategies and targeted interventions can be used to reduce pathogen shedding and prevalence in live cattle populations, but the industry and the research community agree that this area of research is important to the ongoing improvement of beef safety.

During the 2010 Beef Industry Safety Summit, a special Pre-Harvest Symposium was conducted to discuss the latest research and its application within the industry. An action list was generated from the meeting and a consensus that the ubiquitous nature of pathogens such as *E. coli* O157 and *Salmonella* dictate that a systems approach must be used to further develop pre-harvest safety interventions and strategies. The goal is to understand the impact that a change in production-management practices or the application of a novel intervention strategy may have on beef safety, and ultimately human health.

Action items developed from the Pre-Harvest Symposium include:

- Develop and implement major commercial trials for the experimentally available pre-harvest technologies
- Understand price points for the various pre-harvest technologies and be able to communicate those to industry participants
- Conduct research using a systems approach and find ways for beef packers and processors to cooperate in investigations

If reductions can be made in the pathogen loads of cattle entering harvest facilities, a corresponding reduction of foodborne pathogens on carcasses and in beef products will occur. This will benefit the beef industry as a whole and will help us deliver on our promise to consumers to provide the safest beef possible.

To learn more about pre-harvest beef safety research, visit [www.bifsco.org](http://www.bifsco.org) or [www.beefresearch.org](http://www.beefresearch.org).

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