Effecting food safety in cattle-finishing systems—the role of dietary components and other management practices

Dave Smith, DVM, Ph.D., DVM, University of Nebraska, Lincoln

Smith presented results from several studies examining the effect of dietary components and other management practices in cattle-finishing systems on food safety. In introducing his topic, Smith cautioned the audience that the media's interpretation of scientific studies should remind the research community that no conclusions can be made from any single study.

Past research has demonstrated that feedlots differ in *E. coli* O157:H7 carriage, suggesting that individual cattle production systems may influence food safety outcomes. It seems reasonable that feed rations may affect the bacterial population in cattle, however it is not yet clear how cattle rations affect *E. coli* O157:H7, or how to use cattle rations as a preharvest intervention.

Smith presented research that demonstrated contradictory results on the effect feedlot rations may have on pathogen-shedding rates in cattle. He recommended future research should focus on determining what affects the probability for cattle to shed *E. coli* O157:H7 and determine the most effective strategies for intervention, by either limiting direct environmental exposure or reducing the duration of infection.

Beef safety research

Tom Edrington, Ph.D., Food and Feed Safety Research Unit, Agricultural Research Service, U.S. Department of Agriculture

Previous research conducted by Edrington and his colleagues examined the prevalence of MDR *Salmonella* in various classes of dairy cattle. The results suggested that pasteurization of waste milk fed to calves may have a significant effect on decreasing *Salmonella* prevalence in the calves. The researchers hypothesized that unpasteurized milk might serve as a vector for *Salmonella*, as well as antibiotic resistance.

Samples were collected from several large dairy operations in the Southwest United States and compared *Salmonella* prevalence differences between calves fed pasteurized versus non-pasteurized milk. The examination of waste-milk pasteurization on incidence of MDR *Salmonella* in dairy cattle did not produce expected results. In fact, *Salmonella* prevalence was higher in all classes of dairy cattle on a farm feeding pasteurized waste milk versus a farm that was feeding unpasteurized milk. The researchers noted other general management differences between the operations and will consider analyzing those aspects in future research.

Researchers from Edrington's group are also investigating the incidence of multi drug-resistant generic *E. coli*, which is common in young dairy calves and disappears with age. Results may provide information on how to eliminate these bacteria from the gut population at an earlier age in cattle.

Feedlot cattle research to determine whether acyl-homoserine-lactone autoinducer (AHL) is correlated with *E. coli* O157:H7 populations was presented. AHL may repress gene expression that is required for bacterial colonization in cattle. Preliminary results indicate that a forage diet may positively influence AHL.

Edrington presented other research projects examining the effect of stressors on acquisition of multi drug resistance by *Salmonella*, as well as the role of bacteriophage in the acquisition of MDR by *Salmonella.*

Edrington's group has also worked for some years on validating chlorate as a preharvest intervention. Supplementing cattle drinking water with chlorate has been shown to be an effective intervention strategy at the feedlot level and was awarded its first patent in 2002. However, chlorate's use as a feed additive is still under review by the Center for Veterinary Medicine, Food and Drug Administration.

Conclusion

All of these research projects demonstrate the evolution that has taken place in the understanding of beef's safety challenges. By sponsoring this research, the beef industry has demonstrated its commitment to finding effective strategies for reducing, and potentially eliminating, safety challenges to the U.S. beef supply.

For more information, visit

www.bifsco.org

www.beefresearch.org

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2008 Beef Industry Safety Summit

Research Update Session Summary

Introduction

The beef industry, through the Beef Checkoff Program, has devoted more than $25 million to beef safety research. These studies have laid the groundwork for advancing the goal of creating the safest beef supply possible. During the 2008 Beef Industry Safety Summit, leading researchers presented results from studies that will advance the industry's understanding of beef safety risks and aid in the development of solutions to existing challenges. The summit is funded by the Beef Checkoff Program and coordinated by the Beef Industry Food Safety Council (BIFSCo) and the National Cattlemen's Beef Association (NCBA), and continues the tradition of industry driven efforts to improve beef safety.

Overviews of the research projects and results are outlined in the executive summary for the 2008 Beef Industry Beef Safety Summit, which can be accessed at www.bifsco.org. This report summarizes the research in more detail. More beef safety research information can also be accessed at www.beefresearch.org.

Beef safety research updates

Veterinary drug residue issues

Steven Lehotay, Ph.D., U.S. Department of Agriculture-Agricultural Research Service

Veterinary drug residues still present safety and regulatory issues for the beef industry, and continue to be monitored and addressed by regulatory agencies. Lehotay emphasized the need for more rapid screening tests with wider monitoring scope and more reliable results. Research efforts are focused on improving screening methods to make them more cost-effective and to ensure that they meet industry needs.

Chemical residue testing in beef harvest facilities is currently conducted in a two-tiered approach with initial screenings performed by Food Safety Inspection Service (FSIS) inspectors in harvest facilities. Presumptive positive samples are sent to the FSIS laboratory for quantitative and qualitative analysis. Total residue monitoring has decreased since 2001, but violations are increasing, primarily because of flunixin. Cull dairy cows represent the largest percentage of violations.

One of the primary areas of focus is to evaluate the use of muscle tissue and fluid extracted from muscles rather than kidney or liver samples, which are currently utilized in most testing programs. According to Lehotay, muscle tissue is more accessible for easier collection and much less complex to extract and analyze. The lower residue tolerance levels in muscle tissue could potentially reduce nonviolative positives that occur in existing sampling programs. Testing muscle tissue for drug residues would also be a more effective use of resources, as it would eliminate the need for additional analyses of muscle tissue in the event of organ positives. In Lehotay's opinion, the condemnation of organs is a non-issue, when it is the muscle tissue that is ultimately the end product for the majority of consumers. The agency is also working to speed up the testing process to provide accurate residue results within 48 hours on held carcasses.

Nutritional factors influencing prevalence of foodborne pathogens in feedlot cattle

Jim Droulliard, Ph.D., Kansas State University

Ration components for feedlot cattle may have some association with the prevalence of foodborne pathogens. However, further research is needed to accurately understand the causal relationship between diet and pathogen prevalence rates in cattle. Droulliard presented a compilation of project results that examined the effect of various grain processing methods (dry-rolled corn versus steam-flaked corn) and the replacement of ration components with dried distillers grains (DDG) or wheat on pathogen shedding in cattle.

One of the projects tracked a group of cattle that were preselected for 100 percent prevalence rate. The researchers determined DDG consumption appeared to impact the prevalence of *E. coli* O157:H7; however, Droulliard cautioned the audience against foregone conclusions. "It is important to remember that a variety of factors including the removal of starch from the diet, the alteration of the rumen microbial environment and the number of bacteria present may also play roles in this phenomenon. When grain is removed from a ration and replaced with distillers' grains, starch is being removed from the ration," said Droulliard. "That dynamic may modify the environment to the point that it is more hospitable to pathogens or they are better able to proliferate."

To examine that effect, Droulliard and his colleagues conducted a study that added starch back into the ration to potentially make the gastrointestinal environment friendlier to competitive bacteria. That study revealed no differences in pathogen prevalence between cattle on treatment and cattle on control diets. However, Droulliard said this result may be due to low prevalence rates in the study animals to the point that it was difficult to accurately determine differences in shedding rates. Future research efforts will continue to focus on altering the microbial environment so that competitive bacteria can displace the pathogenic species.

Highlights of beef safety research from the U.S. Meat Animal Research Center (MARC)

Mohammad Koohmaraie, Ph.D., MARC, Agricultural Research Service, U.S. Department of Agriculture

Highlights of research to control pathogens in the beef supply focused on work to improve hold and test procedures in beef processing facilities; attribution of antibiotic resistant *Salmonella* to cull cows; and projects examining the effect of feeding wet distillers grains (WDG) on *E. coli* O157:H7 shedding in feedlot cattle.

Previous research has indicated that cull cows may have a higher prevalence of multi drug-resistant (MDR) *Salmonella* than younger cattle processed in fed beef facilities. The effect of lairage had to be eliminated to accurately test the hypothesis. The researchers found that sampling feces from the distal colon after evisceration reflected *Salmonella* shedding rates at the production site and eliminated effects that lairage contamination might have on study results. The study validating this sampling procedure has been submitted for publication in the *Journal of Food Protection.*

In the attribution study, researchers sampled hides at processing plants (cull cow/bull and fed) to determine *Salmonella* rates in lairage pens. Feces from the distal colon were sampled to determine *Salmonella* rates in the production environment. *Salmonella* positive fecal samples were more prevalent in cull dairy animals (70.2 percent) versus beef market animals (37.9 percent) and fed cattle (7.0 percent).

Prevalence of Salmonella

	Hides Salmonella		Feces Salmonella	
	# positive	%	# positive	%
Dairy Cow	716	83.0%	618	71.6%
Dairy Bull	41	93.2%	19	43.2%
All Dairy	**757**	**83.5%**	**637**	**70.2%**
Beef Cow	262	87.0%	118	39.2%
Beef Bull	38	97.4%	11	28.2%
All Beef	**300**	**88.2%**	**129**	**37.9%**
Fed Cattle	**213**	**57.4%**	**26**	**7.0%**

Fecal sample prevalence of multi drug-resistant (MDR) *Salmonella* followed similar trends--32.5 percent dairy market animals, 16.2 percent of beef market animals and 0.8 percent fed cattle, were positive respectively.

Prevalence of MDR-Salmonella

	Hides Salmonella		Feces Salmonella	
	# positive	%	# positive	%
Dairy Cow	327	37.9%	288	33.4%
Dairy Bull	24	54.5%	7	15.9%
All Dairy	**351**	**38.7**	**295**	**32.5**
Beef Cow	82	27.2%	54	17.9%
Beef Bull	7	17.9%	1	2.6%
All Beef	**89**	**26.2**	**55**	**16.2%**
Fed Cattle	**29**	**7.8**	**3**	**0.8**

All MDR data should be considered presumptive subject to confirmation.

A two-phase project examined the effect of varying percentages of wet distillers grain (WDG) on cattle performance, and the effect of WDG (0 to 60 percent of ration, dry matter basis) on *E. coli* O157:H7 shedding. In the second phase of the study, the researchers examined the differences between a control diet and one that included 40 percent WDG on *E. coli* O157:H7 shedding rates. Fecal samples were collected monthly from October until the cattle were harvested in June. Results revealed variations that could not be explained by treatment in shedding rates between pens and within pens throughout the trial.

Beef Safety Interventions

Mindy Brashears, Ph.D., International Center for Food Industry Excellence, Texas Tech University

Results from several studies addressing beef safety interventions, carcass sampling protocols and preharvest intervention practices were presented by Brashears.

A study that examined the timing of three safety interventions (lactic acid-producing bacteria; acidified sodium chlorite; and 3 percent lactic acid spray) on enhanced beef strip loins determined that in general, all three treatments significantly reduced *E. coli* O157:H7 after 21 days of storage prior to enhancement. The effects the three intervention treatments had on sensory characteristics were also examined. Salty flavors were detected in the samples treated with interventions and then enhanced with a solution containing salt and phosphate, so formula alterations might be necessary.

An in-plant study designed to determine the location of *E. coli* O157 on carcasses provided more insight for implementing targeted safety interventions. Researchers determined that the hindshank showed the highest level of contamination across several plants.

Results from another study examining the susceptibility of both MDR and non MDR *Salmonella* to lactic acid treatments was presented. According to Brashears, lactic acid, an intervention strategy commonly used in industry, appears to deal effectively with MDR, as well as drug-susceptible *Salmonella*. Another study examining the necessary dose of lactic acid bacteria to effectively inhibit foodborne pathogens in meat found a lower dose (10^6 cfu/g) was as effective as a higher dose (10^8 cfu/g).

Texas Tech University researchers have conducted several research studies over the years focusing on preharvest safety interventions. The prevention of cross contamination through dust control was examined during load out of cattle at feedlot facilities. Controlling dust resulted in fewer pathogens being isolated from air samples. These results indicate that dust control may play an important role in reducing subsequent contamination of cattle hides and, consequently, carcasses.

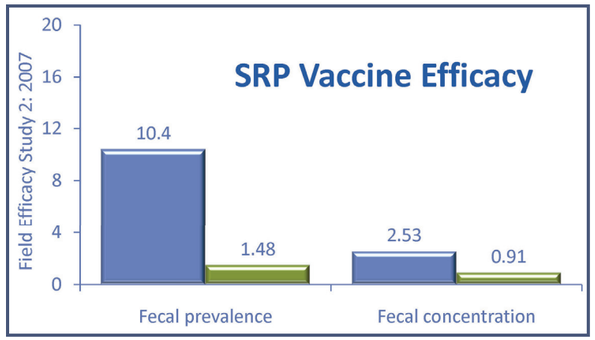
Another preharvest research project analyzed the effectiveness of *Lactobacillus acidophilus* strain NP 51 (LAB) in reducing *E. coli* O157:H7 prevalence in fecal samples. The results indicate that LAB could be applied to manure via spraying to reduce pathogen levels and subsequent contamination of beef hides. The research may also have implications for manure used in fertilizer applications in ready-to-eat crops. LAB applications in a feedlot setting might also reduce environmental contamination of nearby water bodies or crops in the event of excessive storm run-off.

Siderophore receptor and porin protein (SRP)-based vaccines for control of E. coli O157

Guy Loneragan, B.V.Sc., DVM, West Texas A&M University

Loneragan presented preharvest beef safety research examining the potential of a siderophore receptor and porin protein (SRP) based vaccine for control of *E. coli* O157. All bacteria require iron for survival, and in bacteria, iron is acquired via siderophore and porin proteins. A vaccine was developed that stimulates immunity against these cell-surface proteins, which would in turn reduce iron acquisition.

A challenge study was initially conducted to validate the concept. Two subsequent field efficacy studies were performed. Trends to decrease pathogen populations were desirable, however prevalence in study animals was so low in the first field study that biological significance was questionable. The second field study demonstrated a vaccine efficacy of 86 percent with a 98 percent reduction in pathogen concentration in fecal samples. The vaccine did not negatively affect animal performance and demonstrated effectiveness in reducing the burden of *E. coli* O157:H7.



Based on these results, SRP technology has the potential for a variety of vaccine applications against bacterial infections and disease. The studies also provide evidence that immunization can aid in the control of pathogens such as *E. coli* O157. A vaccine using the same technology is conditionally licensed and widely accepted in dairy production to control *Salmonella*, which unlike *E. coli,* can negatively affect animal performance.

The goal of a preharvest intervention such as this vaccine is not necessarily a 100 percent reduction in pathogens in live animals, but rather to reduce pathogen levels to the point that effects of subsequent interventions at the harvest level are optimized.