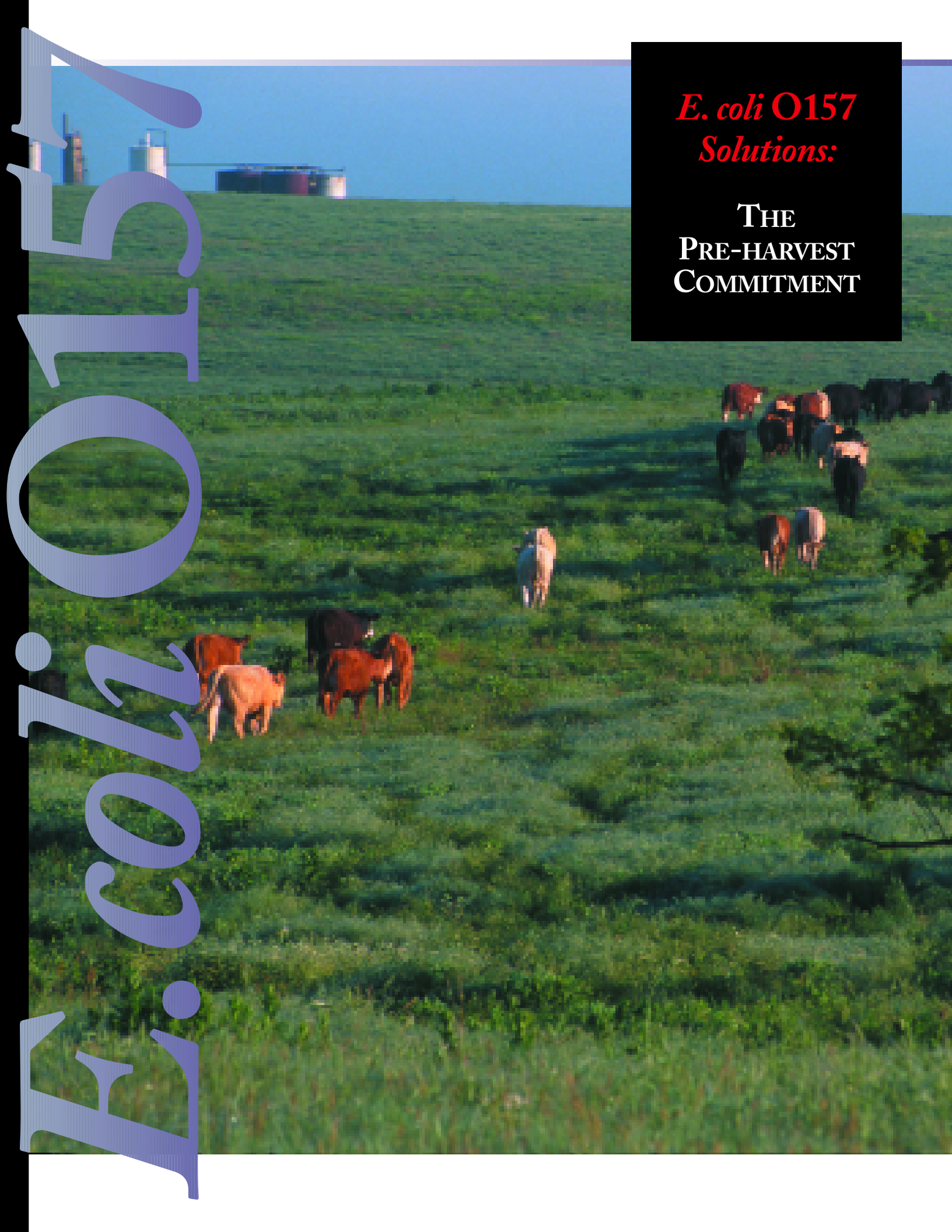


E. coli O157 *Solutions:*

The Pre-harvest Commitment

E. coli O157: The Challenge and the Costs

E. coli O157 can be found throughout our environment, in any place humans or animals live. However, the occurrence of *E. coli* O157 within the food supply generates particular concern for both the public and the beef industry. American beef producers feed millions of people worldwide and enjoy a unique reputation for wholesome, safe product. Any threat to the safety or well-being of beef threatens producers' well-deserved reputation, as well as their livelihood.

Loss of consumer confidence in beef products costs the industry dearly. Research shows that product recalls following *E. coli* O157 outbreaks have a negative effect on beef demand. Boneless beef prices decline an average of 2 percent to 2.5 percent in the five days following a recall. Agricultural Economist Ted Schroeder estimates that from 1991 through 1999, beef recalls due to safety concerns cost the industry as much as $1.6 billion in lost demand. Producers absorb a sizable portion of this loss.

The bacteria *E. coli* O157 is pervasive. Researchers find *E. coli* O157 in all sorts of animals including horses, goats, elk, deer, opossums, raccoons, dogs, poultry, wild birds and even houseflies. The organism has also been found in young beef calves and older cows, in dairy calves, and in dairy cows. Cattle coming into the feedlot carry the organism, as do hides within beef processing facilities.

E. coli O157 is also amazingly adaptive, persisting in many different environments, and remaining viable for months at a time in both feces and soil. *E. coli* O157 survives and replicates in both standing and free-flowing water. Unlike many other bacteria, *E. coli* O157 also survives and replicates in both environments with oxygen (aerobic environments) and environments without oxygen (anaerobic environments). The pathogen responds and adapts to changes in environmental chemicals, pH and temperature in unusual ways, making it an especially resilient organism.

The *E. coli* O157 outbreak on the west coast in 1993 served as a rallying initiative for focusing and growing the beef industry's safety research program and providing continuing improvements in beef safety. The research program provided leadership for the beef industry's Blue Ribbon Task Force, charged with developing an industry blueprint for addressing the *E. coli* O157 issue. The Task Forces' subsequent identification of focus areas served as the agenda for the industry's research program over the past decade.

What Role does the Production Segment Play?

Beef producers play a crucial role in the control of *E. coli* O157. As the originators of beef products, cow/calf producers must be aware of the status of research involving *E. coli* O157, and also understand their role in controlling this industry-wide threat. Controlling *E. coli* O157 throughout the beef production chain makes controlling the pathogen at slaughter plants easier and every beef product safer. This brochure, written specifically for producers' use, aims to clarify the myths surrounding *E. coli* O157 during the cow/calf, backgrounding and feedlot stages (known collectively as the pre-harvest phase). Principle-based husbandry practices producers can put in place to set the stage for future recommendations about *E. coli* O157 control also have been included within these pages.

Historically, most of the pre-harvest research performed by the beef industry concentrated on feedlots. Because cattle live in the feedlot immediately before harvest, research on this important phase of beef production made sense. Additionally, while in the feedlot, cattle remain grouped together, simplifying research and making data easily obtainable.

Due mostly to feedlot studies, a fairly thorough knowledge about the epidemiology, or causes and transmission, of *E. coli* O157 in feedlot cattle, exists. Several issues including: some disagreement about whether *E. coli* O157:H7 can be compared to its very similar cousin *E. coli* O157:H-, variation from study to study in sampling technique, and improvements over the years in microbial detection, remain. However, researchers have discovered several valuable points regarding *E. coli* O157. For example, researchers know that naturally acquired *E. coli* O157 does not cause overt disease, or obvious clinical signs, in cattle. Even though cattle may have *E. coli* O157 within their systems, they won't show outward signs of infection. Other things the industry knows about *E. coli* O157, thanks to recent research, include:

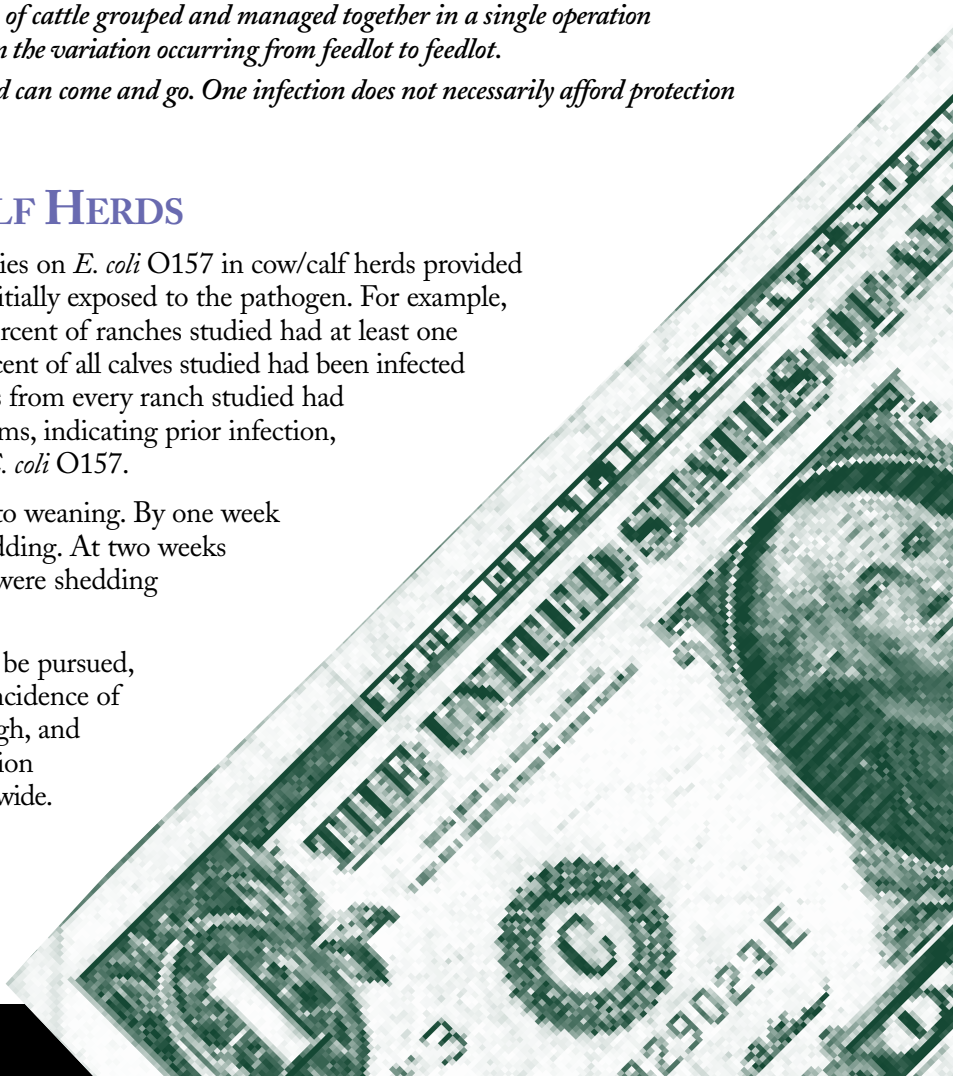
1. ***E. coli* O157** ***is endemic—that is, it can be found in cattle populations across the country, in every state and in every environment.***
2. ***Seasonal differences in the frequency with which cattle excrete the pathogen in their feces, what scientists call "shedding", have been noted. Shedding peaks in summer and early fall, and is lowest in winter.***
3. ***In one of the most confusing findings, pens of cattle grouped and managed together in a single operation displayed greater variation in shedding than the variation occurring from feedlot to feedlot.***
4. ***Most infections in cattle are temporary and can come and go. One infection does not necessarily afford protection against another, later infection.***

E. coli O157 in Cow/Calf Herds

In addition to this knowledge, several studies on *E. coli* O157 in cow/calf herds provided valuable insight into how cattle become initially exposed to the pathogen. For example, one research study found that nearly 87 percent of ranches studied had at least one calf shedding *E. coli* O157. At least 83 percent of all calves studied had been infected with *E. coli* O157 prior to weaning. Calves from every ranch studied had *E. coli* O157 antibodies in their bloodstreams, indicating prior infection, even if they were not currently shedding *E. coli* O157.

Another study followed calves from birth to weaning. By one week postpartum, 25 percent of calves were shedding. At two weeks postpartum, 6 to 14 percent of calves still were shedding the pathogen.

While additional on-farm research should be pursued, existing studies tell the industry that the incidence of *E. coli* O157 on-farm may be extremely high, and widespread geographically, meriting attention and concern from cow/calf producers nationwide.



Principle-based Husbandry

The first step in efficient and wholesome production of any animal-based food is to make sure production areas are well-maintained, clean, appropriately drained and free from vermin and pests. While cleanliness of production areas is not currently proven to directly affect incidence of *E. coli* O157, principle-based husbandry lays a good foundation for optimum animal health and welfare. Since the beginning of livestock production, animal husbandry has involved caring for animals in the way best for the animal and the producer. Today's principle-based animal husbandry must also incorporate best practices to achieve beef producers' mission of feeding an enormous number of people worldwide by providing safe and wholesome end-products. Therefore, principle-based animal husbandry should be included in every producer's Production Best Practices (PBP) involving live animals. Basic principles of cattle management should include:

1. *Clean feed*
2. *Clean water*
3. *Appropriately drained and maintained environments*
4. *Relative freedom from pests, such as biting insects*

These practices are fundamental to any livestock operation, and should be incorporated as a foundation for any specific *E. coli* O157 control methods, or interventions. Additionally, these are good animal welfare practices. They form a solid foundation for any animal husbandry program, and an excellent base for future *E. coli* O157 on-farm intervention recommendations.

Production Best Practices on the Farm: What Works, and What Doesn't?

The top 10 beef packers have already spent over $400 million to control *E. coli* O157, as well as $250 million more to make plant improvements and incorporate interventions to reduce *E. coli* O157. Current practices in slaughter and fabrication intervention include a wide variety of methods. In response to new regulatory requirements during the mid-1990s, packers began using vacuum steaming and hot water washing of carcasses to remove contaminants, and complying with written sanitation standard operating procedures (SSOP). Further, packers developed and implemented hazard analysis critical control point (HACCP) systems. Every day packers meet performance standards for verifying HAACP effectiveness.

Some of the specific methods used in today's packing plants include:

- *Spot carcass decontamination. Using various tools including knives and hand-held steam vacuums to remove visible contaminants to meet FSIS zero-tolerance performance standards.*
- *Chemical decontamination. Application of various chemical mixtures to the hide or carcass prior to further fabrication using spray rinsing cabinets or other spray and/or washing methods.*
- *Thermal decontamination. Treatment of carcasses with high-pressure, hot-water rinse (exceeding 74 degrees C), or exposing carcasses to pressurized steam.*
- *Irradiation of case-ready product.*
- *Other technologies, including ionizing radiation, hydrostatic pressure, electric fields, pulsed light, sonication and microwaves have been proposed for use in packing plants to reduce contamination of meat.*

Each of these interventions has been researched extensively, and proven to reduce pathogen load. Obviously, if fewer pathogens enter the packing plant in or on cattle, controlling their occurrence in the final beef product will be easier—resulting in a safer end-product for consumers. Therefore, all segments of the industry must work together to control *E. coli* O157.

The following table summarizes research on principle-based husbandry practice enhancements and the effect of such enhancements on E. coli O157 control.

MANAGEMENT PRACTICES

1. Market classifications	*Research shows animal age or market classification has no impact on E. coli O157 prevalence.*
2. Housing	*Neither density of animals within a pen, nor regular pen cleaning, showed any effect on the presence of E. coli O157.*
3. Water	*Although research proved that water could be a means of distributing E. coli O157 to a susceptible herd, no studies have indicated conclusively that aggressive and frequent water trough cleaning has any effect on E. coli O157.*
4. Feed	*Although E. coli O157 has been found in feed, no association between E. coli O157's presence in feed and the pathogen's prevalence in live animals has been found. A few articles recommended a shift from high-concentrate to high-roughage feed as a possible way to control E. coli O157, but research cannot validate any positive effect of such a diet. Further, feeds including whole cottonseed, barley, barley silage, or soybean meal have not proven to reduce E. coli O157.* *The only predictable outcome of an abrupt dietary change is an adverse effect on animal performance, which raises animal welfare concerns.* *Because E. coli O157 has been recovered from many non-bovine species including rodents, scavengers such as raccoons and hogs, wild ruminants, other domestic animals and birds, producers incorporating principle-based husbandry should limit these and other non-bovine animals' access to stored commodities and prepared or delivered feed.* *Another potential source of contamination of feed products is through contact with contaminated mechanized equipment. Principle-based husbandry practices include clean feed-handling equipment. Equipment used to clean pens, or move waste or dead animals, should not be used for ration preparation without prior thorough cleaning and disinfecting.*
5. Pests	*Although research focusing on the relationship between E. coli O157 and flies remains inconclusive, producers using principle-based husbandry should take appropriate measures to keep fly populations at an acceptable threshold. Appropriate fly control may include one or more of the following Integrated Pest Management strategies:* ***1.Mechanical/Habitat:** Drainage of standing water, bait traps, scraping pens, mowing/removing weeds, sanitation such as removal of spilt/uneaten food, water trough maintenance, composting of manure, removal/composting of dead animals, or limitation of on-site storage of hay.* ***2.Biological:** Parasitic wasps or targeted microorganisms such as Bacillus species (thuringensi).* ***3.Chemical:** Foliar application (airplane, misters, foggers, sprinkler application) or insecticide baits.*
6. Pre-Harvest/Harvest Interface	*The pre-harvest/harvest interface involves the period of time from when cattle leave the feedyard to hide removal at the packing plant. Not much research has been done on this important area. However, based on research of other human enteric pathogens, notably Salmonella, the pre-harvest/harvest interface provides ample opportunities for cross-contamination particularly during transport and holding. Therefore, feedlot operators practicing principle-based husbandry should assure that cattle trailers or holding pens are not a source of contamination due to deposited fecal material. Internal surfaces of cattle trailers should be free of visible fecal material and should be cleaned and disinfected prior to loading cattle. Holding pens at packing plants should be cleaned before each group of cattle arrives.*

The following table summarizes the current science on pre-harvest interventions.

PRE-HARVEST INTERVENTIONS

1. Probiotics

Probiotic products have been proven to reduce E. coli O157 *prevalence in feces.*

Brashears, M.M., M.L. Galyean, J.E. Mann, K. Killinger-Mann, and G. Loneragan. 2003. Reduction of Escherichia coli O157 and Improvement in performance in beef feedlot cattle with a Lactobacillus Direct Fed Microbial. J. Food Prot. 66: 748-754.

Brashears, M.M., D. Jaroni, and J. Trimble. 2003. Isolation, Selection and Characterization of Lactic Acid Bacteria for a Competitive exclusion Product to Reduce Shedding Of E. coli O157:H7 in Cattle. J. Food Prot 66(3): 355.

Elam, N.A., J.F. Gleghorn, J.D. Rivera, M.L. Galyean, P.J. Defoor, M.M. Brashears, and S.M. Younts-Dahl. 2003. Effects of live cultures of Lactobacillus acidophilus (Strains NP45 and NP51) and Propionibacterium freudenreichii on performance, carcass and intestinal characteristics, and Escherichia coli 0157:H7 shedding of finishing beef steers. J Anim Sci. 81: 2686-2698.

Younts-Dahl, S. M., M. L. Galyean, G. H. Loneragan, N. Elam, M. M.Brashears. 2004. Dietary supplementation with Lactobacillus and Propionibacterium-based direct-fed microbials and prevalence of Escherichia coli O157 in beef feedlot cattle and on hides at harvest. J Food Prot. 67(5):889-893.

Younts-Dahl, S. M., Gary D. Osborn, M. L. Galyean, J. Daniel Rivera, G.H. Loneragan, M. M. Brashears. Reduction of Escherichia coli O157 in finishing beef cattle by various doses of lactobacillus acidophilus in direct-fed microbials. J Food Prot. In Press.

Stephens, T. P., G. H. Loneragan, L. M. Chichester, and M. M. Brashears. 2006. Prevalence and enumeration of Escherichia Coli O157 in steers receiving various strains of Lactobacillus-based direct-fed microbials. J Food Prot. In Press.

2. Tasco 14™

Tasco 14™, a seaweed extract, is being extensively tested. In completed trials, supplementation with Tasco 14™ reduced E. coli O157 levels, but also had adverse effects on animal performance levels.

Braden, K.W. , Blanton, J. R., Allen, V. G., Pond, K. R., Miller, M. F. 2004. Ascophyllum nodosum supplementation: a preharvest intervention for reducing Escherichia coli O157:H7 and Salmonella spp. in feedlot steers. J. Food Prot. 67 (9):1824-1828.

3. Sodium Chlorate	*Sodium chlorate administered intraruminally, and in prepared water and feed, significantly reduced E. coli* O157 *levels.* ***Sodium chlorate is awaiting FDA approval for this use and may not be used in cattle going to slaughter for human food.***
4. Vaccines	*Research trials indicated vaccines significantly reduce E. coli* O157 *prevalence in hide and fecal samples. However, appropriate dosages and administration of such vaccines is still under research.* ***Vaccines are still under investigation and have not been approved for use.***
5. Antibiotics	*Ceftiofur administration resulted in a significant and rapid decrease in E. coli* O157 *shedding between treatment days two and five. Reduction was not as marked beyond day five. This antibiotic requires additional research in naturally infected animals (rather than those infected specifically for research purposes) to determine if an interaction with prior antimicrobial drug treatment exists.* *Administration of neomycin sulfate to naturally infected animals resulted in significant reduction of E. coli* O157. *Adding neomycin to drinking water also resulted in significant reduction. However, use of neomycin to control E. coli* O157 *may not meet neomycin's current approved label use. The Food and Drug Administration Center for Veterinary Medicine has been asked to clarify their interpretation of the label.* ***Use of ceftiofur and neomycin for E. coli* O157 *control has not been FDA approved.***
6. Bacteriophages	*Bacteriophages (viruses that infect bacteria) have not been proven to reduce E. coli* O157.
7. Water treatment	*Water treatment such as chlorination and electrolyzed oxidation has not been shown to have a reductive effect on E. coli* O157 *in live animals, although laboratory research has been encouraging. Further studies are required.* ***Using chlorination and electrolyzed oxidation to control E. coli* O157 *is still under investigation.***
8. Pre-Harvest/Harvest Interface	*Pre-harvest/harvest interface represents the stage of production from the time when cattle leave the feedyard to the time the hide is removed from the carcass within the packing plant. Cattle cleaning systems for live animals as well as hide washes are being investigated. Several companies have implemented hide washes within packing plants.* ***Additional methods to reduce E. coli* O157 *at this beef production stage are still under investigation.***

Knowledge Gaps

Recent data suggest that *E. coli* O157:H7 may be more prevalent than previously thought, particularly when comparing current research to studies conducted before September 1999. Any contribution producers could make to pathogen-load reduction would benefit the beef industry. However, producers must wait until beef industry researchers find effective pre-harvest methods, and government agencies approve such methods (if approval is required). Such methods must not only be proven with scientifically documented outcomes in mainstream live beef and dairy cattle production settings, they must also be cost-effective and easy to incorporate in production systems.

Several knowledge gaps, or important areas on which research should be focused as industry-wide food-safety systems evolve, provide a roadmap for industry researchers. Some of the most acute knowledge gaps are:

Standardized sampling protocols. Both experimental design and numbers of collected samples varies between research projects. This variation makes combining and comparing results difficult. One participant in the *E. coli* Summit suggested that development of a "national database" would assist the industry in standardizing methods for collecting samples from live cattle. Validating future research will require (for the sake of comparison) standardized sampling protocols. Sample collection methodology may be influenced by the laboratory methods used for detecting *E. coli* O157 and by the purposes for data collection.

Standardized testing. Currently, laboratory methodology used to test for *E. coli* O157 presence differs from study to study and laboratory to laboratory. Although relatively subtle, these differences in methodology can sway results substantially. Standardization of laboratory methods, to provide the most accurate and useful results, will make research comparisons easier and allow data sets to be combined into a national database.

Better understanding of E. coli* O157 *shedding. Although scientists understand *E. coli* O157 shedding better than ever before, a substantial number of questions remain unresolved. These include questions surrounding seasonal and regional variation, pen-to-pen variation, persistent colonization of both pens and individual animals, and relationships between wildlife, insects, water and other transmission vectors.

More research on live animal microbial interventions. In addition to encouraging producers to incorporate principle-based husbandry practices, researchers must work to develop and validate intervention systems for use in live cattle production.

Evaluation of intervention implementation. Researchers should make sure proposed interventions are easy and economically feasible to implement. The interventions' effect on other aspects of live animal production should also be taken into account.

Pre-harvest/harvest interface. The industry needs to study animal-to-animal transmission between an animal's departure from the feedyard to hide removal in the packing plant. Knowledge of how cattle handling at this critical juncture influences carcass contamination should also prove valuable.

Multiple microbiological and pathogen ecology under the influence of principle-based husbandry practices. Controlling one pathogen may have unintended effects on another. When developing industry-wide recommendations for pathogen control, researchers must understand these "side-effects" or effects of one pathogen's control on other pathogens and microbial populations. As the industry introduces new technologies to enhance food safety in the livestock production sector, understanding the consequences these technologies may have on pathogens other than those being targeted, and other microbial populations, is critical.

Additional emphasis on market beef and dairy cows and bulls. Approximately one-fifth of the U.S. live harvest consists of mature cows and bulls culled from farms, ranches, and dairies. A large proportion of the resulting product from such livestock is ground beef. Greater research emphasis should be placed on controlling *E. coli* O157 in these populations.

Development of a systems approach to pre-harvest food safety practices. Producers must incorporate principle-based husbandry practices to set the stage for effective microbiological pathogen control interventions. Poor operation hygiene and poor animal handling procedures can cross-contaminate, re-contaminate and re-distribute pathogens, decreasing the effectiveness of any intervention system. Personnel responsible for livestock and feed handling, as well as fabrication and packaging of beef products, take responsibility for, and make a sincere commitment to, beef safety. Such personnel need to be well trained and empowered to take appropriate and immediate action to ensure food safety during operation. Any effective approach must address the entire system-from principle-based husbandry practices to microbial pathogen control interventions.

As soon as producers begin contributing to pathogen-load reduction, the beef industry will benefit.

In the future

Gaps remain in the industry's understanding of the ecology and epidemiology of *E. coli* O157. Effectively addressing the reduction of this pathogen in the pre-harvest segment of the chain requires filling these gaps in basic knowledge. Further research will develop science-based, effective, economical interventions that fit into the current cattle production systems. Industry and government should coordinate their approach to clarify and establish research priorities and enhance funding to develop these interventions. Expedited government review and approval of effective interventions will allow the industry to continue to enhance the safety of beef and beef products.

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