SMALL PLANT INTERVENTION TREATMENTS TO REDUCE BACTERIA ON BEEF CARCASSES AT SLAUGHTER

DENNIS BUEGE
ANIMAL SCIENCES DEPARTMENT

STEVE INGHAM
FOOD SCIENCE DEPARTMENT

UNIVERSITY OF WISCONSIN-MADISON - - JUNE 2003

The slaughter process for cattle and other meat-producing animals involves the removal of the bacteria-free meat from between two contaminated surfaces - the hide and the GI tract. In this process, no matter how carefully it is carried out, there will invariably be transfer of bacteria to the carcass. The food safety goal of the slaughter process is minimize bacterial contamination of the carcass, and effectively remove contamination which has occurred.

The primary weapon in reducing bacterial contamination of beef carcasses is employing effective sanitary dressing procedures during slaughter. There is no substitute for trying to keep bacteria off the carcass in the first place. Workers should know, understand and use the recommended sanitary dressing techniques in whatever slaughter method is used. A list of current "best practices" as developed by the beef slaughter industry, is included at the end of this report.

However, no matter how carefully a plant dresses beef carcasses, it is inevitable that bacteria will contaminate the carcass, some of which could potentially be fecal pathogens such as *E. coli* O157:H7 or *Salmonella*. Therefore, applying "interventions" to carcasses during and after the dressing procedure to effectively remove or inactivate bacterial contamination and improve meat safety is important. Such "interventions" include trimming, steam vacuuming, carcass washing; hot water rinses, organic acid rinses and steam pasteurization. In addition, it has been demonstrated that the process of dry chilling and refrigerated storage of beef carcasses likewise causes a decline in bacteria numbers.

In the fall of 2002, the USDA issued a directive calling for beef slaughter plants (and also beef grinding and fabrication operations) to reassess their HACCP plans. If at slaughter *E. coli* O157:H7 is a hazard "reasonably likely to occur" (and from industry experience and research data it is difficult to argue that it isn't), then a validated intervention must be present in the slaughter process and operated as a critical control point. "Validated" means that there must be scientific evidence that the intervention can reduce the likelihood of *E. coli* O157:H7 being present on the carcass. Besides a CCP associated with a validated intervention, a CCP is required to assure zero fecal contamination on the carcass at the end of slaughter.

The USDA has not mandated the size of the bacteria/*E. coli* O157:H7 reduction required by an intervention process. Reduction in bacteria numbers is usually expressed in terms of "logs" of reduction. A one log reduction means that the number of bacteria has been reduced by 90% (100 to 10). A two log reduction would be from 100 to 1 (99% reduction) and so on. No intervention can be guaranteed to completely eliminate all pathogens all of the time, but significant reductions are a move in the right direction, and a lowering of the risk of food-borne illness.

Currently we are hearing that small slaughter plants are testing or using a wide variety of interventions. The purpose of this summary report is make our recommendations about interventions that are possible and make sense for a smaller-scale beef slaughter plant.

Intervention Guidelines at Slaughter

Many studies have been done on interventions at slaughter. It is easy to get confused by all the ways in which interventions are applied in experimental settings. While studies are important to validate (prove the effectiveness of interventions) an intervention, small plants cannot be expected to duplicate the exact conditions of tests done at university or large-scale plants. Therefore, we have chosen to not focus on specific experimental methods, but rather to look at the basic processes which have been shown in repeated studies to reduce bacteria on carcasses, and eliminate *E. coli* O157:H7. At the end of this report are some references to scientific studies to support the interventions.

Carcass Trimming

- a usual part of the slaughter process, effective in removing physical debris and bacteria associated with it.
- final trim remains a required CCP to meet the zero fecal tolerance requirement.
- not usually regarded as an intervention because it is a "spot" process addressing only visible material, while invisible bacteria remain.
- one study published by Kansas State found trimming followed by carcass washing (95^{o}F water) to reduce added *E. coli* O157:H7 (purposefully added prior to the trimming) by 4.7 logs.

Carcass Wash

- a usual part of the slaughter process to remove bone dust and other material from trimmed carcasses. It will also remove bacteria.
- we recommend that a warm carcass wash be used (90-120^{o}F). This will more effectively remove debris from the carcass.
- be careful not to allow spray from the carcass being washed to contact previously washed carcasses.
- since this is a usual part of slaughter, it is not usually regarded as an intervention, but an important part of carcass dressing and preparing the carcass for other interventions.

Lactic Acid Rinse

- use a warm, thorough carcass wash before applying lactic acid.
- maximum allowable concentration is 2.5%
- usual use level is 2%. Lactic acid as purchased is usually 88% lactic acid. Use 3.25 ounces of that solution per gallon of water (8.3 lbs.) to get a 2.1% solution. 3.75 ounces per gallon of water gives a 2.4% solution.
- apply at solution temperature of ambient to 130^{o}F. The warmer the temperature the more effective the kill (do not go over 130^{o}F - lactic acid will evaporate out of solution).
- we recommend two thorough passes over the entire carcass surface with a garden type sprayer (one plant noted it was applying one pint per side).
- suggested critical limits: (1) documenting the proper concentration of solution at make-up and (2) documenting application to each carcass.

Acetic Acid

- use a warm water, thorough rinse before applying acetic acid solution
- 2% solution is suggested. Vinegar can be used - usually 5% acetic acid (see label).
- for a 5% acetic acid vinegar: use 80 oz. (5 lbs.) vinegar per one gallon of water (8.3 lbs.)
- apply at solution temperature of ambient to 130^{o}F. The warmer the temperature the more effective the kill (do not go over 130^{o}F - acetic acid will evaporate out of solution).
- we recommend two thorough passes over the entire carcass surface with a garden type sprayer.
- suggested critical limits: (1) documenting the proper concentration of solution at make-up, and (2) documenting application to each carcass.
- (Note: acetic acid will be cheaper than lactic acid. One source preferred lactic acid because it was easier on floors, and not as irritating to people).

Fresh Bloom

- available from Excalibur Seasonings - contains citric acid, ascorbic acid and eythorbic acid.
- in one UW in-plant test, Fresh Bloom was only slightly less effective than lactic acid in reducing total bacteria counts (effects on *E. coli* O157:H7 not evaluated)
- use a thorough warm-water carcass wash before applying Fresh Bloom solution.
- use 8 ounces of Fresh Bloom per gallon of water.
- apply at solution temperature of ambient to 130^{o}F. The warmer the temperature the more effective the expected kill.
- we recommend two thorough passes over entire carcass surface with a garden type sprayer.
- suggested critical limits: (1) documenting the proper concentration of solution at make-up, and (2) documenting application to each carcass.

Hot Water Rinse

- use 150 to 180^{o}F water (the higher the temperature the greater the effect)
- must be careful in using - hazardous to people. May cause condensation problems in plant.
- we suggest two thorough passes over entire carcass surface.
- suggested critical limits: (1) periodic check of water temperature, and (2) documentation of application to carcass.

Dry Aging

- a UW in-plant test found a 1.2 log reduction in total bacteria due to the final carcass wash (tap water), a 0.6 log additional reduction from wash through 2 days of aging, and 0.4 log additional reduction from day 2 through 6 days of aging (total reduction of aerobic plate count was 2.2 logs, from before carcass wash through 6 days of aging).
- follow-up laboratory tests simulating slaughter cooler conditions found generic *E. coli* and *E. coli* O157:H7 to die off more than total bacteria (so above tests may have showed even more effective kill for O157:H7).
- suggest cooler be at less than 90% RH and less than 41^{o}F.
- suggest 2 critical limits: (1) cooler temperature less than 41^{o}F, and (2) document that carcasses are chilled/aged for at least 6 days.
- considering dry chilling/aging as an intervention is a new concept (most large plants spray chill and fabricate carcasses after 2 days). However our UW tests support that generic *E. coli* and *E. coli* O157:H7 die off under dry chilling/aging conditions.

Notes:

1. If spraying on an anti-microbial solution, it is worthwhile to invest in a higher quality garden-type sprayer. It is recommended that the rinse be applied with a moderately broad nozzle setting and a high level of pump pressure.

2. Currently in the industry, lactic acid is the most commonly used anti-bacterial chemical treatment used for carcasses. A current cost comparison of 2% lactic acid and 2% acetic acid, staring with white vinegar at $2.25 per gallon and lactic acid at $15 per gallon, when diluted to approximately 2% levels, shows a cost of $0.90 per gallon of acetic acid solution, and $0.35 per gallon of 2% acid solution.

3. There have been reports of acetic acid solutions being harder on floors (eats them up), and also more irritating to workers, than lactic acid.

4. One industry newsletter reported some processors were finding that carcasses sprayed with organic acids developed changes in the surface fat during aging. To date we have not heard of anything like that from local processors.

Research Results on Intervention Processes

Treatment	Microbial Contaminant	Reduction (log CFU/cm^2)	Reference
Trimming	*E. coli* O157:H7 in feces	3.2 - 4.4	1
Trimming	Aerobic Plate Count	3.0	2
Trimming	*E. coli* O157:H7 in feces	3.1	3
Trimming + Washing (95^{o}F)	*E. coli* O157:H7 in feces	4.7	3
Trimming	*E. coli* O157:H7 in feces	3.1	7
Trimming + Hot Water (165^{o}F)	*E. coli* in feces	1.4	4
Spray Washing (60^o, 95^o, 150^o, & 165^{o}F)	*E. coli* (antibiotic-resistant strain in feces)	1.8 - 2.3	4
Washing (tap water)	*E. coli* O157:H7 in feces	1.8	9
Washing (95^{o}F)	*E. coli* O157:H7 in feces	2.0 - 3.5	1
Washing (tap water)	*E. coli* O157:H7 in feces	2.4	7
Washing (165^{o}F - 10 sec.)	*E. coli*	1.4	5
Washing (182^{o}F - 10 sec.)	*E. coli*	2.2	5
Washing (165^{o}F - 20 sec.)	*E. coli*	2.1	5
Washing (182^{o}F - 20 sec.)	*E. coli*	2.9	5
Water (95^{o}F) + 2% lactic acid (131^{o}F)	*E. coli* O157:H7 in feces	3.0 - 4.9	1
Wash (tap) + 2% lactic acid (131^{o}F)	*E. coli* O157:H7 in feces	4.6	7
1% lactic acid (75^{o}F)	*E. coli* O157:H7	1.0	6
3% lactic acid (75^{o}F)	*E. coli* O157:H7	1.7	6
5% lactic acid (75^{o}F)	*E. coli* O157:H7	2.6	6
2% lactic acid (100 - 138^{o}F)	Aerobic Plate Count	0.7	13
2% lactic acid (tap water)	*E. coli* O157:H7 in feces	2.4	10
2% lactic acid (tap water)	*E. coli* O157:H7 in feces	2.2	10
2% lactic acid (tap water)	*E. coli* O157:H7 in feces	2.7	10
2% lactic acid (tap water)	*E. coli* O157:H7 in feces	1.3	10
Water (165^{o}F) + 2% acetic acid (61^{o}F)	*E. coli* (resistant) in feces	3.0	4
Water (95^{o}F) + 2% acetic acid (131^{o}F)	*E. coli* O157:H7 in feces	2.4 - 3.7	1
1% acetic acid (75^{o}F)	*E. coli* O157:H7	1.6	6
3% acetic acid (75^{o}F)	*E. coli* O157:H7	1.9	6

Treatment	Microbial Contaminant	Reduction (log CFU/cm^2)	Reference
5% acetic acid (vinegar) (75^{o}F)	*E. coli* O157:H7	2.0	6
1% citric acid (75^{o}F)	*E. coli* O157:H7	1.2	6
3% citric acid (75^{o}F)	*E. coli* O157:H7	1.7	6
5% citric acid (75^{o}F)	*E. coli* O157:H7	1.8	6
5.7% Fresh Bloom (ambient temperature)	Aerobic Plate Count	0.5	13
Wash + Hot Water (203^{o}F)	*E. coli* O157:H7 in feces	4.0	7
Hot Water Wash (165^{o}F)	*E. coli* O157:H7 in feces	2.6	8
Hot Water (146-162^{o}F)	Aerobic Plate Count	0.3	13
Hot Water (146-162^{o}F) + 2% lactic acid (100-138^{o}F)	Aerobic Plate Count	1.3	13
Dry Chilling/Aging (1 day)	*E. coli* (manure)	1.3	11
Dry Chilling/Aging (7 days)	*E. coli* (manure)	2.1	11
Dry Chilling/Aging (1 day)	*E. coli* O157:H7 in feces	1.7	10
Dry Chilling/Aging (7 days)	*E. coli* O157:H7 in feces	3.3	10
Dry Chilling/Aging (1 day)	*E. coli* O157:H7	0.9	10
Dry Chilling/Aging (3 days)	*E. coli* O157:H7	2.0	10
Dry Chilling/Aging (1 day)	*E. coli* O157:H7	1.3	10
Dry Chilling/Aging (3 days)	*E. coli* O157:H7	2.1	10
Washing (tap) + 6 days Dry Chilling/Aging	Aerobic Plate Count	2.2	12
Dry Chilling (6 days)	*E. coli* O157:H7	1.4/lean; 1.5/fat	14
Dry Chilling (6 days)	*E. coli*	1.3/lean; 1.3/fat	14
Dry Chilling (6 days)	*E. coli* O157:H7/flank	2.2	14
Dry Chilling (6 days)	*E. coli*/flank	1.3	14
Dry Chilling (6 days)	*E. coli* O157:H7/brisket	2.6	14
Dry Chilling (6 days)	*E. coli*/brisket	3.1	14
Dry Chilling (6 days)	*E. coli* O157:H7/plate	3.4	14
Dry Chilling (6 days)	*E. coli*/plate	3.3	14
Dry Chilling - pork carcasses (1 day)	*E. coli*	3.2	15

Some of this information was taken from a table in: Dalazari, I., S.T. Iaria, H.P. Rieman, D.O. Cliver, and T. Mori. 1998. Decontaminating beef for *Escherichia coli* O157:H7. J. Food Prot. 61:547-550.

Note:

There is wide variation in the log reductions among studies. One reason for this is that many studies began by applying manure inoculated with high levels of *E. coli* O157:H7 to the meat surface. That produced very high initial numbers, and the rinsing of surface by the solution itself (apart from the anti-microbial action by the solution) contributes to large numerical reductions.

In contrast, the modest reductions of reference 13 were obtained by comparing normally washed carcass sides to opposite halves washed and then treated with acids and/or hot water. Modest reductions, under these conditions may be as meaningful as more dramatic results obtained by starting with highly contaminated surfaces.

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Verification

Under HACCP, "verification" is designed to check that the controls at the CCP are effective. For beef slaughter, the USDA directive wants plants to do some level of testing of carcasses to verify the elimination of *E. coli* O157:H7. Below are some suggestions related to this verification testing.

- we suggest bi-monthly or quarterly testing of one carcass for the pathogen (*E. coli* O157:H7), using the 3 carcass-site sponge technique.
- be sure to hold the tested carcass until the test results are known.
- if verification test results are consistently negative for 2 years or longer you might consider reducing the frequency of carcass testing.
- if verification test results find a positive *E. coli* O157:H7 result, evaluate your slaughter process for potential problem areas, and consider increasing your frequency of carcass testing for the pathogen. Re-apply intervention to positive carcass and retest.
- in Wisconsin state-inspected plants, the carcass verification testing for *E. coli* O157:H7 may be done by the state inspection program.

Reassessment of Raw-Ground HACCP Plans

In the hazard analysis, *E. coli* O157:H7 should be considered as a potential hazard at receiving. The preventive measure will be that received meat will come from sources that have applied interventions at slaughter (whether this is your slaughter operation or from an outside vendor).

- develop an SOP requiring outside vendors to provide documentation that beef has come from slaughter operations with effective interventions.
- collect and file such required certification from all suppliers (such documents are very common now)
- if using beef from your slaughter operation, note in your hazard analysis that you are using effective interventions.
- the *E. coli* directive expects those grinding beef to conduct some verification testing on ground product.
    - we suggest that bi-monthly or quarterly a ground sample is tested for *E. coli* O157:H7 (hold lot until results are back).
    - after two years of negative results, you can consider reducing your frequency of testing.
    - plants operating under Wisconsin Sate meat inspection may have some of this verification testing for the pathogen conducted by the state program.

Although interventions are applied by slaughter plants, and the requirements of your SOP are that incoming beef has been treated with effective interventions, there still may be other pathogens present which will be dealt with by the CCP you already have in place (usually product temperature).

Reassessment of Raw-Not Ground HACCP Plans

The SOP you prepared for incoming grinding materials should likewise apply to beef being processed as whole muscle product. Thereby, all beef being processed (grinding or cuts) should be under the umbrella of documentation as coming originally from a slaughter source applying effective interventions. This incoming beef product specification requirement is especially important for beef cuts which will be mechanically tenderized, where pathogens on the surface could be carried into the interior of the cut.