STEAM PASTEURIZATION OF BEEF CARCASSES

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Summary

This research evaluated the effectiveness of a newly patented steam-pasteurization process for reducing bacterial populations on the surfaces of freshly slaughtered beef carcasses. The process was developed jointly by Frigoscandia Food Processing Systems (Bellevue, WA) and Excel Corp. (Wichita, KS), a division of Cargill (Minneapolis, MN). In laboratory studies, portions of prerigor beef carcasses inoculated with very high levels of three pathogens, *Salmonella*, *Escherichia coli* O157:H7, and *Listeria*, were treated in a prototype steam-pasteurization chamber, which effectively eliminated at least 99.9% of all three pathogens and was most effective when used in combination with other standard commercial decontamination methods. The effectiveness of a full-scale, automated, steam-pasteurization system was evaluated in a commercial beef slaughter facility. The commercial system was very effective, reducing the naturally occurring overall bacterial population by over 90% and reducing the population of *E. coli* (nonpathogenic) and related organisms to undetectable levels. Steam pasteurization is very effective at reducing bacterial contamination on unchilled beef carcasses and should be viewed as one step in an overall process of reducing the risk of pathogenic bacteria in beef and beef products.

(Key Words: Steam Pasteurization, Slaughter, Beef Safety, *E. coli* O157:H7.)

Introduction

During slaughter, bacterial contamination of beef carcass surfaces is unavoidable. The surface of dressed carcasses may become contaminated with bacteria via many sources including processing equipment and slaughterhouse workers. However the predominant source of bacteria is the animal itself. Materials associated with cattle, such as hide, hooves, intestinal contents, and milk, may harbor large numbers of bacteria, including pathogens. For this reason, current USDA-FSIS regulations require that all visible feces, hair, ingesta, or milk be removed from the surface of beef carcasses. According to USDA-FSIS, the investigation of processing procedures that effectively eliminate physical and microbial contamination is of prime importance.

Our research was conducted in two phases; the first in a laboratory and the second in a commercial setting. The objective of the laboratory phase was to determine the effectiveness of steam pasteurization and four other decontamination treatments, when used in combination and individually, for reducing high levels of three pathogens that had been inoculated onto the surfaces of prerigor beef. The objective of the commercial phase was to determine the effectiveness of a full-scale steam-pasteurization process for eliminating naturally occurring bacteria on freshly slaughtered beef carcasses.

Experimental Procedures

Laboratory Phase. Unchilled prerigor sections of *Cutaneous truncii* (rose meat) muscles from freshly slaughtered fed steers were smeared with bovine feces with added pathogens to inoculate the surface with high levels (5.0 $\log_{10}$ CFU/cm^2) of *Salmonella typhimurium*, *Escherichia coli* O157:H7, and *Listeria monocytogenes* (5.0 log equals 100,000 microorganisms). Meat portions then were treated with either a single decontamination treatment or a combination of two or more treatments. The treatments included steam pasteurization (S) for 15 seconds, knife trimming

(T) of visible contamination, washing (W) with warm (95 F) water, applying a 2% lactic acid (L) solution, and removing visible contamination with a commercial, spot-cleaning, hot water/steam, vacuum system (V). Samples removed from the inoculated meat surface area before and after treatment were analyzed for pathogenic bacteria. All experiments were repeated four times.

Commercial Phase. After passing final inspection and immediately prior to entering coolers, carcass sides were treated in a commercial-size, automated, steam-pasteurization system capable of treating four carcass sides per cycle. Sides were exposed to steam for 8 seconds (meat surface temp of 195 F or higher) and then immediately cooled with a cold (34 F) water shower. Samples were taken from 140 carcass sides (70 cows and 70 fed cattle) before, immediately after, and 24 hours after steam treatment to determine the number of bacteria killed. Samples collected before and immediately after treatment also were analyzed for the presence of naturally occurring *Salmonella*.

Results and Discussion

Laboratory Phase. The mean reduction in populations of each pathogen by various decontamination treatments (Table 1) was analyzed statistically in two separate parts. All treatments in both experimental parts reduced ($P<.05$) the initial populations of all three pathogens. In part 1, all combinations of treatments were equally effective at reducing populations of *E. coli* O157:H7. For both *S. typhimurium* and *L. monocytogenes*, TW, TWLS, and VWLS were slightly more effective, and VW and VWS were least effective. In part 2, regardless of pathogen type, the least effective treatment was warm water wash alone. For *E. coli* O157:H7, all treatments except wash alone were equally effective. Vacuum spot-cleaning and steam pasteurization were very similar to combination treatments in part 1 in their ability to reduce populations of *S. typhimurium* and *L. monocytogenes* and were slightly more effective than trimming alone.

Although several methods were effective at reducing high levels of pathogenic bacteria on the surface of prerigor beef, they are not equally practical in a commercial setting. It is impossible to use knife trimming and vacuum spot-cleaning to decontaminate an entire carcass; warm water washing used alone may simply redistribute contamination; and lactic acid is corrosive to processing equipment and unpleasant for employees. Steam pasteurization does not have these drawbacks.

Commercial Phase. The average bacterial populations on the surface of carcasses before, immediately after, and 24 hours after steam pasteurization are shown in Table 2. The total aerobic bacterial population (which is equivalent to the overall population of bacteria) for both cows and fed cattle was reduced immediately by approximately 1.1 $\log_{10}$ CFU/cm^2, or over 90% (1 log is equivalent to 90%). Although the average *E. coli* (nonpathogenic) population was very low initially, it was reduced to undetectable levels immediately after steam pasteurization. The bacterial populations after 24 h were very similar to those seen immediately after pasteurization, which indicates that the system is not just injuring bacteria but actually killing them.

Commercial steam pasteurization effectively reduced the number of bacteria on the surfaces of carcasses, but did not remove gross physical contamination such as fecal material, ingesta, or hair. Those contaminants should be removed by knife trimming, washing, or other methods prior to steam pasteurization.

Steam pasteurization effectively reduces the overall risk associated with pathogens in meat products.

Table 1. Reductions in Pathogen Populations on Freshly Slaughtered Beef *Cutaneous truncii* Muscles by Laboratory Decontamination Treatments

Experimental Part	Treatment[b]	Mean Reduction (Log_{10} CFU/cm^2)[a]		
		E. coli O157:H7	*L. monocytogenes*	*S. typhimurium*
Part 1	TW	4.7[c]	5.0[c]	4.9[cd]
	TWS	4.4[c]	4.6[cd]	4.4[cde]
	WS	4.2[c]	4.4[cde]	4.8[cd]
	VW	3.5[c]	3.5[e]	3.6[e]
	VWS	3.8[c]	3.8[de]	4.2[de]
	TWLS	4.1[c]	5.1[c]	5.3[c]
	VWLS	4.7[c]	5.0[c]	5.1[cd]
Part 2	T	3.1[c]	2.5[e]	2.7[d]
	W	.7[d]	1.3[f]	1.2[e]
	V	3.1[c]	3.3[def]	3.4[cd]
	S	3.5[c]	3.4[de]	3.7[cd]
	VWLS*5	3.4[c]	4.5[c]	4.5[c]
	VWLS*10	3.6[c]	4.2[cd]	3.9[cd]

[a]Initial level ca. 5.0. [b]Abbreviations are T=knife trimming, W=warm water washing, V=vacuum spot-cleaning, S=steam pasteurization (15 second exposure time unless otherwise noted: *5=5 second exposure, *10=10 second exposure), L=2% v/v lactic acid spray, all listed in order of application. [c-f]Means having the same superscript within columns and experimental part are not different (P>.05).

Table 2. Naturally Occurring Bacterial Populations on Beef Carcasses Treated with a Commercial Steam-Pasteurization System

Carcass Type	Sampling Time	Mean Population (Log_{10} CFU/cm^2)	
		Total Aerobic Bacteria	*E. coli* (nonpathogenic)[a]
Cows n = 70	Before	2.19[b]	.10[b]
	After	.84[c]	ND[c]
	24 h After	.94[c]	ND[c]
Fed Cattle n = 70	Before	2.14[b]	.07[b]
	After	1.03[c]	ND[c]
	24 h After	1.09[c]	ND[c]

[a]ND=none detectable. [b-c]Means having the same superscripts within columns and carcass type are not different (P>.01).