# Efficacy of Washing and/or Trimming Beef Subprimals as a Decontamination Method for *Escherichia coli* O157:H7

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*Abstract*— **Beef top sirloin butts were inoculated with a cocktail of rifampicin-resistant *Escherichia coli* O157:H7 at two levels (high = ~$10^4$ CFU/$cm^2$ and low = ~$10^2$ CFU/$cm^2$). Subprimals then were vacuum packaged and stored (~ 2°C) for 0, 14, or 28 days. After storage, the exterior of the bag, purge, inoculation site on the subprimal, area adjacent to the inoculation site, and surface opposite from the inoculation site were sampled. Subprimals were treated with seven combinations of water wash and/or trimming before microbial sampling. *E. coli* O157:H7 was transferred from the inoculated surface area to other areas of the subprimal, possibly caused by purge. Exterior surfaces of bags also were contaminated. Less than a 1.0 $log_{10}$ CFU/$cm^2$ difference was observed between counts recovered before treatments and after water washing. Full and partial-surface trimming alone decreased counts on the dorsal surface. On the ventral side, full-surface trimming was more effective than partial-surface trimming. Water washing combined with trimming had little to no additional effect on counts recovered, with less than a 0.5 $log_{10}$ CFU/$cm^2$ difference often detected between trimming alone and trimming combined with water washing. Full trimming, with or without a water wash, proved to be the most effective treatment used to reduce *E. coli* O157:H7 to non-detectable levels.**

*Keywords*— ***Escherichia coli* O157:H7, translocation, beef.**

## I. INTRODUCTION

Since the U.S. 1992-1993 foodborne outbreak from *Escherichia coli* O157:H7 in ground beef, a large amount of research has focused on beef safety. Much of the initial research focused on harvest interventions to reduce pathogen contamination. Research has shown that the prevalence of *E. coli* O157:H7 on beef subprimals is low; however, there is a possibility that the exterior surfaces of the subprimals could be contaminated. If the exterior surface of a subprimal is contaminated with *E. coli* O157:H7, blade tenderization or needle injection can force the pathogen into the sterile interior. This presents a potential health risk to the consumer because non-intact meat cooked to lower degrees of doneness has an increased risk of internalized pathogens surviving thermal inactivation. As a result of this potential health risk, the United States Department of Agriculture's Food Safety and Inspection service declared raw, non-intact beef adulterated if it contains *E. coli* O157:H7. Therefore, this project was designed to evaluate the translocation of *E. coli* O157:H7 from one area of the surface to other areas in vacuum-packaged beef subprimals, as well as investigate the efficacy of water wash and/or surface trimming as decontamination methods for subprimals.

## II. MATERIALS AND METHODS

### *A. Subprimal preparation and decontamination treatments*

Ninety-six beef loin, top sirloin butts (cap-on) and ninety-six beef loin, semi-center cut top sirloin butts (cap-off) were used in this project. Subprimals were divided into four replications, with 24 cap-on sirloins and 24 cap-off sirloins designated for each replication.

The following seven decontamination methods were evaluated: water washing (WW), full-surface trimming (FT), partial-surface trimming (PT), water washing followed by full-surface trimming (WWFT), water washing followed by partial-surface trimming (WWPT), full-surface trimming followed by water washing (FTWW), and partial-surface trimming followed by water washing (PTWW). Water washing washed the entire exterior surface with tap water. Full trim removed all exterior surfaces. Partial trim removed only the dorsal surface.

### B. Inoculation

Three strains of rifampicin-resistant *E. coli* O157:H7 were used to create a bacterial cocktail. Ninety-six top sirloin butts ($n$ = 48 cap-on, $n$ = 48 cap-off) were inoculated with approximately $10^2$ CFU/cm$^2$ (low-inoculum), and ninety-six top sirloin butts ($n$ = 48 cap-on, $n$ = 48 cap-off) were inoculated with approximately $10^4$ CFU/cm$^2$ (high-inoculum) by evenly spreading the cocktail over a 100-cm$^2$ area using a sterile disposable plastic spreader. Following inoculation, the subprimals were vacuum packaged, submerged in a hot water bath to heat shrink the packaging, and stored under refrigeration (2°C) for either 0, 14, or 28 days.

### C. Sample collection

Prior to opening the vacuum package, sponge samples ($n$ = 192) were collected from the exterior surface of the package. After aseptically opening the packages, 10 ml samples of purge were collected from the day 14 ($n$ = 64) and day 28 ($n$ = 64) subprimals. No purge was available to collect for the day 0 subprimals; therefore, the inside of the vacuum package bag was rinsed with 10 ml of 0.1% peptone and collected to simulate purge ($n$ = 64).

Before treatment, two 10-cm$^2$ samples were excised and composited from each of the following subprimal surfaces: the inoculated surface area ($n$ = 192), a site adjacent to the inoculated surface area, and the opposite side. After the first treatment was applied, two 10-cm$^2$ samples were excised and composited from each of the subprimal surfaces. The subprimals that received the water wash as the first treatment ($n$ = 96) had samples excised from the inoculated surface area, a site adjacent to the inoculated surface area, and the opposite side. As a result of the trimming process, the inoculated surface area could no longer be distinguished from the adjacent area; therefore, the subprimals that were full-surface trimmed for the first treatment ($n$ = 48) had samples excised from the inoculated side and the opposite side. Subprimals that were partial-surface trimmed for the first treatment ($n$ = 48) also had samples excised from the inoculated side and the opposite side. Following the second treatment, two 10-cm$^2$ samples were excised and composited from the inoculated side and the opposite side.

## III. RESULTS AND DISCUSSION

Contamination was transferred to other areas of the subprimal. Counts recovered at the inoculation site were similar to the original inoculum level applied, with the adjacent site counts being 1.0 to 2.0 $\log_{10}$ CFU/cm$^2$ lower. Counts from the opposite side of the low inoculated sirloins were at or below the detection limit (0.7 $\log_{10}$ CFU/cm$^2$). Less than 1.0 $\log_{10}$ CFU/cm$^2$ difference was observed among storage day and between cap-on and cap-off sirloins.

Purge in the vacuum-packages may have contaminated the rest of the sirloin because the levels of *E. coli* O157:H7 found in the purge were similar to the initial inoculum. The high-inoculated sirloins had an average of 4.4 $\log_{10}$ CFU/ml found in the purge, while the low-inoculated sirloins had an average of 2.1 $\log_{10}$ CFU/ml. Vacuum-package bags for the high-inoculated top sirloin butts had a higher frequency of contamination than bags from the low-inoculated sirloins: 12.5% of the bags from high-inoculated sirloins were contaminated, as opposed to only 1% of the bags from low-inoculated sirloins.

Water washing alone had little to no effect on the level of *E. coli* O157:H7 recovered from any subprimal surface, for both the high and low inoculated sirloins (Table 1, 2, and 3). Less than a 1.0 $\log_{10}$ CFU/cm$^2$ difference was observed between the counts recovered before and after water washing. Washing with cold water has been shown to not be very effective at decontaminating beef carcasses; moreover, cold-water sprays can in some cases spread microbial contamination to other carcass surfaces [*1, 2, 3*]. When applied to chilled beef subprimals, hot water was able to reduce *E. coli* O157:H7 levels by 1.0 $\log_{10}$ CFU/cm$^2$ [*4*]. Therefore, the water washing treatment in this study may have been less effective because it was room temperature water.

The entire dorsal surface was removed during the trimming decontamination methods; therefore, the counts from the inoculated side of trimmed subprimals were compared to both the inoculation site and the adjacent area of the initial and water-washed counts. Full and partial-surface trimming alone significantly decreased the counts recovered from the dorsal surface (Table 1 and 2). With one exception, the high-inoculated sirloins had *E. coli* O157:H7 levels at or below 1.0 $\log_{10}$ CFU/cm$^2$. However, on the opposite side of high-inoculated subprimals, full-surface trimming was much more effective than partial-surface trimming (Table 3). Partially trimmed sirloins often had counts at least 0.5 to 1.0 $\log_{10}$ CFU/cm$^2$ higher than the fully trimmed sirloins. However, it is important to note that bacterial reductions obtained by trimming under laboratory conditions, using sterile equipment, may not represent reductions that can be achieved during normal fabrication interventions.

Water washing combined with a trimming step had little to no additional effect on the counts recovered, with less than a 0.5 $\log_{10}$ CFU/cm$^2$ difference often detected between trimming alone and trimming combined with water

washing. Moreover, the order in which the treatments were applied had no significant effect on the counts recovered.

## IV. CONCLUSIONS

This project showed that surface contamination could spread from one location to another in vacuum-packaged top sirloin butts. The results also showed that trimming was an effective method for removing surface contamination. Therefore, producers of non-intact beef products should consider the potential hazards that may occur in this process and properly address these concerns in their food safety programs.

## ACKNOWLEDGMENT

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Table 1 Least squares means for storage day × cap × treatment effect on counts ($log_{10}$ CFU/$cm^2$) of *E. coli* O157:H7 at the inoculation site[a] or inoculated side of top sirloin butts

| | Cap on | | | Cap off | | |
|---|---|---|---|---|---|---|
| | Day 0 | Day 14 | Day 28 | Day 0 | Day 14 | Day 28 |
| **High** | | | | | | |
| Initial | 4.98 A[b] | 4.79 A | 4.62 A | 4.97 A | 4.77 A | 4.67 A |
| WW | 4.76 A | 4.66 A | 4.28 B | 4.81 A | 4.43 B | 4.44 A |
| WWFT | < 0.70 B[c] | 0.95 B | < 0.70 C | 0.93 B | 1.23 C | 1.43 B |
| WWPT | < 0.70 B | 0.75 B | < 0.70 C | 0.95 B | 0.70 C | 0.73 B |
| FTWW | < 0.70 B | 0.85 B | < 0.70 C | 1.05 B | 1.60 C | 1.13 B |
| PTWW | < 0.70 B | 0.75 B | 0.80 C | 0.88 B | 1.45 C | 0.90 B |
| FT | < 0.70 B | 0.85 B | < 0.70 C | 0.75 B | 1.00 C | 0.83 B |
| PT | 0.73 B | < 0.70 B | < 0.70 C | < 0.70 B | 0.73 C | 1.40 B |
| **Low**[c] | | | | | | |
| Initial | 2.91 A | 2.36 A | 2.33 A | 2.66 A | 2.30 A | 2.27 A |
| WW | 2.38 B | 2.20 A | 2.19 A | 2.51 A | 2.35 A | 2.24 A |
| WWFT | < 0.70 C | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| WWPT | < 0.70 C | 0.75 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| FTWW | < 0.70 C | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| PTWW | < 0.70 C | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| FT | < 0.70 C | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| PT | < 0.70 C | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | 0.73 B |

[a] Inoculation site was a 100 $cm^2$ area on the dorsal surface
[b] Numbers within columns within inoculation levels with different letters differ ($P < 0.05$)
[c] Detection limit = 0.7 $log_{10}$ CFU/$cm^2$

Table 2 Least squares means for storage day × cap × treatment effect on counts ($log_{10}$ CFU/$cm^2$) of *E. coli* O157:H7 at the adjacent site[a] or inoculated side of top sirloin butts

| | Cap on | | | Cap off | | |
|---|---|---|---|---|---|---|
| | Day 0[e] | Day 14 | Day 28 | Day 0 | Day 14 | Day 28 |
| **High** | | | | | | |
| Initial | 3.06 A[b] | 2.66 A | 2.58 A | 3.44 A | 3.04 A | 3.05 A |
| WW | 2.68 A | 2.33 A | 2.03 B | 3.41 A | 3.01 A | 3.28 A |
| WWFT | < 0.70 B[c] | 0.95 B | < 0.70 C | 0.93 B | 1.23 BC | 1.43 B |
| WWPT | < 0.70 B | 0.75 B | < 0.70 C | 0.95 B | 0.70 C | 0.73 B |
| FTWW | < 0.70 B | 0.85 B | < 0.70 C | 1.05 B | 1.60 B | 1.13 B |
| PTWW | < 0.70 B | 0.75 B | 0.80 C | 0.88 B | 1.45 B | 0.90 B |
| FT | < 0.70 B | 0.85 B | < 0.70 C | 0.75 B | 1.00 BC | 0.83 B |
| PT | 0.73 B | < 0.70 B | < 0.70 C | < 0.70 B | 0.73 C | 1.40 B |
| **Low** | | | | | | |
| Initial | 1.25 A | 0.97 A | < 0.70 B | 1.08 A | 0.88 A | 0.95 A |
| WW | 1.11 A | 0.76 AB | 0.94 A | 1.20 A | 0.88 A | 0.68 AB |
| WWFT | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| WWPT | < 0.70 B | 0.75 AB | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| FTWW | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| PTWW | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| FT | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B |
| PT | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 B | 0.73 AB |

[a] Adjacent site was an area on the dorsal surface adjacent to the inoculation site. Inoculated side was the entire dorsal surface
[b] Numbers within columns within inoculation levels with different letters differ ($P < 0.05$)
[c] Detection limit = 0.7 $log_{10}$ CFU/$cm^2$

Table 3 Least squares means for storage day × cap × treatment effect on counts ($log_{10}$ CFU/$cm^2$) of *E. coli* O157:H7 at the opposite side[a] of top sirloin butts

| | Cap on | | | Cap off | | |
|---|---|---|---|---|---|---|
| | Day 0 | Day 14 | Day 28 | Day 0 | Day 14 | Day 28 |
| **High** | | | | | | |
| Initial | 0.90 B[b] | 1.43 A | 1.27 A | 1.61 B | 2.12 AB | 1.97 A |
| WW | 1.43 A | 1.26 A | 1.23 AB | 2.16 A | 1.86 ABC | 1.93 A |
| WWFT | < 0.70 B[c] | < 0.70 B | < 0.70 B | 0.85 CD | 1.68 BC | 0.80 C |
| WWPT | 1.75 A | 1.33 A | 1.50 A | 2.13 AB | 2.08 AB | 2.08 A |
| FTWW | < 0.70 B | < 0.70 B | < 0.70 B | 0.88 CD | 1.28 CD | 1.13 BC |
| PTWW | 1.45 A | 1.30 A | 0.78 AB | 1.53 BC | 2.15 AB | 1.55 AB |
| FT | < 0.70 B | < 0.70 B | < 0.70 B | < 0.70 D | < 0.70 D | 1.00 BC |
| PT | 1.38 AB | 1.43 A | 1.25 AB | 1.83 AB | 2.40 A | 1.85 A |
| **Low** | | | | | | |
| Initial | < 0.70 A | < 0.70 A | < 0.70 A | 0.70 AB | < 0.70 A | < 0.70 A |
| WW | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | < 0.70 A |
| WWFT | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | < 0.70 A |
| WWPT | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | < 0.70 A |
| FTWW | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | < 0.70 A |
| PTWW | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | 0.70 A |
| FT | < 0.70 A | < 0.70 A | < 0.70 A | < 0.70 B | < 0.70 A | < 0.70 A |
| PT | < 0.70 A | < 0.70 A | < 0.70 A | 0.88 A | < 0.70 A | < 0.70 A |

[a] The opposite side was the ventral side
[b] Numbers within columns within inoculation levels with different letters differ ($P < 0.05$)
[c] Detection limit = 0.7 $log_{10}$ CFU/$cm^2$