Project Title: Possible Quality Defects in Beef Caused by Multiple Applications of Antimicrobial Interventions

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Completion Date: May 2013

Background

With the United States Department of Agriculture – Food Safety and Inspection Service (USDA-FSIS) declaration of *Escherichia coli* O157:H7 and shiga-toxin producing *E. coli* (STEC) as adulterants in non-intact raw beef products and intact raw beef products intended for non-intact use, the addition of antimicrobial interventions has become standard procedure during beef harvest and further processing. The concept of using consecutive decontamination processes in beef packing plants as a means of improving the microbiological quality of beef carcasses is beneficial (Bacon et al., 2000) to reduce microbiological contamination of beef carcass surfaces that can occur during the beef harvest process. However, because most carcass decontamination treatments do not sterilize the carcass, microorganisms remaining on carcass surfaces can easily be transferred onto freshly cut surfaces during carcass fabrication, and subsequently carried through grinding operations (Pohlman et al., 2002).

Beef safety and quality are continuous challenges for the meat industry. With foodborne pathogens being of upmost concern, antimicrobial interventions are commonly used as a method to reduce the prevalence of pathogenic bacteria throughout the beef production process. A study conducted by Bacon et al. (2000) validated that sequential multiple hurdle interventions reduce bacteria on beef carcasses more effectively than any one intervention alone. The application of multiple interventions also can lead to the oxidation of fat and lean surfaces, which may ultimately affect the quality of ground beef products. In the past, ground beef processors have expressed concern related to the quality of beef raw materials, especially characteristics such as discoloration, off-odors, and flavors. In addition to the effectiveness of antimicrobial treatments, the impact of such treatments on meat quality factors such as color and odor (Pohlman et al., 2002) must also be considered. The objective of this research was to determine the effects of multiple applications of antimicrobial interventions on quality characteristics of beef.

Methodology

Eight universities (Texas A&M University, Texas Tech University, California Polytechnic State University, University of Florida, University of Missouri, North Dakota State University, Oklahoma State University, and Penn State University) collected 10 types of beef steaks (Top Blade, bone-in Ribeye, boneless Ribeye, bone-in Top Loin, boneless Top Loin, T-Bone, Porterhouse, Top Sirloin, Top Round, and Bottom Round) from 12 US cities (Houston, TX; Tampa, FL; Seattle, WA; New York City, NY; Denver, CO; Las Vegas, NV; Los Angeles, CA; Philadelphia, PA; Kansas City, MO; San Francisco, CA; Atlanta, GA; Chicago, IL). In each city, retail chains comprising the top 33% of the market share were identified and contacted to provide four stores to sample per chain. Additionally, one club store was sampled per city. In five cities (Houston, TX; Tampa, FL; Denver, CO; Las Vegas, NV; Philadelphia, PA), three types of beef steaks (boneless Ribeye, boneless Top Loin, Top Sirloin) were collected from a foodservice establishment. Brand designation, marketing claims, enhancement with percentage pumped, sodium content, form of tenderization, and

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any other important features were recorded on each steak, and each steak was measured for average external fat thickness and steak thickness. Approximately 60% of retail steaks (n = 1,319) were used for consumer sensory panels conducted at six universities, and the remainder of the retail steaks were used for Warner-Bratzler shear force. Foodservice steaks (n = 464) were divided in half and used for consumer sensory panels and Warner-Bratzler shear force. All steaks were cooked to an internal temperature of 70°C. Consumer sensory panels rated samples for overall like, overall like of tenderness, level of tenderness, overall like of flavor, level of beef flavor, overall like of juiciness, and level of juiciness. Four antimicrobial treatment combinations (hot water applied to hot carcass followed by hot carcass lactic acid application; hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray; hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray; hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray); in addition to a control (hot carcass lactic acid spray only), were used in this study. Following carcass treatments (Figure 1), trimmings were assigned to one of four treatment groups (acidified sodium chlorite, Beefxide, lactic acid or control). Trimmings were sprayed following forequarter fabrication, and were subsequently held in cold storage for 48 h prior to grinding. Ground beef patties were produced from each trimming subgroup (n = 40) and designated for shelf-life (Figure 2), consumer panel, or trained panel evaluation. Beef patty temperature, pH and color (L*, a*, b*) measurements were taken on the day of patty production, in addition to daily color measurements taken over the 5 d shelf-life period.

Findings

Overall, no single treatment combination appeared to significantly influence consumer perception (Figures 1, 2, and 3) or instrumental measurements (Table 1) of beef patty quality. While some visual darkening of patty color occurred by the completion of the shelf-life period, few significant changes were seen in color space values for each treatment combination (Table 2).

Implications

In general, findings from this study support that food safety interventions, while effective in reducing microbiological counts on product surfaces, do not negatively impact beef patty quality.

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Table 1 . Least squares means stratified by carcass and trimmings treatment[A] combinations for beef patty temperature (°C), pH, and CIE color space values (*L*, a*, b**).

Treatment combinations	Beef patty quality parameters				
	Temperature (°C)	pH	*L**	*a**	*b**
Hot carcass lactic acid application only					
Acidified sodium chlorite[B]	7.95bcdef	5.79ab	60.23a	17.70abc	20.55ab
Beefxide[C]	8.25abcd	5.69abcd	53.94de	19.45ab	19.99abc
Lactic acid[D]	7.40defgh	5.69cd	58.44ab	16.15c	18.13bcd
Control[E]	8.85a	5.72abcd	56.08bcde	18.56abc	21.24a
Hot water applied to hot carcass followed by hot carcass lactic acid application					
Acidified sodium chlorite	6.54hi	5.71abcd	58.17ab	15.73c	16.44d
Beefxide	8.58abc	5.72abcd	52.27e	19.17abc	18.40abcd
Lactic acid	8.76ab	5.74abcd	52.41e	17.75abc	18.15bcd
Control	7.54cdefg	5.78abc	55.88bcde	17.70abc	18.94abcd
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray					
Acidified sodium chlorite	5.06k	5.79abc	55.17bcde	20.10a	20.61ab
Beefxide	5.94ij	5.69bcd	58.89ab	15.70c	16.81cd
Lactic acid	8.44abc	5.63d	54.40cde	17.99abc	18.98abcd
Control	7.24efgh	5.81a	55.29bcde	17.41bc	18.16bcd
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray					
Acidified sodium chlorite	7.06fgh	5.73abcd	56.86abcd	19.58ab	20.75ab
Beefxide	5.08jk	5.82a	55.01bcde	18.18abc	18.68abcd
Lactic acid	8.36abcd	5.70abcd	57.24abcd	18.08abc	18.93abcd
Control	8.41abc	5.67d	55.74bcde	19.57ab	20.44ab
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray					
Acidified sodium chlorite	6.72ghi	5.70abcd	58.50ab	17.80abc	19.98abc
Beefxide	8.22abcde	5.66d	57.32abc	18.31abc	19.40abc
Lactic acid	8.40abc	5.74abcd	57.53abc	19.31ab	20.55ab
Control	9.22a	5.73abcd	59.08ab	18.09abc	20.06abc

Means within the same column lacking a common letter (a-k) differ ($P < 0.05$).

[A] Following carcass treatments, trimmings were assigned to one of four treatment groups (acidified sodium chlorite, Beefxide, lactic acid or control). Trimmings were sprayed following forequarter fabrication, and were subsequently held in cold storage for 48 h prior to grinding.

[B] Acidified sodium chlorite was applied at room temperature (approximately 25°C).

[C] Beefxide was applied at approximately 55°C.

[D] Lactic acid was applied at approximately 55°C.

[E] No antimicrobial intervention was applied to control trimmings.

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Table 2. Least squares means stratified by carcass and trimmings treatment[A] combinations for beef patty CIE color space values (*L**, *a**, *b**) across shelf-life days.

	*L**			*a**			*b**		
Treatment combinations	d 1	d 3	d 5	d 1	d 3	d 5	d 1	d 3	d 5
Hot carcass lactic acid application only									
Acidified sodium chlorite[B]	55.83a	55.70a	50.50b	15.79a	10.44b	13.81a	20.09ab	18.98b	20.64a
Beefxide[C]	53.15a	52.62a	50.93a	18.06a	11.30b	10.86b	19.56a	16.50b	18.08ab
Lactic acid[D]	53.04a	55.03a	52.45a	17.39a	10.57b	9.90b	19.66a	16.91b	19.03a
Control[E]	55.15a	55.80a	54.03a	17.06a	11.29b	10.57b	20.10a	17.80a	20.10a
Hot water applied to hot carcass followed by hot carcass lactic acid application									
Acidified sodium chlorite	50.17a	48.58a	46.92a	15.95a	10.23b	11.77b	17.94a	16.26a	18.71a
Beefxide	50.80a	49.97a	49.11a	15.36a	11.49a	11.08a	17.64a	16.50a	18.62a
Lactic acid	49.42a	51.97a	49.68a	15.60a	8.38b	10.12b	17.22ab	14.96b	17.93a
Control	51.38a	52.16a	49.00a	15.93a	8.86b	11.22b	18.73a	15.73b	19.04a
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray									
Acidified sodium chlorite	49.92a	52.58a	48.23a	17.54a	11.74b	9.38b	19.15a	17.34a	17.65a
Beefxide	49.57b	52.79a	51.44ab	14.55a	8.70b	8.61b	17.59a	16.05a	17.40a
Lactic acid	51.26a	51.35a	51.69a	14.01a	11.23ab	7.76b	17.35a	16.19a	15.54a
Control	51.17a	51.67a	50.50a	16.29a	12.26ab	9.14b	18.24a	16.77a	16.86a
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray									
Acidified sodium chlorite	53.83a	54.31a	50.74b	17.31a	11.44b	12.90b	19.84a	17.57b	19.83a
Beefxide	52.17a	50.89ab	48.21b	17.59a	11.44c	14.39b	19.16a	16.72b	19.51a
Lactic acid	53.22a	54.43a	52.20a	17.08a	10.07b	11.82b	19.47a	16.63b	18.90a
Control	52.42a	52.51a	50.25a	17.78a	12.31b	12.05b	19.70a	17.41b	19.95a
Hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray									
Acidified sodium chlorite	55.80a	55.30a	53.92a	15.89a	11.08b	10.65b	19.49a	17.58a	17.99a
Beefxide	53.93a	54.47a	50.91a	16.79a	11.36b	11.65b	19.40a	17.50b	18.13ab
Lactic acid	55.89a	55.07a	53.85a	16.78a	11.49b	9.57b	19.69a	16.94b	17.96b
Control	53.22a	53.96a	53.24a	17.57a	10.66b	10.15b	20.48a	17.52b	18.67b

Means within the same hot carcass treatment grouping and within like CIE color space values lacking a common letter (a-c) differ ($P < 0.05$).

[A] Following carcass treatments, trimmings were assigned to one of four treatment groups (acidified sodium chlorite, Beefxide, lactic acid or control). Trimmings were sprayed following forequarter fabrication, and were subsequently held in cold storage for 48 h prior to grinding.

[B] Acidified sodium chlorite was applied at room temperature (approximately 25°C).

[C] Beefxide was applied at approximately 55°C.

[D] Lactic acid was applied at approximately 55°C.

[E] No antimicrobial intervention was applied to control trimmings.

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Figure 1. Spraying lactic acid hot carcass intervention.

Figure 2. Shelf-life evaluation.

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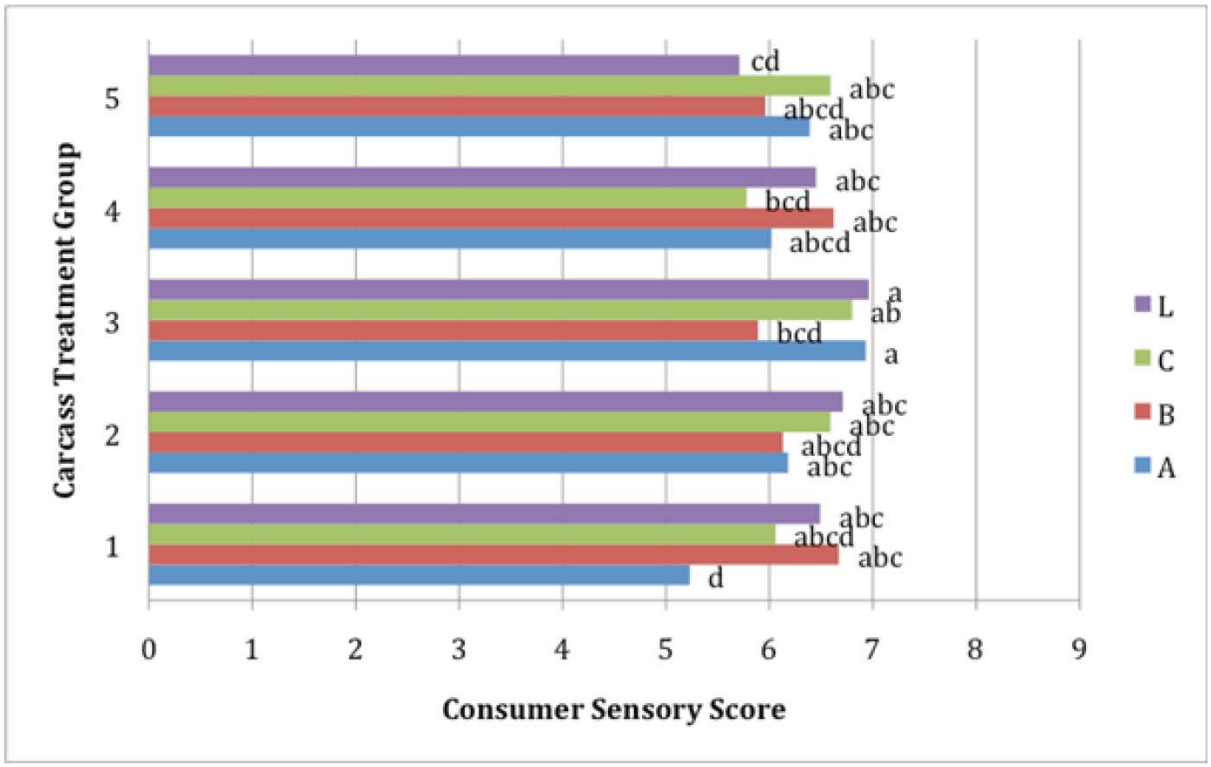

Figure 3. Least squares means for consumer sensory scores of overall like (9 = like extremely; 1 = dislike extremely) for beef patties stratified by carcass treatment group (1 = control group; hot carcass lactic acid application only; 2 = hot water applied to hot carcass followed by hot carcass lactic acid application; 3 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray; 4 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray; 5 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray) and trimmings treatment group (A = trimmings sprayed with acidified sodium chlorite; B = trimmings sprayed with Beefxide; C = control, no antimicrobial application; L = trimmings sprayed with lactic acid). Means lacking a common letter (a-d) differ ($P < 0.05$).

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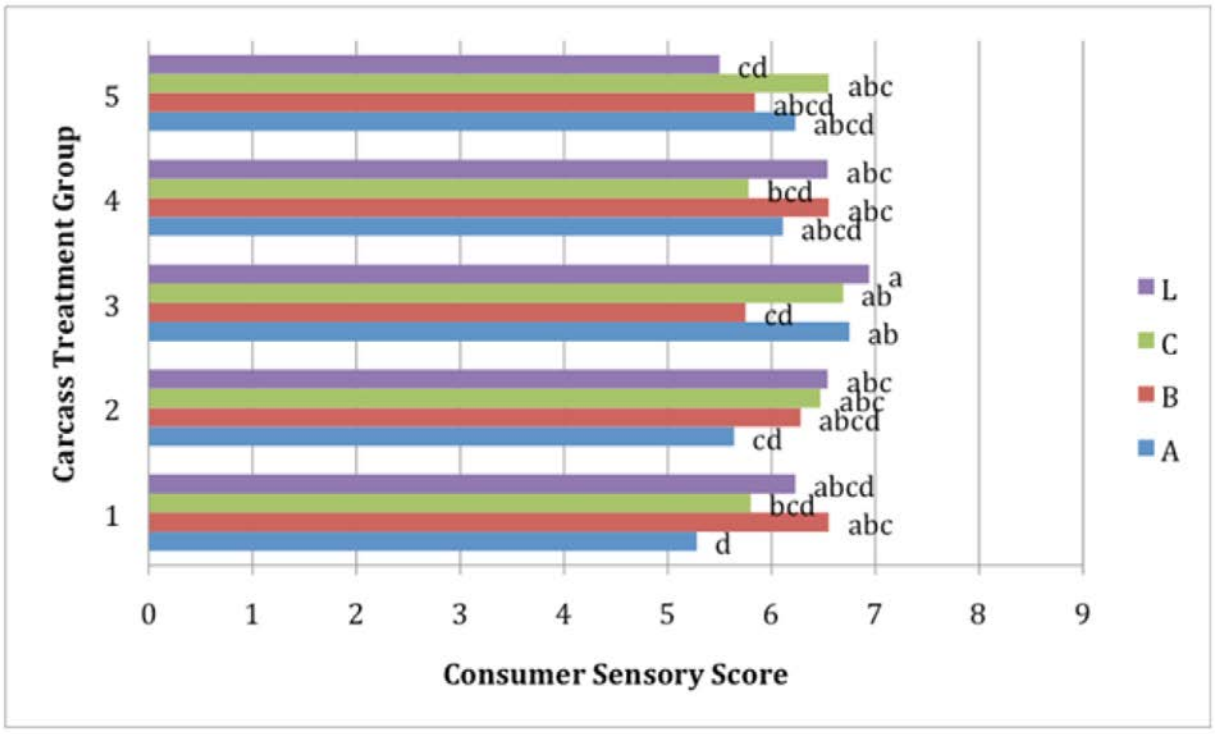

Figure 4. Least squares means for flavor like (9 = like extremely; 1 = dislike extremely) for beef patties stratified by carcass treatment group (1 = control group; hot carcass lactic acid application only; 2 = hot water applied to hot carcass followed by hot carcass lactic acid application; 3 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray; 4 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray; 5 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray) x trimmings treatment group (A = trimmings sprayed with acidified sodium chlorite; B = trimmings sprayed with Beefxide; C = control, no antimicrobial application; L = trimmings sprayed with lactic acid). Means lacking a common letter (a-d) differ ($P < 0.05$).

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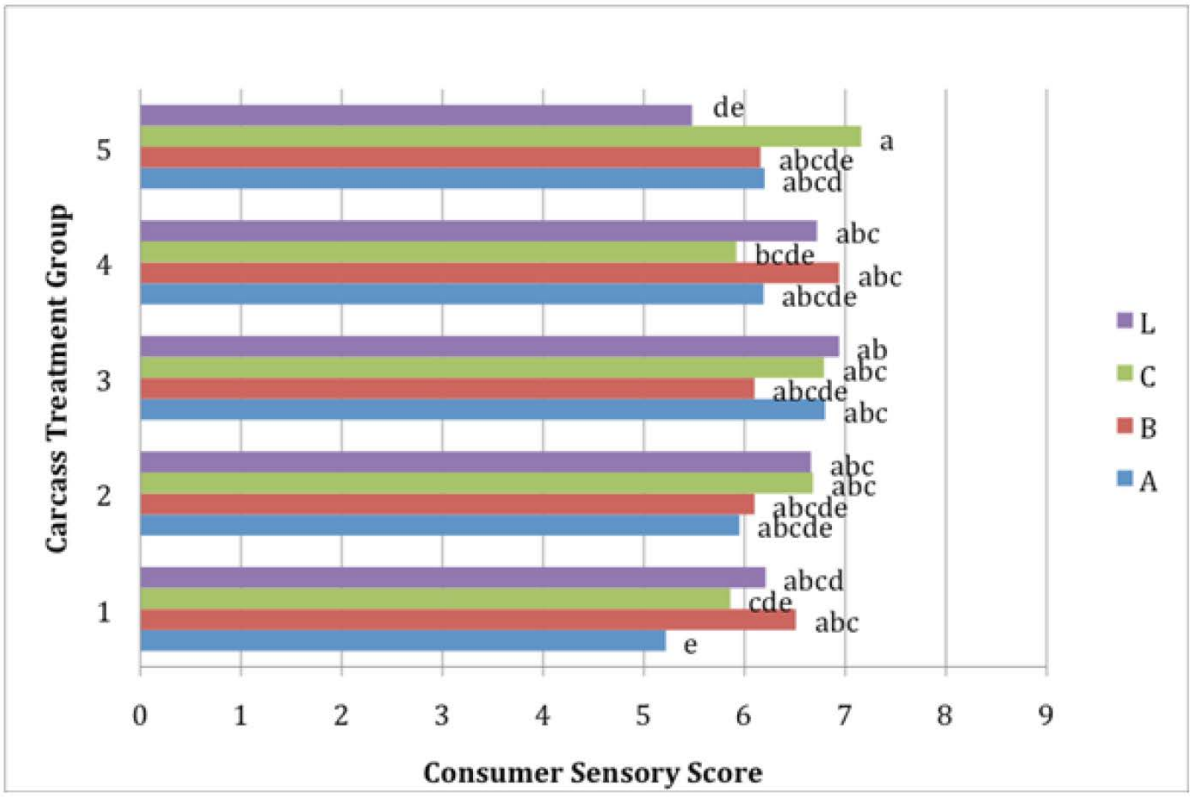

Figure 5. Least squares means for consumer sensory scores of beefy flavor like (9 = like extremely; 1 = dislike extremely) for beef patties stratified by carcass treatment group (1 = control group; hot carcass lactic acid application only; 2 = hot water applied to hot carcass followed by hot carcass lactic acid application; 3 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter lactic acid spray; 4 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter acidified sodium chlorite spray; 5 = hot water applied to hot carcass followed by hot carcass lactic acid application, followed by a pre-fabrication cold forequarter Beefxide spray) and trimmings treatment group (A = trimmings sprayed with acidified sodium chlorite; B = trimmings sprayed with Beefxide; C = control, no antimicrobial application; L = trimmings sprayed with lactic acid). Means lacking a common letter (a-e) differ ($P < 0.05$).

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