EVALUATION OF GROUND BEEF QUALITY FOLLOWING DIFFERENT ANTIMICROBIAL INTERVENTIONS

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Abstract - Multiple antimicrobial interventions were applied to beef carcasses and trimmings to determine if repetitive applications negatively impacted ground beef patty color and consumer sensory ratings. While some visual darkening of patty color occurred by the completion of the shelf-life period, few significant changes were seen. Consumer scores for overall liking, flavor liking, and beefy flavor liking were impacted ($P < 0.05$) by combined antimicrobial treatment effects. Although there were some significant interactions reflected in consumer panel scores, there was no clear trend describing interaction effects and consumer ratings. Additionally, no clear trends were seen relating trained panel ratings to any single or combined antimicrobial treatment for these scores. Findings supported that the applied food safety interventions did not negatively impact beef patty quality.

I. INTRODUCTION

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 [1], the addition of antimicrobial interventions has become standard procedure during beef harvest and further processing. Using consecutive decontamination processes in beef packing plants as a means of improving the microbiological quality of beef carcasses is beneficial in reducing microbiological contamination of beef carcass surfaces that can occur during the beef harvest process [2]. Bacon, Belk, Sofos, Clayton, Reagan and Smith [2] validated that sequential multiple hurdle interventions reduce bacteria on beef carcasses more effectively than any one intervention alone. There is a need to evaluate the impact of such treatments with respect to meat quality. The goal of this study was to determine if multiple hurdle intervention combinations produced ground beef patties with less desirable quality attributes when compared to control patties.

II. MATERIALS AND METHODS

A. Treatment design

For the control (treatment group 1), lactic acid was applied to the entire hot carcass. Treatment groups 2, 3, 4, and 5 received hot water and lactic acid application to each hot carcass. All carcasses were allowed to chill for 36 h at 2 °C. Immediately before fabrication, sides assigned to treatments 3, 4, or 5 received an application of lactic acid, acidified sodium chlorite or Beefxide (lactic acid and citric acid mixture), respectively. The ten forequarters (across all treatment groups) then were fabricated and made into trimmings. For all control and treatment groups, the trimmings were weighed and divided into four similar subgroups (n = 40). The subgroups within each treatment then were assigned to one of four trimmings treatment groups: control (no trimmings spray), lactic acid, acidified sodium chlorite, or Beefxide.

B. Hot carcass intervention application

On the day of slaughter, lactic acid was mixed and titrated before and after the intervention spray. The lactic acid solution temperature was approximately 55 °C before application and was applied to the entire side for 60 s (approximately 500 ml). The hot water intervention was applied to the forequarter only, at 82.2 °C or higher inside the sprayer, for 90 s (approximately 250 ml). The hot carcass interventions were applied to the carcass after a final wash step. Carcasses then were weighed, tagged, and chilled for 36 h at 2 °C.

C. Cold forequarter intervention application and forequarter fabrication

Antimicrobial solutions — lactic acid, acidified sodium chlorite and Beefxide — were mixed on the day of fabrication; each was titrated to ensure proper concentration. Immediately before fabrication, antimicrobial interventions were applied to the designated forequarters. Duration of application of lactic acid, acidified sodium chlorite, and Beefxide was 30 s (approximately 250 ml). Temperature of each intervention was evaluated before application; lactic acid and Beefxide were applied at approximately 55 °C and acidified sodium chlorite was applied at room temperature (approximately 25 °C). Lean trimmings were separated into four similar subgroups and weighed to achieve similar trim groups. Individual plastic lugs were covered and placed on racks in refrigerated storage (2 °C) until the trimmings interventions were applied. The cold forequarter, fabrication, and trimmings interventions were all performed on the same day.

D. Trimmings antimicrobial application

For the application of the trimmings intervention spray, fresh beef trim was placed on a screen to allow for even distribution. Lactic acid and Beefxide were applied at approximately 55 °C. Acidified sodium chlorite was applied at room temperature (approximately 10 °C). Trimmings were sprayed for either a 10 or 15 sec interval (100-150 ml) based on the amount of trimmings in a subgroup and how many screens were needed to achieve even application. Trimmings were covered and allowed to rest in refrigerated storage (2 °C) for approximately 48 h before grinding.

E. Grinding and production of patties

Trimmings subgroups were ground individually using a coarse-grind plate (1.27 cm diameter) followed by a final grind plate (0.32 cm diameter). Ground product was covered and allowed to rest for approximately 12 h. The following day, twenty-one 150 g patties were made per trim subgroup (n = 840). Patties destined for shelf-life evaluation were assessed for color, pH and temperature before being packaged in a PVC overwrap tray. All other patties were crust frozen, individually packaged, and stored at -10 °C until subsequent evaluations.

F. Shelf-life evaluation

Patties were placed in a “retail-like” refrigerated (approximately 4 °C) setting with fluorescent lights to simulate a retail case. Color measurements were taken using a Hunter MiniScan EZ (HunterLab, Reston, VA) colorimeter on days 1, 2, 3, 4, and 5.

G. Sensory evaluation

Both consumer and trained panels were conducted for sensory evaluation. Patties were cooked to an internal temperature of 70 °C. Internal temperatures were monitored using a copper-constantan thermocouple (Omega Engineering, Stratford, CT) inserted into the geometric center of each patty. Each patty then was cut into 1/6 wedges and served warm in individual booths equipped with red theater gel lights.

Consumer panelists were asked to evaluate patty attributes based on a 9-point scale. Attributes included: overall liking (1 = dislike extremely; 9 = like extremely), flavor liking (1 = dislike extremely; 9 = like extremely), beefy flavor liking (1 = dislike extremely; 9 = like extremely), level of beefy flavor (1 = extremely bland or no flavor; 9 = extremely flavorful or intense), off-flavors (yes or no), intensity of off-flavors (1 = extremely bland or no flavor; 9 = extremely intense), tenderness liking (1 = dislike extremely; 9 = like extremely), juiciness liking (1 = dislike extremely; 9 = like extremely). A total of 80 consumers were used.

A 6-member, trained panel was used to determine flavor, basic taste, mouthfeel, after-taste, and texture attributes The panelists evaluated samples using a 16-point universal scale with 0 = none and 15 = extremely intense for attributes defined during ballot development sessions [3]. A total of eight trained panel sessions were conducted with ten samples evaluated per session.

H. Statistical analysis

All sensory data were analyzed using PROC GLM of SAS (SAS Institute Inc., Cary, NC), where main effects and significant two-way interactions were included in the model. Least squares means were calculated; where ANOVA testing indicated significance, means were separated using the PDIFF procedure and an $\alpha < 0.05$.

III. RESULTS AND DISCUSSION

A. Shelf-life

The *L** values across all treatment combinations and shelf-life days showed some statistical differences (data not shown in tabular form). Trimmings derived from carcass treatment groups 2 (hot water and lactic acid applied to the hot carcass) and 3 (hot water and lactic acid applied to hot carcass, followed by a pre-fabrication cold forequarter lactic acid spray) received lower ($P < 0.05$) *L** values compared to other treatment combinations.

*L** values remained consistent for the beginning of the shelf-life period, but showed a significant decrease ($P < 0.05$) by day 5. There was a decrease ($P < 0.05$) in *a** values over the shelf-life period. The *b** values showed a decrease ($P < 0.05$) from shelf-life days 1 to 3 and a significant increase from day 3 to day 5. Stivarius, Pohlman, McElyea and Waldroup [4] noted that hot water and lactic acid treatments applied to fresh beef trimming before grinding resulted in lower overall color and greater discoloration when compared to a control treatment. Quilo, Pohlman, Dias-Morse, Brown Jr., Crandall and Story [5] also noted decreasing *a** values for antimicrobial treated ground beef versus the control over a 7-day shelf-life period.

B. Sensory evaluation

Overall, few significant relationships were noted between the combined effects of hot carcass, cold forequarter, and trimmings antimicrobial intervention sprays and consumer perception on ground beef quality. Consumer panel scores for overall liking, flavor liking and beefy flavor liking attributes were impacted ($P < 0.05$) by combined antimicrobial treatment effects. Trimmings assigned to either control or lactic acid treatment groups generally performed better in consumer panel responses for overall liking. Further, trimmings derived from carcass treatment group three and subjected to a lactic acid trim spray scored higher ($P < 0.05$) with consumer panelists for overall liking scores when compared to lactic acid treated trimmings from carcass treatment group five. While not significant in all cases, trimmings treated with acidified sodium chlorite tended to return less favorable consumer sensory panel scores for overall liking. In general, consumer panelists again rated control and lactic acid trimmings groups higher for flavor liking than other trimmings treatment groups, regardless of carcass treatment designation. In similar studies, no major differences for beef flavor or off flavor attributes of ground beef patties that received lactic acid antimicrobial treatments were found when compared to a control [6, 7]. Acidified sodium chlorite received lower ($P < 0.05$) beefy flavor liking for treatment group one. In general, consumer panelists again rated control and lactic acid trimmings groups higher for beefy flavor liking than other trimmings treatment groups, regardless of treatment group designation. This did not hold true for treatement group five, as the lactic acid trimmings treatment groups recevied lower scores from consumer panelists. In a similar study, Quilo, Pohlman, Brown, Crandall, Dias-Morse, Baublits and Aparicio [8] found that ground beef patties that received either peroxyacetic acid or acidified sodium chlorite antimicrobial treatments received only slightly lower scores for beef odor when compared to the control.

Of the 32 attributes outlined in the trained panel ballot, panelists detected only 18 attributes over the course of this study. Scores for sour milk/dairy ($P = 0.0132$) and cardboardy ($P = 0.0014$) were impacted by treatment combination effects. Although these patties were frozen immediately after production and thawed for approximately 18 h before each trained panel session, sour milk/dairy and cardboardy attributes are typically considered indicators of spoilage and oxidative rancidity,

respectively. Further, on a 16-point scale (0 = attribute not detected; 15 = strong presence of attribute) panelists did not rate either attribute higher than a three, with mean scores of 0.12 and 0.06 for cardboardy and sour milk/dairy, respectively. Because attributes that showed significance returned low mean scores, there was no reason to believe that the antimicrobial intervention combinations impacted patty quality. Jimenez-Villarreal, Pohlman, Johnson and Brown Jr. [7] found that trained panelists were not able to detect any differences for beef flavor and off flavor when comparing ground beef patties treated with multiple hurdle interventions and a control group, which supports current findings. The lack of differences noted by trained panelists across different studies suggests that multiple hurdle interventions can be used without negatively impacting taste attributes for ground beef.

IV. CONCLUSIONS

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. Overall ground beef quality was not impacted by the combination of antimicrobial interventions used in this study.

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