Project Summary

Exploring a New, Non-Invasive Mechanical Strategy for Tenderizing and Injecting Beef

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Background

Blade tenderization and injection enhancement are currently part of beef processing to improve beef quality attributes like tenderness and juiciness when needed; however, there may be alternative means to apply these technologies. One potential method involves utilizing a needle-free injection system similar to that currently being investigated for use in vaccinating cattle. This project investigated the use of needle-free injection as an alternative strategy to beef blade tenderization and needle injection enhancement.

The objectives for this project were to:

1. Determine the optimal instrument settings and pattern of needle-free injection enhancement for maximized beef tenderness.
2. Determine the safety and efficacy of using needle-free injection for enhancing beef muscles.
3. Determine the application of needle-free injection technology for use with injection-enhanced beef.

Methodology

Preliminary research was conducted to determine the optimal pounds per square inch (psi) to be used for needle-free injection. *Longissimus* muscles (n=5) from USDA Select carcasses were obtained from a commercial abattoir at 4-5 days postmortem and then stored at 2°C for an additional 9-10 days. Muscles were divided into four sections and assigned to one of seven treatments: 1) 90 psi sterile colored saline solution; 2) 55 psi sterile colored saline solution; 3) 50 psi sterile colored saline solution; 4) 45 psi sterile colored saline solution; 5) 30 psi sterile colored saline solution; 6) 25 psi sterile colored saline solution; or 7) 20 psi sterile colored saline solution. The sterile saline solution was mixed with blue food-grade coloring so that the dispersion of the solution could be tracked throughout the product after injection. Slices approximately 0.6 cm thick were made through the muscles for visual evaluation of depth, uniformity and extensiveness of the injection enhancement solution. The psi was selected based on dispersion, visual acceptability, and penetration level. It was determined that 25 psi was the best choice due to the greatest amount of distribution, the absence of injection 'channels' (which were found in all psi levels above 30), and the deepest penetration.

Needle-free injections were made 0.805 cm apart in a grid pattern, using a Plexiglas template, at a psi of 25. The number of injection sites for the template was selected based on this equation: 3785.41 ml (1 gallon of water)/2 ml = 0.0042 lbs; 1.2 lbs (10% of the average 12 lb strip loin)/0.004 lbs = 283.91 injections. This was then applied in the equation to determine template spacing: 90 in.^{2} (the typical size of a striploin)/283.906 injections = 0.317 in x 2.54 cm = 0.805 cm. Microbiology data was also collected during this project but will not be reported here.

Beef *longissimus* muscles (n=15) from USDA Select, A-maturity carcasses were obtained from a commercial abattoir at 2 d postmortem and transported to the Kansas State University Meat Laboratory where they were stored (2°C) until 9 d postmortem. The fat was trimmed to 1/8", and each loin was halved and randomly assigned to one of two treatments: 1) needle (N) injected (Model N30, Wolftec Inc., Werther, Germany), or 2) Needle-free (NF) injected (Pulse Needle-Free Systems, Lenexa, KS). A Plexiglas template, with holes at a distance of 0.805 cm, was used to space

the injection sites for NF injection. The NF injection was done using the pre-determined optimal setting of 25 psi. Both sides of the loins were injected in the NF treatment based on preliminary trials that showed the necessity of injecting both sides in order to achieve the desired pump yield. The needles on the N injector were spaced 1.77 cm x 2.54 cm apart. The N injection was set to achieve a desired pump yield of12%. Needle injections were made from the fat side only. A solution of water, salt (0.3%), phosphate (0.3%), and potassium lactate (1.5%) was used for injections.

After the loins were injected, three steaks (2.54-cm thick) were cut from the anterior end of each muscle section. Two of these steaks were placed in separate Styrofoam trays and covered with polyvinyl chloride film to be placed into simulated retail display and evaluated for visual color. The remaining steak from each muscle section was vacuum-packaged and stored at 2°C for 4 d while it awaited its use for longissimus slice shear force measurements. Steaks for visual color evaluation were displayed under continuous fluorescent lighting for 5 d at 2°C. Packages were rotated once daily in order to maintain a random sample placement.

Trained visual color panelists (n=8) evaluated initial color on day 0 of display, and display color and surface discoloration were measured daily on days 1 to 5 of display. On day 13 postmortem, steaks were taken from the 2°C storage environment and cooked for *longissimus* slice shear force measurements.

Findings

Pump Yields

Pump yields were designed to be similar for both treatments so that differences in color and tenderness between treatments would not be a result of differing amounts of enhancement solution in the muscle. The average yields for NF and N injection were 14.73% and 14.05%, respectively.

Display Color and Discoloration

Treatment had no effect on initial color scores at day 0. Steaks from both treatments became darker ($P<0.0001$) as day of display increased, as expected. There was a treatment x day interaction ($P < 0.05$) for visual color in which N injected steaks were darker on day 1 of display but not after day 1. There was no significant treatment or treatment x day interaction ($P > 0.05$) effect for discoloration scores. As expected, discoloration scores indicated that steaks from both treatments had increasing amounts of discoloration as day of display increased ($P<0.0001$). Results suggest that NF treatment improved visual color on day 1, but there were no significant differences between treatments for the remaining days of display.

Longissimus Slice Shear Force Measurements

Longissimus slice shear force values indicate that all of our steaks were tender, but steaks from loins that were injected using the NF technology were more tender ($P < 0.05$) than those from loins that were injected with the traditional N injector (Table 2). Given the closer spacing of NF injection sites and application of injection from both sides, this increased mechanical tenderization is no surprise. However, the difference in the appearance of muscle structure between steaks from the two treatments was virtually unnoticeable at the 25 psi setting that was used.

Implications

Using NF injection technology as an alternative to the traditionally used N injector did not have a detrimental effect on color display life, and it did not significantly alter the extent or occurrence of discoloration of steaks. Given that it improved tenderness without negatively affecting appearance, it seems that needle-free technology has potential for application to improve tenderness in an industry setting. Even though *longissimus* slice shear force values from both treatments fell within a range that is generally considered relatively tender, if used on less tender cuts of beef, this magnitude of difference in slice shear force values might represent the difference between "acceptable" and "unacceptable" tenderness. If further research yields similar results, additional research exploring the use of NF injection enhancement should be conducted on cuts of beef that are expected to be less tender. If NF injection is accepted as an improved method of injection enhancement, more industrialized equipment could be developed to administer needle-free injections on a larger scale.

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