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A comparison of needle-free and needle-injection methods and solutions for enhancement of beef *longissimus lumborum* muscles

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ABSTRACT

In Experiment 1, beef strip loins ($n = 15$) were halved and assigned to needle (N) or needle-free (NF) injection enhancement with a phosphate plus salt solution (PS) to determine effects on color, water-binding, and palatability. Pump yields tended ($P = 0.08$) to be higher for NF injection. Needle-injected steaks were darker ($P < 0.05$) on day 1 only. The NF treatment had greater instrumental tenderness and intensity of off-flavors but less cooking loss and beef flavor (both $P < 0.05$). In Experiment 2, strip loins ($n = 28$) were halved and assigned to one of four treatments: (1) N, or (2) NF injection with PS; (3) N, or (4) NF injection with a calcium lactate solution (CL) to determine effects on water-binding and palatability. Needle-free injection resulted in a greater incidence ($P < 0.05$) of off-flavors and abnormal texture. The PS solution resulted in greater ($P < 0.05$) instrumental, myofibrillar, and overall tenderness; greater juiciness; greater incidence of off-flavors and abnormal texture; and less ($P < 0.05$) connective tissue and cooking losses than CL. The PS and NF combination had the highest pumped yields and least cooking losses (both $P < 0.05$). Enhancing beef strip loins with PS and NF injection has potential to improve yield, tenderness, and juiciness but harm texture and flavor.

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1. Introduction

Meat tenderness is the most important palatability attribute affecting consumers' overall eating experience (Dikeman, 1987; Miller, Huffman, Gilbert, Hammon, & Ramsey, 1995). As a result, injection enhancement and blade tenderization have long been used to improve this important trait (Grobbel, Dikeman, Hunt, & Milliken, 2008). However, there is a chance that bacteria present on the meat's surface can be transferred to the interior during these processes (Phebus, Thippareddi, Sporing, Marsden, & Kastner, 2000; Ray et al., 2009; Sporing, 1999). Luchansky et al. (2009) concluded that bacterial translocation resulting from blade tenderization occurs primarily in the top portion of the meat, and it is not a food safety concern if the meat is cooked to at least a rare degree of doneness.

Needle-free injection technology has been used effectively in the livestock industry to administer vaccines to livestock (Hollis, Smith, Johnson, Kapil, & Mosier, 2005; Houser et al., 2004; Mousel, Leeds, White, & Hoesing, 2008). Houser et al. (2004) suggested that vaccinating livestock with needle-free technology rather than traditional needle-injections would be beneficial because it would eliminate the occurrence of needle-fragments in carcasses. Ray et al. (2009) used needle-free technology to injection enhance meat. They evaluated its effect on microbial translocation of generic *Escherichia coli* in beef strip loins. There was a 0.8 log CFU/g increase in bacterial transfer from the surface to the interior of the meat. An extremely high level of inoculation was used to develop a "worst-case" scenario and also so that the magnitude of *E. coli* translocation could be quantified. As a result, Ray et al. (2009) concluded that the difference between needle and needle-free injection enhancement of beef strip loins in terms of microbial translocation was "arguably insignificant in microbiological terms".

Because needle-free injection enhancement is relatively similar to traditional needle-injection enhancement with regard to food safety, it should be evaluated for its effects on meat color, instrumental tenderness, sensory traits, and yields.

Injection enhancement has been shown to improve many traits such as juiciness, color stability, and cooking yield (Grobbel et al., 2008; Knock et al., 2006a; Molina, Johnson, West, & Gwartney, 2005). Much research has been conducted to determine the effects of injection enhancement on meat as well as the optimal enhancement solution; however, not all solutions have been adequately evaluated, and more research on the effectiveness of common enhancement solutions is needed.

Lawrence, Dikeman, Hunt, Kastner, and Johnson (2004) conducted an injection enhancement study to compare the use of a solution of phosphate and salt plus rosemary (PS) to a solution of calcium lactate plus rosemary (CL). They did not find differences

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in Warner–Bratzler shear force values between treatments, but panelists perceived steaks enhanced with CL to be less tender and juicy than steaks enhanced with PS. However, steaks enhanced with the PS solution had a greater occurrence of off-flavors of metallic and salty, a darker initial color, and more color deterioration. Available literature comparing a CL solution to a PS solution for enhancement of beef is limited.

Therefore, the objectives of this research were to determine the effects of needle-free versus needle-injection methods and/or CL versus PS solutions for enhancement of beef *longissimus lumborum* muscle on meat color, instrumental tenderness, sensory traits, pump yield, and cooking loss.

2. Materials and methods

2.1. Preliminary study

Preliminary research was conducted to determine the optimal injection pressure (pounds per square inch (psi)) for needle-free (NF) injection. *Longissimus* muscles ($n = 5$) from strip loins (NAMP # 180, 2007) from USDA Select carcasses were obtained from a commercial abattoir at 4–5 days postmortem and then transported to the Kansas State University meat laboratory and stored at 2 °C for an additional 9–10 days. Muscles were divided into four sections and assigned to one of seven treatments with sterile colored saline solution: 90, 55, 50, 45, 30, 25, or 20 psi. 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. The manufacturer (Pulse Needle-Free Systems, Lenexa, KS; Fig. 1) of the NF injector stated that each injection dispenses 2 ml of liquid. 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 optimal injection pressure was selected based on dispersion, visual appraisal, and penetration level. It was determined that 25 psi was the optimum level because it had the greatest distribution, the absence of injection 'channels' (which were found in all levels above 30 psi), and the deepest penetration.

Needle-free injection enhancements were made 0.95 cm apart in a grid pattern by using a plexiglass template, at 25 psi. In a preliminary trial, the desired pump yield was not achieved using the plexiglass template with injections from only one side of the loin. We attributed this to unanticipated draining and waste of the solution during the injection process. We were able to achieve pump yields of approximately 12% by injecting loins from both sides (dorsal and ventral).

2.2. Experiment 1

2.2.1. Samples and injection

Beef longissimus muscles ($n = 15$) from USDA Select, A-maturity carcasses were obtained from a commercial abattoir at 2 days postmortem and transported to the Kansas State University meat laboratory, and stored at 2 °C until 9 days postmortem. The fat was trimmed to 0.32 cm, 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 plexiglass template with holes spaced 0.95 cm apart was used to space the injection sites for NF injection. The NF injection was done using our pre-determined optimal setting of 25 psi. Both the dorsal and ventral sides of the strip loins were injected in the NF treatment because preliminary trials showed that injecting both sides was necessary to achieve the desired pump yield of 12%. Needles on the N injector were spaced 1.77 cm × 2.54 cm apart. The needle injector was set to achieve a desired pump yield of 12%. Needle-injections were made from the fat side only. A solution containing 2.2% salt, 4.4% sodium tripolyphospate (Brifisol 85 Instant, BK Giulini Corp., Simi Valley, CA) and 1.5% potassium lactate (PS) (PURASAL Hipure P; PURAC America, Inc., Lincolnshire, IL) was used for injections.

2.2.2. Pump yield

Each muscle section was weighed prior to injection (initial weight). After injection, each muscle section was placed on a wire rack and allowed to drain for 30 min before a final weight was taken. Pump yield was calculated as [(final weight − initial weight)/initial weight] * 100.

2.2.3. Packaging

After the strip loins were injected, four steaks (2.54 cm thick) were cut from the anterior end of each muscle section. Two of these steaks were placed on separate Styrofoam trays and covered with polyvinyl chloride film to be placed into simulated retail display and evaluated for visual color. The remaining two steaks from each muscle section were vacuum packaged (62.2 cm Hg vac; Multivac C500; Multivac Inc., Kansas City, MO); one of which was stored at 2 °C for 4 days until it was used for longissimus slice shear force measurements, and the other steak was frozen at −20 °C for sensory analysis.

2.2.4. Display case and color measurements

Steaks for visual color evaluation were displayed (Unit model DMF8, Tyler Refrigeration Corp., Niles, MI) under continuous fluo-

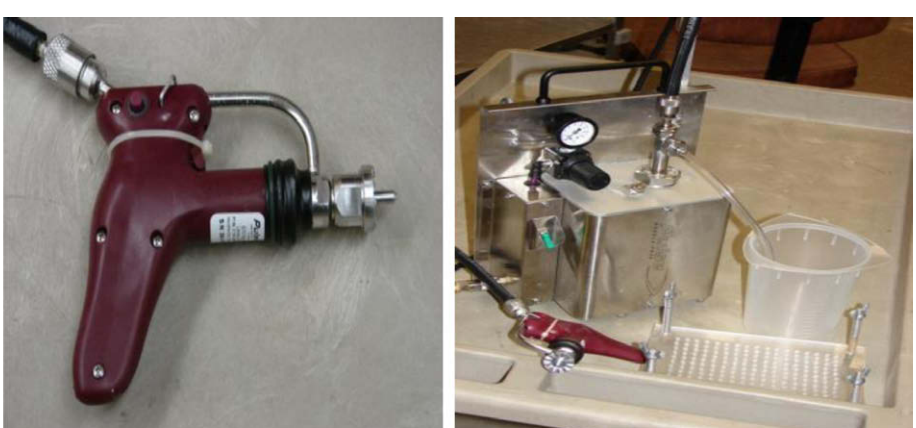

Fig. 1. Photograph of injector (left) 96 and injector, pump, container and template (right).