POST-MORTEM FAT INJECTION IMPROVED PALATABILITY AND VALUE OF BEEF *LONGISSIMUS LUMBORUM* STEAKS

L.D. Holmes, K.R. Brooks, and T.E. Lawrence

Department of Agricultural Sciences, West Texas A&M University, Canyon, Texas 79016-0002, USA

Abstract – Forty beef *longissimus lumborum* muscles were collected from a commercial abattoir, trimmed, longitudinally split into two equal halves and randomly assigned to either control or fat-injection treatment 14 days post-mortem to determine if fat enhancement would improve overall palatability and consumer acceptance. Proximate analysis revealed fat-injected steaks had 13.4% more ($P < 0.05$) fat and 9.9% less ($P < 0.05$) moisture than control steaks. In-home consumer panelists rated fat-injected steaks more ($P < 0.05$) tender, juicy, and flavorful than control steaks. Moreover, fat-injected steaks had Warner-Bratzler Shear Force (WBSF) values that were 6.0N less ($P < 0.05$) than control steaks. Cooking loss was 8.6% greater ($P < 0.05$) for fat-injected steaks than controls. Consumers were willing to pay $3.61/kg more for fat-injected steaks versus control steaks. In summary, fat-injected steaks had the lowest peak shear force values and were preferred and valued as superior by in-home consumer panelists.

Key Words – Consumer, Marbling, Tenderness

I. INTRODUCTION

Beef tenderness is one of the primary quality attributes affecting consumer satisfaction and purchasing decisions. Consumer satisfaction is the most important factor influencing beef consumption in the United States (Reicks [1]). Beef is a primary protein source in many countries due to its inherent nutrition, availability, tradition, wholesomeness, satiety value, and religious beliefs. Solomon *et al.* [2] stated that tenderness is one of the most important sensory characteristics of meat. For many years, the meat industry has worked to develop methods to improve meat palatability, which in turn has increased the value of meat products. Hamling and Calkins [3] stated that the beef industry faces a major dilemma of inconsistent tenderness at the retail level and that consumers were willing to pay a premium for beef considered more tender.

Multiple studies (Dolezal *et al.* [4]; Tatum *et al.* [5]) have concluded that marbling has a low, but positive, relationship to beef palatability traits.

Injection enhancement technology via calcium addition (Lawrence *et al.* [6]), water-salt-phosphate addition (Vote *et al.* [7]), and lipid addition (Durham *et al.* [8]) have illustrated the ability to reduce inherent palatability variation between carcasses, muscles, and grades of beef. Of those methods, lipid addition has received little attention.

The objectives of this study were to determine if post-mortem mechanical addition of fat into beef strip loins would improve overall palatability and consumers' willingness to pay for steaks.

II. MATERIALS AND METHODS

Beef Cuts

Beef strip loin subprimals (NAMP 180; n = 40) from USDA Choice, Select and Standard quality grade carcasses were collected from the fabrication line of a commercial beef processor, vacuum packaged, transported to the West Texas A&M University meat laboratory, and stored at 2° C until 14d post-mortem.

Fabrication

At 14d postmortem, loins were randomly allocated to either fat-injection treatment or no treatment in the following manner: 1) treated lateral side-control medial side or 2) treated medial side-control lateral side. Subcutaneous fat was trimmed to the epimysial connective tissue via mechanical knife (Whizard Knife Series II, 1000M2, Bettcher Industries, Inc., Vermilion, OH, USA), then the vein portion (containing both *gluteus medius and longissimus lumborum* muscles) was removed and the remaining loin was cut longitudinally through the center, creating two equal halves.

Fat Preparation

Internal and subcutaneous beef fat (98 kg) were coarse ground (1.27 cm plate) and melted to facilitate separation of lean and collagen from fat. Melted fat was cooked to >71°C then strained through 10" shortening filter cones (model FC-10-3, Disco Manufacturing Company, McDonough, GA, USA) to remove solids. Strained fat was stored in a aluminum container maintained at 60°C, using a drum belt heater (model 710-55-230, Morse Manufacturing Co., Inc., East Syracuse, NY, USA) for approximately 2 hours until injected into loins.

Lipid Injection

Muscles were injected with prepared and filtered 60°C edible beef fat using a mechanical injector (Günther Injectamatic 280/282 PI 9-21 Brine Injector, Koch Equipment, Kansas City, MO, USA). After injection, treated halves were cooled so the liquid fat would solidify and then weighed to obtain an injected weight, and to calculate the percentage pump for each treated half. Treated and control loins were vacuum packaged and stored in a freezer at -29°C.

Processing

Frozen muscles were cut into 2.54 cm thick steaks (Figure 1) and allocated for analyses: 1st and 2nd pair - Warner-Bratzler Shear Force, 3rd pair - proximate analysis, 4th-7th pairs – in-home consumer panel and survey.

Figure 1. Beef *longissimus lumborum* steaks; control (left), fat-enhanced (right).

Proximate Analysis

Steaks were thawed and homogenized in a food processor (Cuisinart, East Windsor, NJ). Analyses for fat and water content were conducted via the procedures of Novakofski *et al.* [9]. Samples were oven dried and then weighed to determine moisture content. Fat was extracted using $CHCl_3$:methanol (4:1) and weighed again.

Warner-Bratzler shear force

Steaks were defrosted at 2°C for 24 hours prior to being cooked in a forced-air convection oven (Blodgett, model CTB/R, G.S. Blodgett Co., Burlington, VT) set at 177°C until an internal endpoint temperature of 71°C was reached. Steaks were weighed (g) prior to and immediately after cooking to determine cooking losses. Steaks were allowed to cool for 8-10 min, wrapped in cellophane and chilled for 24 hours at 2°C. Three (1.27 cm diameter) cores were randomly removed from each steak parallel to muscle fiber orientation using a mechanical coring device. Cores were immediately sheared once through the center using a V-shaped blade on a Warner-Bratzler shear force machine (G-R Manufacturing, Manhattan, KS). Peak shear force was displayed on a Mecmesin BGN-500 Shear Force Gauge (Newton House, United Kingdom).

Sensory evaluation

Pairs (n=177) of sample steaks were randomly distributed from the West Texas A&M University Meat Lab for an in-home sensory evaluation. A verbal explanation of the project was given without revealing which steak had been treated. Consumers were instructed to prepare the steaks in the manner to which they were normally accustomed and to evaluate each steak based on tenderness, juiciness and flavor utilizing a 9-point hedonic scale (9 = like extremely, 1 = dislike extremely; AMSA [10]).
Ballot questions revealed demographic information (gender, age, highest level of education, ethnicity, annual household income, beef consumption frequency, beef grade

preference), preparation methods (defrost method, seasonings applied, cooking method, degree of doneness, cooking time), and palatability questions (tenderness rating, juiciness rating, flavor rating, overall steak preference). To increase response rates, participants were offered a $20 gift certificate to the WTAMU meat lab for participation.

Auction Survey

In addition to completing the sensory evaluations and prior to being mailed the $20 gift certificate incentive, 118 consumers of the 177 who received sample steaks for in home evaluation, participated in an auction to purchase additional strip steaks of each type (control and fat-injected). The auction was conducted via methods outlined in Lusk and Shogren [11] and worked as follows: 1) each participant placed a bid on each of the two steaks; 2) five participants were randomly selected to participate in the survey in which their bid for the randomly selected type of steak was compared to a randomly selected “secret price” to determine if they won the auction or not; 3) if they won the auction, they received the balance between the “secret price” and the $20 gift certificate; 4) if they did not win the auction, they received the full $20 gift certificate; 5) participants not randomly selected to participate in the auction, received the full $20 gift certificate and their bids for beef strip steaks did not enter the auction.

Statistical Analysis

A randomized complete block design was used for this experiment; beef strip loins were the experimental block and each half of a loin was an experimental unit, with treatments being assigned randomly via a random number generator. Individual steaks were sampling units. The UNIVARIATE procedure SAS (SAS Institute, Inc. 2010) was used to obtain medians and quartile deviations for the Wilcoxon test (NPAR1WAY procedure) that tested for differences in consumer sensory ratings. The Chi-square test was used to determine if the difference in overall preference between treatments was beyond random chance. Proximate analysis (PA), WBSF values, and auction value results were analyzed using the MIXED procedure; main effect was treatment and random effect was location (medial or lateral) and animal. Means were generated via the LSMEANS statement and separated when significant (α=0.05) via the PDIFF statement.

III. RESULTS AND DISCUSSION

Fat-injected steaks had 60.8% moisture and 20.6% fat which was different (P < 0.05) than controls that averaged 70.7% moisture and 7.2% fat (Table 1).

Warner-Bratzler shear force values indicated that fat-injected steaks (25.4N) had lower (P < 0.05) peak force values as compared to control steaks (31.4N). Fat- injected steaks lost more (P < 0.05) raw weight during cooking (31.06% vs. 22.45%) than non-enhanced controls.

Table 1. Consumer ratings, Warner-Bratzler shear force values, cook loss percentages and proximate analysis percentages for control and fat-injected beef strip loin steaks

	Mean[a]			Median ± Quartile Deviation		
	Control	Fat Injected	SEM	Control	Fat Injected	P-value
Tenderness[b]				3 ± 0.5	2 ± 0.3	0.0022
Juiciness[b]				3 ± 0.5	2 ± 0.3	0.0019
Flavor[b]				2 ± 0.5	2 ± 0.4	0.0160
Peak Force (N)	31.4	25.4	0.2			0.0001
Cook Loss (%)	22.5	31.1	0.8			0.0001
Moisture (%)	70.7	60.8	1.1			0.0001
Fat (%)	7.2	20.6	1.4			0.0001

[a] Non-fat injected control; Fat Injection. Fat injection at an average of 15% by weight.
[b]1=Extreme Like, 2=Like Very Much, 3=Like Moderately, 4=Like Slightly, 5=Neutral, 6=Dislike Slightly, 7=Dislike Moderately, 8=Dislike Very Much, 9=Extreme Dislike

Consumers rated fat-injected steaks higher (P < 0.05) in tenderness, juiciness and flavor attributes. Smith and Carpenter (1974) discovered that fat may contribute to water-holding capacity of meat, by lubricating the muscle fibers during the cooking process, increasing the perceptible sensation of juiciness, or by stimulating saliva during mastication.

Consumers were willing to pay $35.66/kg for fat injected steaks versus only $32.05/kg for control steaks, an advantage of $3.61/kg for fat-injection. Determining whether consumers are willing to pay for changes in beef quality will assist the beef industry in maintaining a competitive advantage over competing proteins.

IV. CONCLUSION

Enhancing steaks via fat-injection increased tenderness, juiciness and flavor ratings and also resulted in the lowest peak shear force values. Consumers were willing to pay more for a fat-injected product that had improved palatability. This non-traditional approach to investigating the effects of post-mortem fat addition upon palatability was revealing. However, more research is needed to investigate production methodologies and specific muscle cuts that would best be improved by this technology.

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