



Consumer and trained panel evaluation of beef strip steaks of varying marbling and enhancement levels cooked to three degrees of doneness

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ABSTRACT

The palatability of USDA graded beef strip loins of seven treatments [High Enhanced (HE: 112% of raw weight) Select, Low Enhanced (LE: 107% of raw weight) Select, Prime, upper 2/3 Choice (Top Choice), lower 1/3 Choice (Low Choice), Select, and Standard] cooked to three degrees of doneness [DOD; rare (60 °C), medium (71 °C), or well-done (77 °C)] was evaluated by consumer and trained sensory panelists. For consumers, Select HE steaks rated higher ($P < 0.05$) for juiciness, tenderness, flavor identity, flavor liking, and overall liking than all non-enhanced treatments other than Prime. No differences ($P > 0.05$) were observed between Select LE and Prime samples for most traits evaluated. The effect of USDA grade and enhancement on trained panel palatability scores was independent of DOD for all traits other than juiciness, with the role of marbling in juiciness increasing as DOD increased from rare to well-done. These results indicate enhancement as an effective method to improve the palatability of lower grading beef.

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1. Introduction

Increased marbling (intramuscular fat) level and USDA quality grade have repeatedly been shown to be associated with increased beef eating quality (O'Quinn et al., 2012; Savell et al., 1987; Smith et al., 1985). Thus, higher marbled USDA Choice and Prime beef from the loin and rib is marketed at premiums ranging from 5 to 48% higher than USDA Select product (USDA, 2015a). Additionally, USDA Select beef has been shown to fail to meet consumer eating expectations more than 33% of the time (Corbin et al., 2015). Currently, more than 24% of young, U.S. grain-finished cattle grade USDA Select or lower (USDA, 2015c). With increasing beef prices and consumer quality demands, the need for improving the palatability of this lower quality beef is greater than ever before.

For the past decade, the pork and poultry industries in the U.S. have used enhancement technology extensively as a means to improve product quality and reduce variation in eating experience (National Cattlemen's Beef Association, National Pork Board, & Sealed Air Corporation, 2010). Numerous studies have demonstrated increased tenderness, juiciness, and flavor traits for enhanced pork products (Cannon, McKeith, Martin, Novakofski, & Carr, 1993; Detienne &

Wicker, 1999; Sheard, Nute, Richardson, Perry, & Taylor, 1999; Sutton, Brewer, & McKeith, 1997) as well as increased cooking yields (Cannon et al., 1993; Detienne & Wicker, 1999). Moreover, similar reports have shown beef injected with salt and sodium phosphate solutions exhibit noteworthy improvements in water binding ability, shear force, and sensory panel juiciness, flavor, and tenderness scores (Brooks et al., 2010; Robbins et al., 2003; Trout & Schmidt, 1986; Vote et al., 2000). Additionally, beef injected with CaCl₂ solutions have also been shown to improve beef palatability (Carr, Crockett, Ramsey, & Miller, 2004; Kerth, Miller, & Ramsey, 1995; Miller, Huffman, Gilbert, Hamman, & Ramsey, 1995). However, much of this previous work has focused on comparing enhanced beef products to a limited number of USDA quality grades or treatments.

Consumer perception of beef palatability is highly influenced by degree of doneness (DOD) preference, with close to 40% of consumers reporting they prefer beef steaks cooked to at least a "medium-well" DOD (Cox, Thompson, Cunial, Winter, & Gordon, 1997; Reicks et al., 2011). It is well established that cooking to elevated DOD often results in reduced beef palatability (Cross, Stanfield, & Koch, 1976; Lorenzen et al., 1999; Luchak et al., 1998). However, published reports evaluating the effects of enhancement and USDA quality grade on beef palatability across a wide range of DOD are limited. It was therefore the objective of this study to compare the palatability traits of enhanced USDA Select strip loin steaks to steaks from other USDA quality grades when cooked to three DOD.

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2. Materials and methods

2.1. Product

Beef strip loins (Institutional Beef Purchase Specifications #180; NAMP, 2010) were selected to equally represent seven quality treatments for use in this study. Treatments included five USDA quality grades [Prime, upper 2/3 Choice (Top Choice), lower 1/3 Choice (Low Choice), Select, and Standard], as well as two enhanced USDA Select treatments [Select High Enhanced (HE): 112% of initial product weight and Select Low Enhanced (LE): 107% of raw product weight].

Strip loins ($n = 12/\text{treatment}$) were selected by Texas Tech University (TTU) personnel at a commercial beef processing plant in Nebraska, USA. All strip loins were vacuum-packaged and transported, under refrigeration (2 °C), to the TTU Gordon W. Davis Meat Science Laboratory. Strip loins not intended for enhancement were aged 21 d postmortem under vacuum at 2 to 4 °C in the absence of light.

At day seven of the aging period, USDA Select strip loins in the HE and LE treatment groups ($n = 12/\text{level}$) were enhanced with a water, salt (Morton Coarse Kosher Salt, Morton, Inc., Chicago, IL), and sodium tripolyphosphate (Brifisol 916, ICL Food Specialties, Simi Valley, CA) solution to an average of 112% ($\pm 2.2\%$) and 107% ($\pm 1.6\%$) of raw weight. Each solution was formulated to contain 0.3% salt and 0.45% sodium tripolyphosphate on a finished weight basis, with a target pump level of 15% (HE) and 8% (LE). Pump solutions were mixed with a commercial mixer (Model RS-02, Admix, Manchester, NH) until all solutes were dissolved and chilled (2 to 4 °C) for 24 h prior to pumping. Pump solution (HE: pH = 7.52; LE: pH = 7.23) was injected into strip loins using a multi-needle injector system (Schroder Model IMAX 350, Wolf-Tec Inc., Kingston, NY). Strip loins were weighed before and after enhancement to determine solution uptake. Injected loins were allowed to rest for 30 min at 2 to 4 °C before recording final weights. Injected strip loins were vacuum-packaged and stored at 2 to 4 °C in the absence of light for the remainder of the 21-d aging period.

After completion of the 21-d aging period, all strip loins were fabricated into 2.5-cm thick steaks. The most anterior “wedge” steak was cut by hand and used for proximate analyses. The remaining strip loin was fabricated into nine 2.5-cm thick steaks from anterior to posterior. Groups of three consecutively cut steaks (steaks 1, 2, and 3; steaks 4, 5, and 6; steaks 7, 8, and 9) were assigned to one of three DOD [rare (60 °C), medium (71 °C), or well-done (77 °C)]. One of the three steaks from each DOD group was assigned to consumer panel, trained panel, and slice shear force (SSF) testing. All steaks were individually labelled, vacuum-packaged, and frozen (−20 °C).

2.2. Proximate analysis

Steaks for proximate analysis were thawed for 24 h at 2 to 4 °C. Proximate analysis was tested using the wedge steak from each strip loin that was ground through a 4-mm plate. Prior to grinding, all external fat, heavy connective tissue, and multifidus dorsi were removed, leaving only the longissimus lumborum for analysis. Proximate analysis of raw steaks was conducted by an AOAC official method (Anderson, 2007) using a near infrared spectrophotometer (FoodScan, FOSS NIRSystems, Inc., Laurel, MD). Chemical percentages of fat, moisture, and protein were determined for each strip loin.

2.3. Slice shear force analysis

Before cooking, steaks were thawed at 2 to 4 °C for 24 h and were trimmed to remove external fat. Thawed weight and raw initial temperature (Digital Meat Thermometer Model SH66A, Cooper Instruments, Middlefield, CT) were recorded. The steaks were cooked on a belt grill (model TBG- 60 Magigrill, Magi-Kitch'n Inc., Quakertown, PA) to achieve a final internal temperature of 60 °C (rare), 71 °C (medium), or 77 °C (well-done). Steak weights and peak internal temperatures

were recorded following calculation of cook loss (data not reported) and endpoint temperature.

Tenderness was evaluated by SSF as described by Shackelford et al. (1999). In brief, three min after cooking, a 1–2 cm slice was removed across the width of the steak from the lateral end to square off the steak and expose the muscle fibers. Using a cutting guide, a 5-cm long \times 1-cm thick section was obtained from the lateral end by cutting at a 45° angle parallel to the muscle fiber orientation. The sample was center-sheared perpendicular to the muscle fiber orientation using a United Force Analyzer (Model #SSTM-500 with tension attachment, United Calibration Corp., Huntington Beach, CA) with a cross head speed of 500 mm/min with a load cell of 490.33 N.

2.4. Consumer sensory evaluation

The TTU Institutional Review Board approved procedures for use of human subjects for sensory panel evaluations (IRB 503992). Consumer panels were conducted at the TTU Animal and Food Science Building in a large banquet room under florescent lighting. Panelists ($N = 252$) were recruited from communities in and around Lubbock, TX and paid cash to participate in the study. Consumers were screened during recruiting for DOD preference and served only samples cooked to their preferred DOD. Panel sessions were conducted with 28 consumers seated in individual sensory booths and lasted about 1 h. Panels took place on three separate nights with three sessions conducted each night. Each set of three sessions in a night represented one of the three predetermined DOD and consisted of only consumers who were prescreened and preferred the DOD used.

Consumers were provided with a ballot, plastic fork, toothpick, napkin, expectorant cup, cup of water, and palate cleansers (unsalted crackers and apple juice) to use between samples. Each paper ballot packet contained an information sheet, demographic questionnaire, beef steak purchasing behavior sheet, and seven sample ballots. Before the start of each panel, panelists were given verbal instructions regarding the ballot and usage of the palate cleansers.

Steaks for consumer evaluation were prepared as previously described in Section 2.3. Four steaks were placed on the belt grill every 5 min approximately 2.5 cm away from each other. Following the rest period, 14 1.27-cm² \times 2.5-cm pieces were cut from each steak and two pieces were served immediately to each of seven predetermined consumers. No consumer was seated adjacent to another consumer evaluating the same steak sample. Consumers were served one sample from each of the quality grades (USDA Prime to Standard), a HE Select and LE Select in a predetermined, random order. Attributes for each sample were ranked on a paper ballot with 100-mm continuous-line scales labelled only at end-points for juiciness, tenderness, flavor identity, flavor liking, and overall liking. The zero anchors were labelled as not juicy, not tender, extremely unbeef-like, dislike flavor extremely, and dislike overall extremely; the 100-mm anchors were labelled as very juicy, very tender, extremely beef-like, like flavor extremely, and like overall extremely. Additionally, consumers were asked if each palatability trait was acceptable (yes or no). Furthermore, consumers classified each sample as either unsatisfactory, everyday quality, better-than-everyday quality, or premium quality.

2.5. Trained sensory evaluation

Panelists were trained according to the *Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Meat* (AMSA, 2015). Panelists were trained in a total of six to eight, 1 h training sessions in the 10 days immediately preceding testing. In each training session, panelists evaluated beef steak samples representing a wide range of juiciness, tenderness, and flavor traits and included steaks from various muscles (psoas major, semitendinosus, gluteus medius, and longissimus lumborum), degrees of doneness [rare (60 °C), medium (71 °C), and well-done (77 °C)]

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