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Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments

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ABSTRACT

The palatability of tender [Warner-Bratzler shear force values <33.34 N (3.4 kg)] beef strip loins of 10 different treatments [USDA Prime, High Choice (upper 1/3 Choice), Low Choice (lower 1/3 Choice), Select, Standard, Australian Wagyu, American Wagyu, Holstein Select, Holstein Top Choice (upper 2/3 Choice) and Grass-finished] was evaluated by consumers and a trained flavor panel. In general, tenderness, juiciness, flavor, and overall liking ratings as well as acceptability percentage for each trait, increased with increased fat levels. Moreover, overall liking was highly correlated ($P < 0.01$) with flavor liking ($r = 0.96$) as well as fat percentage ($r = 0.79$). Beef flavor scores were positively associated ($P < 0.01$) with fat-like ($r = 0.67$) and umami ($r = 0.59$) flavors. Fat level was the primary driver of beef flavor acceptability in all samples when no undesirable off-flavors were present.

1. Introduction

Increased marbling level has a positive effect on beef tenderness, juiciness, flavor, and overall palatability (Emerson, Woerner, Belk, & Tatum, 2013; O'Quinn et al., 2012; Savell et al., 1987; Smith et al., 1985). However, in many studies evaluating marbling and palatability, tenderness level varied among samples. Tenderness has been cited as the most important factor affecting beef palatability (Miller, Carr, Ramsey, Crockett, & Hoover, 2001; Miller et al., 1995; Savell et al., 1987). However, additional studies have shown that when tenderness reaches an acceptable level, flavor becomes the next most important driver of beef eating satisfaction (Behrends et al., 2005a, 2005b; Goodson et al., 2002; Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004b). Moreover, several studies have shown consumer overall acceptability to be more highly correlated with flavor than tenderness or juiciness, regardless of tenderness variation (Neely et al., 1998; O'Quinn et al., 2012; Thompson, 2004). According to the most recent U.S. National Beef Tenderness Survey, over 94% of retail and foodservice steaks from the rib and loin would be considered tender or very tender (Guelker et al., 2013). With such a large percentage of the U.S. beef supply classified as tender, the importance of flavor to overall beef eating satisfaction is magnified.

Beef from cattle finished exclusively on forage-based diets has a flavor profile that differs from beef from cattle finished on grain-based diets (Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004a; Sitz, Calkins, Feuz, Umberger, & Eskridge, 2005). Additionally, beef from Holstein cattle has been shown to have a more desirable flavor profile than beef from Angus cattle (O'Quinn, 2012). With the diversity of beef in the U.S. retail market, a better understanding of the role animal diet and cattle type plays on beef flavor is needed.

Consumers often generalize and misevaluate sensory traits because of a favorable evaluation of another trait; termed the halo-effect (Roeber et al., 2000). Thus, consumers are more likely to rate flavor as desirable if tenderness is desirable. To more accurately determine the role marbling plays in beef flavor perception of consumers, this halo-effect, specifically tenderness variation among samples, should be minimized. Therefore the objectives of this study were to measure the effects of varying marbling levels on consumer assessment of beef strip loin steaks that are classified as tender based on Warner-Bratzler shear force values (WBSF) and evaluate the roles fat level, animal diet, and cattle type play in flavor perception.

2. Materials and methods

2.1. Product

Beef strip loins [Institutional Meat Purchase Specifications #180; NAMP, 2010], representing 10 different treatments that are currently

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available to beef consumers in U.S. retail and food service markets were used for this study. Sixty sides of beef [12 per USDA quality grade; Prime, High Choice (upper 1/3 Choice), Low Choice (lower 1/3 Choice), Select, and Standard; (USDA, 1997)] were selected by trained Texas Tech personnel through visual appraisal of marbling and maturity of the product at the time of selection from a processing plant in Omaha, Nebraska. USDA Prime represented the highest quality grade within young "A" maturity carcasses, while USDA Standard represented the lowest. Additionally, two treatments from cattle of predominantly Wagyu breed type (one from the U.S. and the other from Australia) were selected to represent fat levels higher than the USDA Prime product. Four strip loins from Australian Wagyu (AUWA) cattle, finished on a barley-based diet, were obtained from a distributor in Australia and steaks from four strip loins from American Wagyu (AMWA) cattle, finished on a corn-based diet, were obtained from a distributor in Omaha, Nebraska. In addition to fat level treatments, 24 strip loins from Holstein cattle [12 per USDA quality grade: Top Choice (upper 2/3 Choice) and Select] were obtained from a foodservice steak purveyor in Houston, Texas. Lastly, 9 strip loins from cattle that were finished exclusively on a forage-based diet in New Zealand were obtained from a distributor in the United States to allow a grain-finished beef versus grass-finished beef comparison.

Strip loins were collected and shipped to the Gordon W. Davis Meat Science Laboratory, Lubbock, Texas and aged under vacuum packaging at 2–4 °C for 28 d postmortem, with the exception of the grass-finished products, which were aged 48 d postmortem. All exterior fat, connective tissue and the *gluteus medius* muscle were removed from each strip loin. Strip loins were fabricated into 2.5-cm thick steaks from anterior to posterior. The most anterior steak from each strip loin was used for proximate analysis. The following steak from the anterior end was used for WBSF determination. All remaining steak portions were further processed into 5-cm × 5-cm steak pieces following Meat Standards Australia (MSA) protocols (Gee, 2006a). Four 5-cm × 5-cm steaks from each strip loin were saved for use in trained flavor descriptive analysis. All steaks were vacuum-packaged and stored frozen (−20 °C) until subsequent analyses.

2.2. Proximate analysis

Proximate analysis of fat, crude protein, and moisture was conducted using an AOAC-approved (AOAC, 2005) near infrared spectrophotometer (FoodScan, FOSS NIRsystems, Inc., Laurel, MD) as described by O'Quinn et al. (2012).

2.3. Warner-Bratzler shear force analysis

Steaks were thawed overnight at 2 °C and cooked to an internal temperature of 71 °C, monitored by a thermocouple probe (Type J, Cole Parmer, Vernon Hills, IL) attached to a thermometer (Digi-Sense; Cole Parmer), on a clamshell grill (Model S-143 K; Silex Grills Australia Pty. Ltd., Marrickville, Australia) with plate temperature set at 225 °C. The grill was preheated for 45 min before cooking to equilibrate and stabilize temperatures throughout the heating elements and cooking surface. After cooking, steaks were cooled overnight at 2 °C. Six 1.3-cm cores were removed parallel to the muscle fiber from each steak and sheared once perpendicular to the muscle fiber using a WBSF analyzer (G-R Elec. Mfg., Manhattan, KS). The values from the six cores from each steak were averaged.

2.4. Sample selection

Following proximate and WBSF analyses, 4 to 8 strip loins per treatment best matching the fat percentages of the USDA quality grades presented by O'Quinn et al. (2012) were selected for the consumer sensory evaluations. Moreover, all samples selected for consumer analyses possessed a WBSF of 33.34 N (3.4 kg) or less. This value was chosen because previous research has shown that 99% of consumers were satisfied with steak tenderness at this shear force value (Miller et al., 2001). Additionally, the USDA has recently set WBSF standards for tenderness certification, certifying beef with a WBSF value of 43.25 N (4.4 kg) or lower as "Certified Tender" and of 38.25 N (3.9 kg) and lower as "Certified Very Tender" (ASTM, 2011). Thus, all of the samples used in the present study would have met the WBSF criteria for the USDA "Certified Very Tender" claim. Only tender samples were used in the current study in an attempt to minimize any halo-effect that tenderness variation might have on flavor ratings.

2.5. Consumer sensory evaluation

The Texas Tech University Institutional Review Board approved procedures for use of human subjects for sensory panel evaluations. Sample preparation for consumer panels followed a modified MSA protocol (Gee, 2006b). Samples were cooked with equipment described for WBSF. Samples were cooked 10 at a time following a strict timing schedule. Steaks were cooked for 5 min with the lid closed on the grill followed by a 3-min rest period. Following the rest period, samples were cut into two equally sized pieces and served immediately to two predetermined consumers. The grill remained empty for 75 s between cooking rounds to facilitate cleaning. Modifications to the original protocol included extending the cooking schedule to accommodate 10 rounds. Additionally, no warm-up samples were served to consumers before evaluation of test samples.

Consumer panels were conducted at the Texas Tech University Animal and Food Science Building in a large banquet room under florescent lighting. Panelists ($n = 120$) were recruited from communities in and around Lubbock, Texas and paid to participate in the study. Panel sessions were conducted with 20 consumers seated in individual sensory booths, and lasted about 1 h and 20 min. Two panels each night were conducted on three separate nights.

Panelists were provided with a ballot, plastic utensils, toothpick, napkin, expectorant cup, cup of water, and palate cleansers (unsalted crackers and apple juice) to use between samples. Each ballot packet contained an information sheet, demographic questionnaire, 10 sample ballots, and a post-panel survey concerning beef purchasing habits. Before the start of each panel, panelists were given verbal instructions about the ballot and use of the palate cleaners. Panelists were instructed to cut samples into pieces representative of the size consumed per bite in the home or restaurant.

Consumers were served 10 samples from each quality grade treatment (USDA Prime to Standard), an AMWA, AUWA, Grass-finished (GR), Holstein Top Choice (HTC), and Holstein Select (HSEL) in a predetermined, balanced order. The design provided a balance for frequency, order, and carryover effects (Watson, Gee, Polkinghorne, & Porter, 2008). Attributes for each sample were ranked on a paper ballot with 100-mm continuous-line scales for tenderness, juiciness, flavor liking and overall liking. The zero anchors were labeled as not tender, not juicy, dislike flavor extremely, and dislike overall extremely; the 100 mm anchors were labeled as very tender, very juicy, like flavor extremely, and like overall extremely. Also, each consumer rated each sample as either acceptable or unacceptable for each palatability trait. Furthermore, consumers were asked to designate each sample as unsatisfactory, good everyday quality, better than everyday quality, or premium quality.

2.6. Trained panel flavor descriptive analysis

Samples from each of the strip loins evaluated in the consumer study were evaluated by a highly trained, descriptive 5 member flavor panel from the Sensory Analysis Center at Kansas State University (Manhattan, Kansas). The panel evaluated flavor traits using the beef flavor lexicon previously developed by Kansas State University (Adhikari et al.,