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Effects of post-mortem aging time and type of aging on palatability of low marbled beef loins

A.N. Lepper-Blilie [1], E.P. Berg *, D.S. Buchanan, P.T. Berg

Department of Animal Sciences, North Dakota State University, NDSU Dept. 7630, P.O. Box 6050, Fargo, ND, United States

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ABSTRACT

The study objective was to evaluate the effect of post-mortem aging period (14 to 49 days), dry vs. wet (D vs W) type of aging on the palatability of bone-in (BI) beef short loins (n = 96) and boneless (BL) strip loins (n = 96) possessing United States Department of Agriculture marbling scores between Slight and Small. Warner-Bratzler shear force (WBSF) scores decreased linearly over time (P = 0.0001). WBSF was not influenced by aging method or loin type. Aged flavor was higher for DBL than for DBI with WBL and WBI intermediate. Dry aging strip loins increase aged flavor yet did not improve beefy flavor compared to wet aging. Based on objective data and panelist's scores for tenderness, juiciness and aged flavor, a boneless, 28 days wet aged strip steak, cooked to 71 °C would provide the best combination of eating satisfaction and value.

1. Introduction

The United States Department of Agriculture (USDA) is responsible for the standards utilized in the grading of beef carcasses in the United States (USDA, 1997). According to Morris (2013) these grading standards provide a basis for pricing commensurate with the quality and quantity of the animal and the products they produce; help to ensure a uniform supply of beef of the quality desired by consumers, retailers and institutions; and aid in the advertising, promotion and marketing of beef. With respect to grade standards, quality refers to factors which affect eating satisfaction (marbling (intra muscular fat, IMF), carcass maturity, lean color and texture) while quantity is a prediction of lean tissue proportion of a carcass estimated by USDA yield grade. Morris further stated that virtually all beef which is eligible for the USDA grades of Prime (PR), Choice (CH) and Select (SE) are graded by the major beef processors.

According to Wasser and Lundeen (2012) beef cuts with higher levels of marbling are more likely to be more tender, flavorful and juicier than cuts with lower marbling levels. They further state that USDA PR and the upper two-thirds of USDA CH (modest marbling or higher) offer the greatest probability of a positive eating experience. Killinger, Calkins, Umberger, Feuz, and Eskridge (2004) showed consumers ranked steaks with greater marbling (modest and moderate) higher for flavor, juiciness, and overall acceptability than steaks with lower marbling (slight). In their study, steaks of the two marbling classes were paired on tenderness by Warner-Bratzler shear force (WBSF) values to reduce the influence of tenderness on perception of other sensory aspects.

However, George, Tatum, Belk, and Smith (1999) found in an eight US city audit that 60% of the steaks in the retail market were USDA SE and the lower one third of USDA CH (slight and small marbling respectively). These investigators suggested the need for research to improve eating quality of these lower marbled cuts. They further stated that there is a one in four chance of obtaining a tough steak from within the USDA SE grade and a one in five chance associated with the lower one third of USDA CH. Beerman (2009) stated that for beef, consumers consider tenderness to be the most important palatability trait for eating satisfaction followed by flavor. Neely et al. (1998), in a consumer-home study, showed flavor improved as the quality grade increased due to greater intramuscular fat (IMF) associated with higher USDA grade.

The role of aging beef to improvement tenderness and flavor development has been extensively reported: (Dikeman (1987), Warren and Kastner (1992), Brooks et al. (2000), Sitz, Calkins, Feuz, Umberger, and Eskridge (2006), Smith et al. (2008), Dikeman, Obuz, Gok, Akaya, and Stroda (2013). In general these studies compared the effects of aging relative to USDA grade differences (most often the upper two-thirds of USDA CH and USDA PR), aging period differences and/or wet versus dry aging. Because beef from carcasses with marbling in the slight and small classes (corresponding to USDA SE and USDA low CH), is perceived to be less tender and less flavorful than beef with higher degrees of marbling, research on methods to overcome these negative perceptions is warranted. This study focused on a narrow range of marbling (slight^{50} to small^{50}) rather than USDA quality grades. To ensure the benefits of aging had been completed, we extended the aging period to

* Corresponding author.
E-mail addresses: anblilie@hormel.com (A.N. Lepper-Blilie), eric.p.berg@ndsu.edu (E.P. Berg), david.s.buchanan@ndsu.edu (D.S. Buchanan), paul.berg@ndsu.edu (P.T. Berg).
[1] Present address: 2 Hormel Place, Austin, MN 55912.

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49 days. Bone-in and boneless and wet versus dry methods were also compared.

2. Materials and methods

2.1. Loin collections

Ninety-six short loins, North American Meat Purchasing Specification (NAMPS 174) and 96 strip loins (NAMPS 180); (NAMPS, 2012) were collected within 48 h post mortem from two commercial processing facilities over a five month period. The short loins and strip loins were from carcasses that were selected by university personnel experienced in USDA beef grading standards and had USDA marbling score between slight^{50} and small^{50} and maturity class A^{50} to A^{100}. Carcass weight, ribeye area (REA), fat depth, marbling level and carcass maturity were recorded at the plant. Strip loins and short loins from the selected carcasses were processed and sealed in oxygen barrier bags at the plant of origin and transported to the North Dakota State University Meat Laboratory. Within three days post mortem, loins were weighed and randomly assigned to one of four treatments, dry bone-in (DBI), dry boneless (DBL), wet bone-in (WBI), and wet boneless (WBL) and further assigned to an aging group of 14, 21, 28, 35, 42 or 49 days post mortem. A split-plot design with dry versus wet cross-classified with boneless versus bone-in aging in a 2 × 2 factorial was utilized.

2.2. Aging conditions

Loins assigned to dry aging were removed from the vacuum bag, encased in a muslin sock, and suspended from a rail in a refrigerated aging chamber. The chamber temperature was held at 1 °C and relative humidity was maintained at 70% during the aging period. An ultraviolet air purifying system (Germguardian model EU9102, Guardian Technologies LLC, Beachwood, OH, USA) circulated air (5.66 m^3/h) to limit any surface microbial growth. Wet aged samples remained in vacuum sealed oxygen barrier bags (Cryovac Sealed Air Corp.) and were placed in a large walk-in cooler that held a temperature of 1 °C. The WBI loins were placed on racks split chine-bone down, whereas the WBL loins were placed with the subcutaneous fat up. Bags were monitored daily for vacuum integrity and repackaged promptly if the seal was broken.

2.3. Aging sample collection

At 14, 21, 28, 35, 42, and 49 d, loins were removed from the aging chamber for further processing into steaks for sensory and objective evaluation. Only one loin at a time was on the processing table from beginning to completion of the fabrication process. The table was cleaned after each loin was processed. Harvest dates varied such that a maximum of five loins were scheduled for processing on any day. Processing time was recorded and averaged no more than 30 min per loin. An out-of-sock/bag odor was evaluated by the same two assessors throughout using a five-point scale with one being no off-odors and five having an extreme off-odor (musty, sour, yeasty, putrid). Loins were weighed to determine evaporative loss or purge, trimmed of subcutaneous (to a depth of less than 0.3 cm) and kidney fat (NAMPS 174), and reweighed to determine fat trim weight. Discolored, dehydrated or putrefied surface tissue was trimmed and loins were stripped of heavy connective tissue and reweighed to determine trim loss (retail sale weight). A final odor score was assessed by the same evaluators on the whole loin immediately after trimming using the same scale as the initial odor. Loins were cut into 2.54 cm steaks and the third, and fourth steak from the cranial end of the longissimus muscle were identified for WBSF, and trained sensory panel analysis. Minolta color was assessed on the sensory panel steak after a 20 min bloom period. Steaks were labeled, individually vacuum-packaged, frozen, and stored below −20 °C until further analysis (not longer than 90 d).

2.4. Tenderness analysis

Steaks designated for WBSF were placed in a 4 °C cooler for 24 h prior to cooking to ensure an internal temperature of 4 °C prior to cooking on a George Foreman Lean Mean Grilling Machine™ clamshell style grills to an internal temperature of 71 °C as per protocol (AMSA, 1995). Temperatures were measured in the center of each steak with a copper-constantan, Neoflon PFA insulated wire and were recorded using an Omega handheld digital thermometer model HH801B (Omega Engineering Inc., Stamford, CT). Final temperature was recorded once the steaks were removed from the grill and reached peak temperature.

After cooking, WBSF steaks were weighed, overwrapped with polyvinyl chloride film, and allowed to cool to room temperature. A minimum of six 1.27 cm diameter cores were obtained from each steak parallel to the muscle fibers (AMSA, 1995). Cores were sheared on a WBSF machine (G-R Electrical Manufacturing Co., Manhattan, KS, crosshead speed set at 200 mm/min and load cell at 9.072 kg) perpendicular to the muscle fibers and recorded as kg of force. The mean of the six cores per steak was used for statistical analysis.

2.5. Sensory analysis

Procedures using human subjects for sensory panel analysis were approved by the North Dakota State University Institutional Review Board prior to initiation of the study. An eight member trained sensory panel participated in four orientation sessions where they evaluated samples similar to the test samples to become familiar with the sensory definition descriptors of beef flavor lexicon (Adhikari et al., 2011) and are listed in Table 1. A panel leader facilitated the training to promote consistent intensity ranking. Panelists evaluated the samples for tenderness, juiciness, overall aged flavor, beefy, bloody/serumy, brown/roasted, and sour on an 8-point scale (1 = extremely tough, dry, or bland; 8 = extremely tender, juicy, or flavorful; AMSA, 1995). For flavor attributes, panelists were instructed to indicate their failure to detect an attribute with a “non-response” as there were no zeros on the ballot. These were recorded as zero (0) upon data entry.

Table 1
Sensory definitions and references for beef strip and short loins aged wet and dry.

Attribute	Definition	References[a]
Overall aged flavor intensity	Full, blended and sustained cooked beef flavor that has fewer dominating individual flavor notes[b,c]	21 d dry aged steak = 5.0 14 d wet aged steak = 3.0
Beef flavor intensity	Amount of beef flavor identity[d]	80% lean ground beef = 4.0
Bloody/serumy	Aromatic associated with blood on cooked meat[d]	USDA choice strip steak = 3.0
Brown/roasted	A round, full, dark, caramelized aromatic associated with beef that has been cooked with dry heat[d]	80% lean ground beef = 6.0
Sour	Taste factor associated with citric acid[d]	0.15% citric acid solution = 6.0

[a] Measured on a 1 to 8 scale with 1 being extremely bland and 8 extremely flavorful.
[b] DeGeer et al., 2009.
[c] Campbell et al., 2001.
[d] Adhikari et al., 2011.