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Impact of elevated aging temperatures on retail display, tenderness, and consumer acceptability of beef

Andrew M. Cassens, Ashley N. Arnold, Rhonda K. Miller, Kerri B. Gehring, Jeffrey W. Savell*

Department of Animal Science, Texas A&M AgriLife Research, Texas A&M University, College Station, TX 77843-2471, USA

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ABSTRACT

Palatability, color, and aroma of steaks derived from subprimals aged for 14 d at conventional temperatures (0.0 to 1.1 °C) versus those aged for 7 d at conventional temperatures followed by 7 d at elevated temperatures (3.3 to 4.4 °C) were evaluated before and after 5-d retail display. Subprimals from the elevated temperature aging treatment had stronger ($P < 0.05$) sweet and sour aromas, and the top sirloin had stronger ($P < 0.05$) bloody/serumy scores. After the 5-day retail display, aroma (sour, bloody/serumy) and discoloration of T-bone/Porterhouse steaks were most impacted compared to other steaks. Elevated temperature during the last 7 d of aging did not significantly improve consumer panelists' palatability scores, and no differences ($P = 0.66$) were seen in WBS force between aging treatments. Using higher storage temperatures to age beef does not warrant the risk associated with impacting color and odor characteristics that could negatively influence consumer acceptance of retail beef.

1. Introduction

While we understand that consumer acceptance of beef is influenced by tenderness, knowledge gaps still remain regarding the most effective aging practices for beef. Increasing the ambient temperature during chilling has been shown to influence proteolysis and tenderness of beef (Whipple, Koohmaraie, Dikeman, & Crouse, 1990). Koohmaraie (1992) showed decreasing product temperature during aging decreases autolysis of key muscle proteins, which leads one to question if increasing product temperature during aging will improve tenderness. Therefore, a better understanding of the impact of product temperature during aging will help processers determine how to best meet consumer expectations for tenderness without sacrificing color and odor characteristics of steaks.

Because retailers focus primarily on merchandising beef rather than establishing procedures to enhance tenderness, there is a wide range in aging times at retail stores. Retail aging times have been shown to vary from 1 to 358 d (Guelker et al., 2013) and 6 to 102 d (Martinez et al., 2017).

Pierson and Fox (1976) found that aging beef at an elevated temperature (20 °C versus 3 °C) for short periods (3 to 5 d) increased muscle tenderness. King et al. (2009) reported reductions in slice shear force values for steaks from the strip loin and top sirloin butt when increasing storage temperature from -0.5 to 3.3 °C. These studies did not evaluate the impact of higher storage temperatures on color and shelf-life of beef. Therefore, this study was designed to evaluate palatability, color, and aroma of steaks derived from strip loin, short loin, ribeye, and top sirloin butt subprimals aged for 14 d at conventional temperatures (0.0 to 1.1 °C) versus those aged for 7 d at conventional temperatures followed by 7 d at elevated temperatures (3.3 to 4.4 °C).

2. Material and methods

2.1. Product collection

All products were selected from a commercial beef processing facility. Twelve USDA (2016) Choice, yield grade 2 or 3 carcasses were selected and paired ribeyes, top sirloin butts, and strip loins were removed. Twelve additional USDA (2016) Choice, yield grade 2 or 3 carcasses were selected and paired short loins were removed. Subprimals were fabricated from these carcasses to comply with the Institutional Meat Purchase Specifications (IMPS), as described by the North American Meat Institute (2014): beef rib, ribeye, lip-on (IMPS 112A) ($n = 24$); beef loin, strip loin boneless (IMPS 180) ($n = 24$); beef loin, short loin, short-cut (IMPS 174) ($n = 24$); and beef loin, top sirloin butt, boneless (IMPS 184) ($n = 24$). Subprimals were individually vacuum-packaged using a Cryovac-Sealed Air Corp. Model 8300-24 (Charlotte, NC) with a seal pressure of 124 kPa. Boneless subprimals

* Corresponding author.
E-mail address: j-savell@tamu.edu (J.W. Savell).

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were packaged in 2.4 mil bags with an Oxygen Transmission Rate (OTR) of 3 to 6 [1 cm^3 (STP)/(m^2/24 hr/1 atm) @ 40°F/0%RH] (Item No. B6620; Cryovac-Sealed Air Corp., Charlotte, NC). Bone-in subprimals were packaged using 6.9 mil bone-guard bags with an OTR of 3 to 6 [1 cm^3 (STP)/(m^2/24 hr/1 atm) @ 40°F/0%RH] (Item No. B4620TGW; Cryovac-Sealed Air Corp.). Following packaging, all subprimals were boxed, aged for 5 d at 0.0 to 1.1 °C, and then shipped using a commercial refrigerated truck to Rosenthal Meat Science and Technology Center at Texas A&M University (College Station, Texas). The pack date was identified as day 0 for the aging period on all subprimals selected.

2.2. Aging temperature treatment design

Upon arrival at Rosenthal Meat Science and Technology Center, all products were stored for an additional 2 d of aging bringing the total to 7 d of aging at 0.0 to 1.1 °C. Then, subprimals were aged an additional 7 d at either (1) conventional temperatures of 0.0 to 1.1 °C, or (2) elevated temperatures of 3.3 to 4.4 °C. Ambient temperatures of each storage area were monitored using Dickson Data Loggers (Model SP425; Dickson, Addison, IL). Data loggers recorded temperatures every minute for both conventional and elevated aging periods. Mean ambient temperatures (°C) with standard deviations were -0.81 (0.18) and 4.3 (1.22) for conventional and elevated aging treatments, respectively.

2.3. Purge, aroma, pH, and color evaluation

After the 14-d aging period, subprimals were evaluated for purge, aroma, and pH. Determinations for subprimal net weight and purge weight followed the procedures of Laster et al. (2008). Purge percentage was calculated by dividing purge weight by the subprimal net weight and multiplying by 100.

Aroma was evaluated using a 6-member trained panel using AMSA (2016) sensory guidelines as a reference. Packages were opened, and aroma was evaluated immediately. Individually, members of the trained panel evaluated the aroma attributes based on 10-point scales: sweet (0 = none; 9 = strong aroma), sour (0 = none; 9 = strong aroma), plastic (0 = none; 9 = strong aroma), and bloody/serumy (0 = none; 9 = strong aroma).

pH was measured for each subprimal using a digital pH meter (Model IQ 150; Spectrum Technologies, Aurora, IL). Using the round-tipped probe, pH was measured on the lean surface of each subprimal at three different locations, recorded, averaged, and used as the pH measurement for that subprimal. To ensure accuracy, the pH meter was calibrated after every 60th measurement at approximately 10 °C using pH 4.00 and 7.00 standard buffers (VWR Analytical, Radnor, PA).

Following pH evaluation, subprimals were fabricated into steaks. Using a bandsaw with a boneless saw blade, ribeyes and strip loins were cut perpendicular to the long axis into 2.54-cm thick ribeye steaks, lipon, short-cut (IMPS 1112B) and strip loin steaks (IMPS 1180), respectively. Short loins were cut perpendicular to the long axis to 2.54-cm thick T-bone/Porterhouse steaks (IMPS 1173) on a bandsaw using a bone-in saw blade. Top sirloin butts were fabricated by hand perpendicular to the long axis into 2.54-cm thick center-cut sirloin steaks (IMPS 1184F).

Instrumental and visual assessments of steak color were conducted after a 30-min bloom time at approximately 10 °C. Color measurements were taken in three different locations using a Hunter MiniScan EZ (Model 4500L; Hunter Labs, Inc. Reston, VA; 31.8 mm aperture, Illuminant D65, 10° observer) colorimeter and averaged to represent the value for each steak. For each measurement, CIE L^*, a^*, and b^* color space values were recorded. To ensure accuracy, the Hunter MiniScan EZ was calibrated after every 60th measurement using manufacturer provided white and black reference tiles. Hue angle and chroma values were calculated according to the American Meat Science Association (2012) Meat Color Measurement Guidelines. Visual assessment of lean color (1 = extremely bright cherry-red or bright red; 8 = extremely dark red), fat color (1 = white; 5 = yellow), bone color (1 = bright reddish-pink to red; 7 = black discoloration), and discoloration/uniformity (1 = none; 5 = extreme) were performed by a 6-member trained panel using American Meat Science Association (2012) Meat Color Measurement Guidelines.

After color evaluation, steaks were assigned to either retail display, sensory or shear force. Retail display steaks were placed in plastic-foam retail trays and overwrapped using polyvinyl chloride (PVC) film. Sensory and shear force steaks were labeled, vacuum-packaged, and stored frozen (approximately -10 °C).

2.4. Retail display

For retail display, tray-packed steaks were placed in a refrigerated (approximately 4 °C) setting with 1600 lx fluorescent lighting (Lithonia Lighting, Aculty Lighting Group, Inc., Conyers, GA) using cool white bulbs to simulate a retail display case. The steaks were held under these conditions for 5 d. Following retail display, PVC overwrap was removed, and each steak was evaluated for aroma as well as instrumental and visual assessment of color using the methods previously described.

2.5. Cooking method

Steaks were thawed at approximately 4 °C for 48 h. Weights and internal temperatures were recorded before cooking steaks on a 2.54-cm thick flat-top Star Max 536TGF 36-inch (91.44 cm) Countertop Electric Griddle with Snap Action Thermostatic Controls (Star International Holding Inc. Company, St. Louis, MO) set to 176 °C. Internal steak temperatures were monitored with a thermocouple reader (Omega™ HH506A, Stamford, CT) using 0.02-cm diameter, copper-constantan Type-T thermocouple wires. All steaks were flipped upon reaching an internal temperature of 35 °C and removed from the grill upon reaching the final internal temperature of 70 °C. Thermocouples were removed from each steak, and steak weights were recorded. Cooked steaks destined for WBS force evaluation were covered with PVC and chilled for 16 to 18 h at approximately 2 to 4 °C. Cooked steaks assigned to sensory evaluation were placed in a food warmer set at 60 °C (Alto-Shaam, Model 750-TH-II, Milwaukee, Wisconsin) for no longer than 20 min before serving panelists.

2.6. Warner-Bratzler shear force evaluation

Chilled steaks were equilibrated to room temperature (approximately 30 min) before being trimmed of visible fat and heavy connective tissue to expose muscle fiber orientation. From each steak, six 1.3-cm cores were removed parallel to the muscle fibers using a hand-held coring device. The *M. longissimus lumborum* was the only muscle sampled for T-bone/Porterhouse steaks. Cores were sheared once, perpendicular to the muscle fibers, on a United Testing machine (United SSTM-500, Huntington Beach, CA) at a cross-head speed of 500 mm/min using a 10-kg load cell, and a 1.02-cm-thick V-shape blade with a 60° angle and a half-round peak. The peak-shear force was recorded, and the mean-peak-shear-force values were used for statistical analysis.

2.7. Sensory evaluation

Consumer sensory panel methods were approved by the Institutional Review Board (Protocol number: IRB2015-0497M). Panelists (n = 81; demographics in Table 1) were recruited from the Bryan/College Station area using an existing database.

For sensory evaluation, steaks were thawed and cooked using the methods previously described. Each cooked steak was identified with a three-digit code using random number tables from Meilgaard, Carr, and Civille (2006). Steaks were cut into cuboidal portions (approximately