Meat Science 119 (2016) 110–117

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Influence of extended aging on beef quality characteristics and sensory perception of steaks from the *biceps femoris* and *semimembranosus*

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ARTICLE INFO

Article history:
Received 13 March 2015
Received in revised form 8 December 2015
Accepted 20 April 2016
Available online 21 April 2016

Keywords:
Beef
Aging
Shelf-life
Tenderness
Consumer panel

ABSTRACT

The objective was to determine the influence of post-fabrication aging (2, 14, 21, 42, and 63 days) on beef quality characteristics and consumer sensory perception of *biceps femoris* (BF) and *semimembranosus* (SM) steaks. Lipid oxidation and aerobic plate counts increased ($P < 0.05$) with longer aging periods and retail display times. An aging period by day of retail display interaction ($P < 0.05$) was observed for a* and b* values of the BF and SM. Warner–Bratzler shear force values decreased ($P < 0.05$) with longer aging for the SM, while no difference was observed for the BF. Consumer panel results revealed that longer aging periods increased ($P < 0.05$) acceptability of the SM, tenderness of both muscles, and tended to increase ($P = 0.07$) juiciness of the SM. Our results show that extended aging reduces retail color stability yet has positive effects on consumer perception of tenderness of both muscles and overall acceptability of the SM.

1. Introduction

The 2010/2011 National Beef Tenderness Survey revealed that post-fabrication aging times for subprimal cuts in cold storage facilities ranged from 1 to 358 days and 9 to 67 days for retail and foodservice subprimals, respectively (Guelker et al., 2013). Effects of aging on beef tenderness have been well-documented (Bratcher, Johnson, Littell, & Gwartney, 2005; Colle et al., 2015; Dixon et al., 2012; Eilers, Tatum, Morgan, & Smith, 1996; Gruber et al., 2006). Bratcher et al. (2005) concluded that USDA Select muscles should be aged at least 14 days postmortem, whereas beef from carcasses in the upper two-thirds of USDA Choice was tender by 7 days postmortem. Gruber et al. (2006) also demonstrated that most USDA Select muscles require longer aging times than those from carcasses grading in the upper two-thirds of Choice. Recently, Colle et al. (2015) aged USDA select beef strip loin and top sirloin for up to 63 days, and concluded that in order to optimize the consumer's perception of tenderness the strip loin does not need to be aged past 14 days, while the top sirloin should be aged for at least 21 days. Additionally, the Meat Standards Australia (MSA) model assumes that the aging response is linear from 5 to 21 days and then decreases exponentially (Thompson, 2002). Thompson (2002) also noted that low connective tissue muscles have a higher aging response than high connective tissue muscles. To date, most research on beef tenderness, including the work cited above, has focused on the effects of relatively short term aging (28 days or less) on Warner–Bratzler shear force. Consequently, little is known about the effects of extended aging of beef on shear force or consumer acceptability.

In addition to the paucity of information regarding the effects of extended aging on beef tenderness, relatively little is known about the effects of extended aging on beef color and flavor development. McKenna et al. (2005) demonstrated that beef muscles can be classified based on color stability. These authors categorized the *semimembranosus* (SM) and *biceps femoris* (BF) as being "moderate" and "low" color stability muscles, respectively, when aged for 3 days and subjected to 5 days of retail display.

Aging influences numerous volatile compounds in beef muscles, and positive flavor compounds generally decrease while negative compounds increase with aging from 7 to 14 days (Stetzer, Cadwallader, Singh, McKeith, & Brewer, 2008). Colle et al. (2015) recently found that sensory panel flavor scores did not differ over 63 days of aging USDA Select strip loin and top sirloin. Little is known regarding the effects of aging longer than 35 days on consumer perception of beef BF and SM flavor.

Biceps femoris and SM steaks derived from USDA Select carcasses have been shown to exhibit moderate to high aging responses, respectively, with potential to continue tenderizing beyond 28 days of aging (Gruber et al., 2006). Consequently, peptides and amino acids generated by proteolysis may contribute to flavor development in these muscles

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http://dx.doi.org/10.1016/j.meatsci.2016.04.028
0309-1740/

during extended aging. Although the effects of aging on beef tenderness are well established, relatively few experiments have examined the effects of aging longer than 28 days on beef shelf-life and palatability. Our specific objective was to determine the influence of wet aging for 2, 14, 21, 42, and 63 days on retail color stability, microbial growth, lipid oxidation, Warner–Bratzler shear force, soluble and insoluble collagen levels, and consumer acceptability of beef BF and SM steaks.

2. Materials and methods

2.1. Human subject participation in consumer panel

The University of Idaho Institutional Review Board certified this project as Exempt.

2.2. Product procurement

At 48 h postmortem (fabrication = day 0), beef outside round [Institutional Meat Purchase Specifications (IMPS) 171B; NAMP, 2011], and top (inside) round (IMPS 168; NAMP, 2011) from the left side of USDA Select carcasses (n = 12) were purchased from AB Foods (Toppenish, WA) and transported to the University of Idaho Meat Science Laboratory. The drip and sales coolers at AB Foods are set at 1.1 to 0 °C and 2.8 °C, respectively. Additionally, electrical stimulation occurs in two sections, the first is 26–29 V and the second is 26 V. It takes about 1 min for a carcass side to go through the two sections.

2.3. Preparation of product

The *biceps femoris* (BF) and *semimembranosus* (SM) were removed from their respective wholesale cuts for aging and subsequent analysis. The muscles were cut into five sections at least 5.1 cm-thick (Fig. 1). Each section was randomly assigned to one of the five aging periods (2, 14, 21, 42, and 63 days post-fabrication). Sections were vacuum shrink packaged (7 × 12 in. Durashrink bags, Winpak Films, Senoia, GA) and subsequently aged for the pre-determined time period at 0 °C.

At the end of each aging period, designated sections were cut into two 2.54 cm-thick steaks, which were randomly assigned to determine either consumer acceptability or retail shelf-life followed by Warner–Bratzler shear force (WBSF) and collagen analysis. Steaks used for retail display were weighed, swabbed (3 M Quick Swab) for microbial analysis, sampled for thiobarbituric acid reactive substances (TBARS) analysis, placed in white Styrofoam trays, and overwrapped with an oxygen permeable PVC film (Koch Industries, Inc. #7500-3815; Wichita, KS) with the freshly cut surface exposed to oxygen. Steaks were displayed in a glass-fronted retail display case (Model GDM-69, True Manufacturing Co., O'Fallon, MO) at 3 °C for 4 days. The display case was equipped with natural white Hg 40 W lights which were on throughout retail display, and the average light intensity was 409 lx. Following retail display, steaks were weighed, swabbed for microbial analysis, sampled for TBARS analysis, cooked, measured for tenderness (WBSF), and frozen for collagen analysis. Steaks designated for consumer acceptability were weighed and exposed to retail display conditions as described above for 1 day, then reweighed, swabbed for microbial analysis, sampled for TBARS analysis, vacuum packaged, and frozen at −20 °C, to stop the aging process, until completion of all aging periods when consumer panels were conducted.

2.4. Fluid loss

Each section was weighed prior to vacuum packaging and after aging to determine percent purge. Steaks were weighed prior to and following 4 days of retail display to determine percent retail fluid loss.

2.5. Retail color

Steaks were packaged and allowed to bloom for at least 60 min, then two instrumental color measurements per steak were taken using a Hunter MiniScan EZ (Restin, Virginia). Each point was selected avoiding large marbling flecks, connective tissue, and the product edge. This represented day 0 of retail display, and subsequent color measurements were taken on days 1, 2, 3, and 4. The Hunter MiniScan was equipped with a 25 mm-diameter measuring area and a 10° standard observer. The instrument was set to illuminant A and Commission International de l'Eclairage (CIE) L* (lightness), a* (redness), and b* (yellowness) values were recorded. Calibration of the machine was carried out each day by measuring through the packaging film against black and white calibration tiles.

Steaks were evaluated daily during retail display for oxygenated lean color, amount of browning, discoloration, surface discoloration, and color uniformity by two evaluators following the Meat Color Measurement Guidelines (AMSA, 2012). Evaluators were familiar with assessed traits and were calibrated in a preliminary study. To avoid potential effects due to display case location, steaks were rotated after each measurement.

2.6. Microbial growth

Each steak was dry swabbed (5 cm × 5 cm area) twice on days 0 and 4 of retail display using 3M™ Quick Swabs (3M, St. Paul, MN). Letheen broth contained in the top of the swab was added and the samples were plated on 3M™ Petrifilm™ Plates (3 M, St. Paul, MN). One sample was plated on a 3M™ Petrifilm™ Aerobic Count Plate and the other sample was plated on a 3M™ Petrifilm™ *E. coli*/Coliform Count Plate. The 3M™ Petrifilm™ Aerobic Count Plate was incubated at 35 °C for 48 h to examine the growth of mesophilic organisms, while the 3M™

Fig. 1. Sectioning of the biceps femoris (left) and semimembranosus (right) muscles. Diagrams represent proximal to distal and lateral to medial from left to right and top to bottom, respectively. Sections were at least 5.1 cm-thick and assigned so that each aging period was represented at each location.