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Effects of subprimal type, quality grade, and aging time on display color of ground beef patties

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ABSTRACT

A factorial design was used to evaluate the effects of two subprimal types (chuck roll and knuckle), two quality grades (Premium Choice and Select), and three vacuum-storage aging times before processing (7, 21, and 42 d) ground beef patty display color attributes. Patties from chuck roll and Premium Choice subprimals had brighter red visual color scores, less discoloration, and higher L*, a*, b*, and chroma values than those from knuckle and Select subprimals, respectively. With an increased display time, patties became darker red, more discolored, and had decreased L*, a*, b*, and chroma values. Therefore, aging Premium Choice chuck rolls for less time (fewer than 21 d) could maximize display color life.

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1. Introduction

Ground beef is a commonly consumed beef product in the United States. Historically, the source of ground beef comes from lower quality cuts, trimmings from subprimals, and subprimals from cull cows; however, alternative grinds from whole and/or premium quality subprimals are becoming more popular with consumers and creating a greater demand for distinctive menu items. Consumers associate meat color with freshness and use color as a major criterion in selecting meat products (Kropf, 1993). They generally associate a bright red color with freshness and wholesomeness (Jenkins & Harrington, 1991) and find products less desirable as color darkens. Longer display life without discoloration would result in more opportunities for sale and fewer discounts and/or reworks.

Muscles from different subprimals can possess different properties and influence the display life of meat products. Oxygen consumption (OC) is an inherent property of meat where a series of reactions, principally involving Kreb cycle enzymes, consume (scavenge) oxygen in meat (AMSA, 2012). Molecular oxygen continues to be reduced by NADH at the end of the electron transport chain and competes with myoglobin for oxygen (Lanari & Cassens, 1991). The interactions between mitochondria and myoglobin suggest that both the electron transport chain and reductase enzymes can reduce metmyoglobin and are involved in color stability (Mohan, Hunt, Muthukrishnan, Houser, & Barstow, 2010). McKenna et al. (2005) studied the biochemical properties of 19 beef muscles and identified high-color stability muscles to have high oxygen penetration depth (OPD) and low Oxygen Consumption Rates (OCR), whereas muscles with low color stability had low OPD and high OCR. Metmyoglobin reducing ability (MRA) is another inherent property of meat involving a series of reactions that help reduce metmyoglobin and maintain meat color stability during display (Mancini & Hunt, 2005). They concluded that in addition to reducing enzyme systems, meat color life and metmyoglobin formation depend also on muscle's oxygen scavenging enzymes and the NADH pool. McKenna et al. (2005) found that beef muscles with high color stability had the highest MRA, whereas very low-stability muscles had the lowest MRA.

Higher quality subprimals such as Premium Choice subprimals have increased intramuscular fat and differences in fatty acid composition (Turk & Smith, 2009). Researchers (Liu, Huffman, Egbert, McCoskey, & Liu, 1991; Mancini, 2001; Troutt et al., 1992) have reported that ground beef containing higher percentages of fat (>15%) have brighter-red color and less discoloration than ground beef with lower percentages of fat (<10%). In addition, ground beef with higher percentages of fat had greater brightness (L*) values than ground beef with lower percentages of fat (Liu et al., 1991; Mancini, 2001; Troutt et al., 1992).

Vacuum-packaged subprimals can be stored for extended lengths of time and utilized later for ground beef. The time postmortem at which subprimals are ground can vary based on the accessibility and marketing of these subprimals and may affect discoloration during retail display. Mancini and Hunt (2005) concluded that both enzymatic activity and the NADH pool are continually being depleted with increasing time postmortem. Therefore, meat aged for longer periods of time could potentially accumulate metmyoglobin at a more rapid rate during display and discolor more rapidly. King, Shackelford, Kalchayanadand,

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and Wheeler (2012) reported that steaks from strip loins aged 35 d had decreased a* and chroma values and expressed much more rapid changes in color attributes than those aged 4 and 14 d.

During display in traditional polyvinyl chloride (PVC) packaging, discoloration increases and MRA decreases on the surface of beef steaks (Sammel et al., 2002; Seyfert et al., 2006). Furthermore, Mancini et al. (2002) found that increased storage (12 d) and display time (48 h) of ground beef significantly increased microbial counts. McKenna et al. (2005) found that thiobarbituric acid-reactive substances (TBARS) values increased with more days of retail display and reported that less color-stable muscles have higher TBARS values.

Therefore, the objective of this study was to determine the effects of two subprimal types (chuck rolls and knuckles representing estimated fat percentages of 15–20% and 5–10%, respectively), two quality grades (Premium Choice and Select), and vacuum-storage aging time (7, 21, and 42 d) before processing on ground beef patty display color.

2. Materials and methods

2.1. Product selection and manufacture

A total of 72 Chuck Rolls [116A, a subprimal cut composed primarily of the Longissimus dorsi, Rhomboideus, Spinalis dorsi, Complexus, Multifidus dorsi, Serratus ventralis, Subscapularis, and Splenius muscles on the medial side of the scapula (NAMP, 2010)] and 144 Peeled Sirloin Tip Knuckles [(167A, a subprimal cut composed of the Vastus intermedius, Vastus lateralis, Vastus medialis, and Rectus femoris muscles with the Tensor fasciae latae muscle, fat, and "skin" tissue removed (NAMP, 2010))] from Select and Premium Choice (upper two-thirds of Choice) quality grade categories were obtained from a commercial processing facility. Each treatment combination [subprimal types (n = 2) × quality grades (n = 2) × aging times (n = 3)] was replicated six times. The experiment was conducted from products randomly selected from two different days of production. Each day of production had an equal number of chuck roll and knuckle subprimals representing their respective quality grades. Upon arrival at the Kansas State University Meat Lab, subprimals from each day of production were then randomly assigned to an aging time of 7, 21, or 42 d post-packaging and remained in their individual vacuum bag until the end of their assigned aging period (0 ± 1 ºC). Abnormal cuts or leaking bags were eliminated from the study. At the end of each aging time, four knuckles (16.10 ± 1.81 kg) or two chuck rolls (19.87 ± 1.76 kg) representing their respective quality grade categories were combined to make a subprimal type × quality grade × aging time treatment sample (experimental unit) and ground through a Hobart Grinder (Hobart Mfg. Co., Troy, OH; Serial 1865825, Model 4732) with a 0.95-cm grinding plate followed by a fine grind with a 0.32-cm grinding plate. From each of the six subprimal type × quality grade × aging time treatment samples (n = 72), three subsamples weighing approximately 200, 125, and 30 g were placed into sterile bags (Whirl-Pak, Nasco, Modesto, CA) for proximate analysis, initial TBARS values, and myoglobin concentration, respectively. For each of the treatment replications, ground beef patties were made using a Hollymatic patty machine (Patty Maker, Super model 54 Food Portioning Machine, Hollymatic Corporation, Countryside, IL; Serial 61281) to form 0.11-kg patties that were 10.8 cm in diameter and 1.3 cm thick.

Nine patties from each of the treatment replications were randomly selected, individually placed on 12.7 × 12.7 × 1.3-cm Styrofoam trays (1S, Cryovac Sealed Air, Duncan, SC), and wrapped with an oxygen-permeable PVC overwrap (Prime Source, oxygen transmission rate 0.6 g/254 cm^2/24 h at 0 ºC; water vapor transmission rate 0.6 cc/254 cm^2/24 h at 0 ºC and 0% relative humidity). Patties were randomly selected for pH, display color, oxygen consumption at 0 and 24 h of display, metmyoglobin reducing ability at 0 and 24 h of display, microbial analysis at 0 and 24 h of display, and TBARS at 24 h of display.

2.2. Retail display

Ground beef patties selected for display were placed in a coffin-type retail display case (Unit Model DMF8, Tyler Refrigeration Corp., Niles, MI) under continuous fluorescent lighting (3500 K, 2140 lx and CRI = 85, Bulb Model F32T8/ADV830/Alto, Phillips, Bloomfield, NJ) at 2 °C for 72 h. Case temperatures were monitored throughout the study using OMEGA RD-Temp-XT loggers (Stamford, CT). During the study, display case temperature averaged 2.23 ± 1.08 ºC. The location of the packaged patties was randomly rotated daily within the case to minimize any potential case-location effects.

2.3. pH

A ground beef patty from all treatment replications was randomly selected to measure initial display pH. On d 0 of display the pH was determined using a standardized pH probe (Hanna Instruments; H199163; Woonsocket, RI) attached to an Accumet Basic pH Meter (Fisher Scientific, Pittsburgh, PA). Measurements were taken in two locations and averaged from the patty chosen to test pH.

2.4. Myoglobin concentration

Myoglobin concentration was measured using the methods by Warriss (1979) and Krzywicki (1982), and calculations were made using equations from Tang, Faustman, and Hoagland (2004). Eight total composite samples were created from each day of production for measuring total pigment of Premium Choice chuck rolls, Select chuck rolls, Premium Choice knuckles, and Select knuckles. Samples were submersed into liquid nitrogen, pulverized in a Waring commercial blender (model 51BL32, Torrington, CT), poured into a clean sample bag (Whirl-Pak, Nasco, Modesto, CA), and stored at −80 °C until the analyses were completed (within 30 d).

Duplicate 5-g samples were suspended in 25 mL of ice-cold phosphate buffer (pH 6.8, 0.04 M) in 50-mL centrifuge tubes. The samples were mixed, held in ice (0–4 °C) for 1 h, and centrifuged (Beckman Coulter, Model J2-21, Brea, CA) at 15,000 ×*g* for 30 min at 5 °C. A 3-mL sample was removed and filtered through a 0.45-nm filter (Nalge Nunc International, Rochester, NY) into a spectrophotometer cuvette (Fisher Scientific Disposable Plastic Cuvette, Pittsburg, PA; Semimicro Style Methacrylate, 10-mm lightpath, 1.5 mL). Individual absorbances were taken at 503, 525, 557, 582, and 700 nm using a Hitachi spectrophotometer (U-2010, Schaumburg, IL) against a blank that contained only the phosphate buffer. Myoglobin concentration (mg/g meat) was calculated.

2.5. Proximate analysis

Proximate analysis samples (200 g) were submersed in liquid nitrogen, pulverized in a Waring commercial blender (model 51BL32, Torrington, CT), placed into a clean sample bag (Whirl-Pak, Nasco, Modesto, CA), and stored at −80 °C until analyses were completed. Moisture and fat content were determined by following AOAC Official Method PVM-1:2003 using the CEM automatic fat extractor and CEM automatic volatility computer (Instrument: CEM SmarTrac System, Matthews, NC). Protein was determined following AOAC Official Method 990.03 with a LECO protein analyzer (LECO FP-2000, St. Joseph, MI).

2.6. Visual color evaluation

All visual panelists were selected from those who passed the Farnsworth-Munsell 100-Hue Test for color blindness and their ability to detect differences in hue. Panelists were oriented prior to the initiation of the study to the scoring ballot and trained with ground beef patty samples and pictorial references. All trained color panelists (a minimum of 6 per day) evaluated patty visual color and discoloration