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Cooked color of precooked ground beef patties manufactured with mature bull trimmings

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ABSTRACT

Lean (80%) ground beef was formulated with 0, 25, 50, 75, or 100% mature bull trimmings, formed into patties, cooked to 71 °C in an air-impingement oven, and stored at −20 °C until reheating to 71 °C either in a microwave oven or on a gas-fired chargrill. Instrumental color of raw patties was not ($P \geq .080$) affected by levels of bull trim. After initial cooking, internal cooked redness values were not affected ($P \geq .202$) by the proportion of bull trim; however, the internal reheated patty redness increased (greater a* values and lesser HA; $P \leq .001$) with increasing proportions of bull trimmings. Formulating ground beef with high levels (> 50%) of mature, bull trimmings had minimal effects on raw ground beef color, but patties formulated with the highest proportions of bull trimmings appeared undercooked even after cooking twice to 71 °C.

1. Introduction

Ground beef is the most popular beef product purchased in the United States, and is the most commonly consumed form of beef in, and away from, the home. Cooking fresh ground meats denatures the myoglobin, resulting in a dull-brown internal cooked color, and, albeit not recommended, consumers routinely use internal cooked color of ground beef as an indicator of doneness and safety (King & Whyte, 2006; Suman, Nair, Joseph, & Hunt, 2016). However, ground beef patties cooked with predominantly oxidized myoglobin (metmyoglobin) can appear fully cooked at temperatures well below the thermal death of pathogenic bacteria (referred to as "premature browning"; Lavelle, Hunt, & Kropf, 1995; Warren, Hunt, & Kropf, 1996a, Warren et al., 1996b; Hunt, Sørheim, & Slinde, 1999). Nevertheless, patties cooked with predominantly reduced myoglobin (deoxymyoglobin) can result in a persistent red/pink internal color at temperatures > 71 °C (Hunt et al., 1999; Warren, Hunt, & Kropf, 1996a). Moreover, Olsen, Røssvoll, Langsrud, and Scholderer (2014) noted that 50.1% of consumers felt "fear" and "disgust" when confronted with a medium-rare-appearing hamburger, which they associated with a greater risk of evoking an *E. coli* infection.

Precooked ground beef patties are an emerging market as quick, convenient in-home meals (Thongtan, Toma, Reiboldt, & Daoud, 2005), and may be perceived by consumers as safer (Katsanidis & Addis, 1999) because they are fully cooked prior to packaging and frozen storage. To date, however, the vast majority of the research on precooked ground beef patties has focused on either initial cooking or reheating methodology on palatability of precooked ground beef patties (Cross, Muse, & Green, 1979; Joseph, Smith, & Cross, 1980; Kirchner, Beasley, Harris, & Savell, 2000) or ingredient incorporation, such as texturized soy proteins (Bowers & Engle, 1975), carrageenan and sodium alginate (Lin & Keeton, 1998), rosemary extract (Thongtan et al., 2005), and dehydrated potato extract (Katsanidis & Addis, 1999). With the exception of Berry, Marshall, and Koch (1981), who compared physical characteristics of precooked beef patties formulated with lean trimmings from either U.S. Choice or U.S. Cutter and Canner carcasses, there is no information on the effects of lean sources on quality characteristics of precooked ground beef patties. Moreover, Berry (1996) compared cookery methods on the internal cooked color of once- or twice-cooked ground beef patties; otherwise, internal cooked and reheated color has not been reported by previous researchers.

Even though trimmings from mature bulls have been included in ground beef manufacture for years, only Cross, Berry, Nichols, Elder, and Quick (1978) compared the palatability attributes of ground beef

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manufactured from U.S. Choice, U.S. Utility, and mature bull trimmings. Therefore, the objective of this experiment was to test the effects of various proportions of mature bull trimmings on physical characteristics and instrumental color of fresh, precooked, and reheated ground beef patties.

2. Materials and methods

2.1. Ground beef manufacture

Mature bull carcasses were selected based on physiological skeletal ossification (C– and D-maturities), and necks from the individually identified carcasses were collected during carcass fabrication at a commercial slaughter facility (Lone Star Beef Processors, San Angelo, TX, USA). Vacuum-packaged bull necks were transported under refrigeration to the University of Arkansas Red Meat Abattoir and stored for 2 d at 2 °C. In addition, A-maturity, USDA Select beef knuckles (IMPS #167A; USDA, 2014) and 50% lean beef trimmings were purchased from a commercial beef processor (Cargill Meat Solutions, Wichita, KS, USA), and shipped under refrigeration to the University of Arkansas Red Meat Abattoir and stored at 2 °C for 2 d before grinding.

Bull necks and knuckles were removed from their vacuum packaging, trimmed free of all visible fat, and cubed before necks, knuckles, and 50% lean trimmings were individually coarse ground through a 1.59-cm plate (Hollymatic Corp., Countryside, IL, USA) into 18.1-kg-capacity, 63.5 × 40.6 × 21.6-cm containers (Cross Stack Jumbo Lug; Buchorn, Inc., Milford, OH, USA). Samples (250 g) were collected from each container of coarse ground materials, and fat content of each sample was analyzed with a HFT 2000 Digital Fat Tester (Data Support Co., Inc., Encino, CA, USA) before the manufacture of 25, 13.6-kg batches (5 batches·treatment formulation^{-1}) of 80% lean ground beef. The “lean” portion consisted of 0, 25, 50, 75, or 100% ground mature bull necks (MBT), with the remainder composed with ground knuckles (100, 75, 50, 25, or 0%, respectively), and 50% lean beef trimmings were used as the “fat” portion of the ground beef blend (Table 1). Additionally, rosemary extract (Newly Wed Foods Inc., Chicago, IL, USA) and chilled tap water were added to each batch at 0.035% and 5.0% of total batch weight, respectively. Batches were then ground through a 0.95-cm grinder plate attached to a Hollymatic 150 mixer/grinder (Hollymatic Corp., Countryside, IL, USA), and 151-g patties were formed using a commercial patty-forming machine (Hollymatic Corp., Countryside, IL, USA). Batches of ground beef were manufactured in a random order, and the grinder was disassembled, cleaned, rinsed and dried between each batch.

Six patties were selected randomly from each batch, 2-g samples of each patty were homogenized in 20 ml of distilled, deionized water, and pH of the homogenate was measured with a temperature-compensating combination electrode (model 30,073.1; Denver Instrument Co., Arvada, CO, USA) attached to a pH/ion/FET-meter (model AP25; Denver Instrument Co., Arvada, CO, USA). In addition, fat content of each patty was measured in duplicate using a ground beef fat analyzer (HFT 2000 Digital Fat Tester; Data Support Co., Inc., Encino, CA, USA). Because patties were cooked from the fresh state, all patties from each batch were stacked (4 patties·stack^{-1}) in batch-identified, wax-lined boxes, and held overnight (approximately 14 h) at 2 °C in the dark.

Table 1
Ground beef formulations (kg/batch).

	Ground beef treatments[A]				
Raw materials	0	25	50	75	100
No. of batches	5	5	5	5	5
Mature bull necks	0.00	2.12	4.25	6.37	8.5
Select, peeled knuckles	8.50	6.37	4.25	2.12	0.00
50% lean beef trimmings	5.10	5.10	5.10	5.10	5.10

[A]Five replications of each treatment batch.

2.2. Patty dimensions

Randomly selected fresh patties (12 patties·batch^{-1}) were weighed before the surface area of each patty was traced onto acetate paper (patty area was measured at a later date with a compensating planimeter; Planix 8; Overland Park, KS, USA), and patty thickness was measured at four edges (90° between measurements) with digital calipers (Ultratech no. 1433; General Tools & Instruments LLC, Secaucus, NJ, USA). Patty weights, as well as patty thicknesses (average of the 4 measurements·patty^{-1}) and tracings of patty surface areas, were also recorded on these segregated patties after initial cooking, frozen storage (immediately before reheating), and reheating. Initial and reheated cooking losses were calculated as: ((raw patty weight − cooked patty weight)/raw patty weight) × 100, and ((frozen patty weight − reheated patty weight)/frozen patty weight) × 100, respectively. Additionally, patty thickness change for cooked and reheated patties was calculated as: ((raw patty thickness − initial cooked patty thickness)/raw patty thickness) × 100, and ((frozen patty thickness − reheated patty thickness)/frozen patty thickness) × 100, respectively, whereas cooked and reheated patty area losses were calculated as: ((raw patty area − cooked patty area)/raw patty area) × 100, and ((frozen patty area − reheated patty area)/frozen patty area) × 100, respectively.

2.3. Cooking and reheating procedures

Within 24 h of patty formation, all patties from each batch were cooked to an internal endpoint temperature of 71 °C in a gas-fired, forced-air impingement oven (model 1116–080-A; Lincoln Foodservice Products Inc., Fort Wayne, IN, USA) set at 204.4 °C and a belt time of 10.5 min. Patties were placed on the conveyor chain and internal temperature was checked with a hand-held thermometer (model KM28; Comark Instruments Inc., Beaverton, OR, USA), and, those patties that had not reached the correct internal temperature were pushed back into the oven until reaching the specified internal endpoint temperature. Cooked patties (30 patties·batch^{-1}) were frozen immediately at −20 °C, stacked (5 patties·stack^{-1}), placed in 45.7 × 71.1-cm, 4-mil bags (Sealed Air Corp., Charlotte, NC, USA), heat sealed (Omcan Inc., Mississauga, ON, Canada), and subsequently stored at −20 °C for two weeks.

At the end of frozen storage, half of the frozen patties (15·batch^{-1}) were reheated on a gas-fired, open-hearth charbroiler (model 614RCBD; Star Manufacturing International, Inc., Smithville, TN, USA) set at medium-high heat to an internal endpoint temperature of 71 °C. Patties were turned every 2 min until reaching the specified endpoint temperature, monitored by a hand-held thermometer (model MK28; Comark Instruments Inc., Beaverton, OR, USA). The other 15 frozen patties of each batch were reheated in a 1100-watt microwave oven (model WES1450; General Electric Co., Louisville, KY, USA) for 2 min to the desired internal endpoint temperature of 71 °C (internal endpoint temperature was confirmed with a hand-held thermometer inserted into the geometric center of the patty). Moreover, after air-impingment cooking, as well as after chargrill- and microwave-reheating, 3 patties from each batch were selected at random for measuring cooked and reheated patty pH following the previously described procedure.

2.4. Instrumental color data collection

After patty formation, 12 randomly selected fresh patties from each batch were exposed to air for 30 min at 2 °C before raw instrumental color (L*, a*, and b*) and visible spectrum reflectance (400 to 700 nm) data were measured from 3 random readings on the external surface of each patty. In addition, both immediately after initial cooking and immediately after reheating, randomly selected cooked (12·batch^{-1}) and reheated patties (12·batch^{-1}·reheating method^{-1}) were placed in Ziploc freezer bags and submerged in an ice-water bath to stop the