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Identifying consumer preferences for specific beef flavor characteristics in relation to cattle production and postmortem processing parameters

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ABSTRACT

Sensory analysis of ground LL samples representing 12 beef product categories was conducted in 3 different regions of the U.S. to identify flavor preferences of beef consumers. Treatments characterized production-related flavor differences associated with USDA grade, cattle type, finishing diet, growth enhancement, and postmortem aging method. Consumers (N = 307) rated cooked samples for 12 flavors and overall flavor desirability. Samples were analyzed to determine fatty acid content. Volatile compounds produced by cooking were extracted and quantified. Overall, consumers preferred beef that rated high for beefy/brothy, buttery/beef fat, and sweet flavors and disliked beef with fishy, livery, gamey, and sour flavors. Flavor attributes of samples higher in intramuscular fat with greater amounts of monounsaturated fatty acids and lesser proportions of saturated, odd-chain, omega-3, and trans fatty acids were preferred by consumers. Of the volatiles identified, diacetyl and acetoin were most closely correlated with desirable ratings for overall flavor and dimethyl sulfide was associated with an undesirable sour flavor.

1. Introduction

Tenderness frequently is cited as the most important determinant of a beef steak's sensory performance (Miller, Carr, Ramsey, Crockett, & Hoover, 2001). However, for some beef consumers, a steak's flavor profile is equally important to the overall sensory experience (Neely et al., 1998) and, when tenderness is within an acceptable range, flavor often becomes the more important driver of eating satisfaction (Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004b). Consumer sensory studies have shown that beef consumers differ in their individual preferences for particular beef flavor attributes (Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004a; Oliver, 2012). Moreover, consumers' individual flavor preferences are reflected in their beef purchase decisions (Sitz, Calkins, Feuz, Umberger, & Eskridge, 2005), which underscores the importance of beef flavor in the marketplace.

Previous research has identified several factors along the beef production and processing chain (e.g., cattle breed, finishing diet, intramuscular fat content, postmortem aging method) that influence beef flavor characteristics (Emerson, Woerner, Belk, & Tatum, 2013; Jeremiah, Beauchemin, Jones, Gibson, & Rode, 1998; Melton, Amiri, Davis, & Backus, 1982; Melton, Black, Davis, & Backus, 1982; Warren & Kastner, 1992) and, in recent years, innovative marketing approaches involving differentiation of beef products according to production-related differences in flavor (Oliver, 2012) have emerged and are gaining momentum. However, scientific information linking consumer preferences with specific beef flavor characteristics, originating from differences in production history, is limited. Therefore the objectives of this study were to: 1) evaluate specific beef flavors associated with differences in cattle production history, USDA quality grade, and method of postmortem aging and 2) relate those specific flavor characteristics with preferences of beef consumers.

2. Materials and methods

2.1. Experimental treatments and sample preparation

Beef strip loins (LL section removed from the 13th rib to the last lumbar vertebra; IMPS #180; NAMP, 2010), representing 12 different product categories (treatments) were purchased for use in the study. Experimental treatments (Table 1) were chosen specifically to permit identification and characterization of beef flavor differences associated with the effects of USDA quality grade (Prime, Premium Choice — defined as the upper 2/3 of USDA Choice, Low Choice — defined as the lower 1/3 of USDA Choice, or Select), cattle breed-type (Angus, Holstein, or American Wagyu), finishing diet (finished exclusively on forages, finished on corn-based grain diets, or finished on barley-based grain diet), use of growth technologies (none, implants only, or implants plus β-

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Table 1
Description of experimental treatments.

Treatment	Production system	USDA grade (marbling degree)	Breed-type	Finishing diet (days on grain)	Growth technologies	Postmortem aging method
T1s	Conventionally raised	Premium Choice (≥modest^{00})	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 14 d
T2	Conventionally raised	Low Choice (small)	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 14 d
T3	Conventionally raised	Select (slight)	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 14 d
T4	Conventionally raised	Low Choice (small)	Calf-fed Holstein	Corn-based (>200 d)	Implants only	Wet aged 14 d
T5	Maximized growth	Low Choice (small)	Angus (≥51% black)	Corn-based (>100 d)	Implants & β agonists	Wet aged 14 d
T6	Maximized growth	Low Choice (small)	Angus (≥51% black)	Barley-based (>100 d)	Implants & β agonists	Wet aged 14 d
T7	Conventionally raised	Premium Choice (≥modest^{00})	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 46 d
T8	Conventionally raised	Premium Choice (≥modest^{00})	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 17 d, dry aged 30 d
T9	Conventionally raised	Prime (≥slightly abundant^{00})	Angus (≥51% black)	Corn-based (>100 d)	Implants only	Wet aged 17 d, dry aged 30 d
T10	Naturally raised	Prime (≥slightly abundant^{00})	≥50% Wagyu	Corn-based (>100 d)	None	Wet aged 16 d, dry aged 30 d
T11	Naturally raised	Low Choice (small)	Angus (≥51% black)	Corn-based (>100 d)	None	Wet aged 14 d
T12	Grass-fed, organic	Select (slight)	Angus (≥51% black)	Forages only (no grain)	None	Wet aged 14 d

adrenergic agonists), and postmortem aging method (wet-aged or dry-aged). Product specifications for each product listed in Table 1 were verified by Colorado State University (CSU) personnel using official USDA grades, acceptance into USDA certified programs (when applicable), and personal communication with individual suppliers to verify origin and cattle production practices.

Strip loins (one/animal) representing treatments 1 through 7 (9 loins/treatment) were selected at a commercial beef processing plant in Northern Colorado and transported, under refrigeration (2 °C), to the CSU Meat Laboratory where they were vacuum packaged and wet-aged (i.e., stored in vacuum packages in the absence of light at 2 to 4 °C) for the specified aging period (Table 1). Samples were checked daily throughout the wet-aging period to ensure that vacuum seals were maintained on all packages. Strip loins representing treatments 8 through 11 (9 loins/treatment) and treatment 12 (12 loins) were purchased from commercial meat purveyors. Strip loins from T10 (Table 1) were produced by Wagyu crossbred (50% Wagyu, 50% Angus) cattle. Dry-aged strip loins (treatments 8, 9, and 10) were aged (without protective packaging) at a commercial dry-aging facility at 1 to 2 °C and approximately 77% relative humidity for 30 d following an initial wet-aging period of 16 or 17 d. These dry-aging parameters are similar to those commonly used by U.S. meat purveyors for production of dry-aged product for upscale restaurants (Savell, 2008). Strip loins representing T11 and T12 (Table 1) were wet-aged for 14 d at the CSU Meat Laboratory using procedures described previously for other wet-aged samples. Strip loins representing T12 were certified USDA Organic and strip loins representing T11 were USDA-verified as Naturally Raised.

Following postmortem aging, each strip loin was trimmed, removing all exterior fat and connective tissue. Within each treatment, 3 batches were created by randomly assigning an equal number of trimmed strip loins to each batch (3 loins/batch for treatments 1 through 11; 4 loins/batch for treatment 12). Each batch of beef was ground using a meat grinder (Model 84186, Hobart, Troy, OH) equipped with a coarse (1 cm) grinding plate. Following grinding, batches were mixed for 120 s in a twin-shaft paddle mixer (Keebler Engineering Co., Chicago, IL). After mixing, each batch was ground a second time using the same grinder equipped with a fine (4 mm) grinding plate.

It is well documented that differences in one sensory property, such as tenderness or texture, will often influence a panelist's perception of other traits; termed the halo-effect (Meilgaard, Civille, & Carr, 2007). Beef samples were ground as described to create as uniform a sample across all treatments as possible. This grinding eliminated inherent variation in tenderness and texture among treatments, allowing consumers to be presented with samples that would be consistent for these traits, regardless of treatment. Reducing these non-flavor related differences among treatments allowed for panelists to more accurately evaluate the flavor profile of samples without interference of textural differences.

Each batch of ground beef was stuffed into cellulose casings (6.4 cm in diameter) using a vacuum stuffer (Model VF50, Handtmann, Germany). Filled casings were placed in a freezer (−20 °C) and stored overnight (approximately 18 h) before portioning into patties. After freezing, casings were removed from the samples and a band saw (Model 400, AEW-Thurne, AEW Engineering Co., Ltd., Norwich, UK) was used to cut the samples into patties (1.9 cm thick and 6.4 cm in diameter). A set of 3 patties (consisting of 1 patty from the beginning, 1 patty from the middle, and 1 patty from the end of each processed batch) was obtained from each batch to be used for each objective analysis. Remaining patties from each batch were assigned randomly to predetermined cooking groups, vacuum packaged, and placed in frozen storage (−20 °C).

2.2. Consumer sensory analysis

The Colorado State University Institutional Review Board approved procedures for use of human subjects for sensory panel evaluations. Consumer sensory analysis was conducted at 3 culinary schools located in the states of New York, Colorado, and California. Untrained consumer panelists (N = 307) consisted of culinary students and professionals trained in the culinary arts. Each panel session (4/school) included 24 to 26 panelists and lasted approximately 1 h. Individual panelists were supplied with a ballot, plastic eating utensils, a napkin, an expectorant cup, a cup of tap water, and unsalted crackers to serve as a palate cleanser. Verbal instructions outlining procedures for the tasting session were discussed immediately before each panel session. During this discussion, panelists were instructed to focus their evaluations primarily on the flavor attributes of each sample and to disregard between-sample differences in juiciness and texture when assigning flavor ratings. Each participant filled out a brief demographic questionnaire before the tasting session began.

Samples were thawed at 2 to 4 °C for 24 h before sensory evaluation. All samples were cooked over open gas burners on griddle pans with a non-stick coating. Pans were allowed to heat to 246 °C prior to sample cooking. Samples were turned once, half-way through cooking, and were cooked to an internal temperature of 74 °C monitored by a Type K Thermocouple Thermometer (AccuTuff 340, model 34040, Cooper-Atkins Corporation, Middlefield, CT). Following cooking, sample patties were halved into 2 equally sized pieces, resulting in 26 servings, and immediately served to panelists.

Panelists received 1 sample from each of the 12 treatments served in random order. All consumers within a single session received samples in the same order to prevent any flavor cross-over among treatments during cooking and to facilitate the flight-based system used during serving. Each sample was identified with a random 3-digit numeric code. Panelists evaluated each sample for flavor desirability and the intensity of 12 different flavors described as: beefy/brothy, browned/grilled, buttery/beef fat, bloody/metallic, grassy/hay like, gamey, nutty/roasted nut, livery, fishy, sour/acidic, sweet, and bitter (Table 2). Each sensory attribute was rated on a 10-cm, unstructured line scale with 0 cm verbally anchored at very low intensity for all flavors and dislike