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Abstract

Nutritional concerns have impacted the protein market, decreasing red meat consumption as well as prompting the advent of lean and extra lean ground beef. However, such lean blends of ground beef may suffer in palatability. This study seeks to bridge the gap between perceived health and palatability. Participants were asked to identify the relative importance of characteristics commonly used in purchasing ground beef and select a preferred package of ground beef from labeled and unlabeled sections consisting of 4%, 10%, 20%, and 27% fat content. Instrumental color data and their main drivers were also collected. Participants then completed a blind taste sampling of ground beef with variable fat contents as previously described. Color, fat, and price were found to be significantly more important ($P < 0.05$) than label, which was significantly more important than company for package preference. No trend towards fatter or leaner blends was found between labeled and unlabeled selections, with 62.64% of participants selecting identical packages between the two sections. Instrumental color data found significant trends in lightness and oxymyoglobin ratio, the proportion of pigment that is bright cherry red, that may be used to identify leaner product without a label. No significant differences were found between the blends for any trait in sensory taste evaluation. These results suggest that while consumers have specific preferences when purchasing ground beef that can be replicated without a label using visual inspection alone, they are less discerning between cooked ground beef of different fat contents. This may explain the continued demand for lean ground beef.

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Meet the Student-Author

Fred Pohlman II

I am from Prairie Grove, Arkansas and graduated with honors from Prairie Grove High School in 2013. I graduated from the University of Arkansas in May 2017 with dual honors degrees in Animal Science in the Dale Bumpers College of Agricultural, Food and Life Sciences, summa cum laude, and Biochemistry in the J. William Fulbright College of Arts and Sciences, summa cum laude. I also graduated with Senior of Significance, Razorback Classic, and Phi Beta Kappa distinction.

I was a Sturgis Fellow at the University of Arkansas and was active with the Bumpers College Honors Student Board, Alpha Epsilon Delta Premedical Society, Global Medical Brigades, and the Honors College Service Committee. I studied abroad in Ghana during the summer of 2014, India the summer of 2015, and South Africa the summer of 2017. I will pursue a dual MD/MPH at Duke School of Medicine and the University of North Carolina.

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Introduction

Food has become a topic of intense interest and concern for many consumers, especially those of the millennial generation. This newfound focus on food has many motivations—food sourcing, its production method and the use or lack of technology, perceived health benefits, nutrition, and others can influence consumer preferences through an almost endless combination of these factors. Many consumers are willing to pay significantly more for preferred food that meets all or most of their valued characteristics, evidenced by the rise of luxury and specialty grocery stores and products that fulfill this demand (Batte et al., 2007).

Nutrition and the impact of food on health has become a foremost concern for many consumers, leading to a change in consumption patterns that has affected the food and agriculture industries. Meat consumption trends provide some insight into how growing nutritional concerns and awareness are altering diets. Meats that are considered lean, such as poultry, have seen an increase in consumption over the past decades, while meats associated with higher fat contents have experienced a simultaneous decrease in consumption. Using per capita disappearance of boneless retail weight as a proxy for consumption, United States Department of Agriculture (USDA) data show that from 1975 to 2015, total poultry consumption increased from 33.4 to 75.6 lbs while beef consumption decreased from 83.2 to 51.5 lbs per capita in the U.S. (USDA-ERS, 2017). Similar changes can be seen on a global scale, with data from the Food and Agricultural Organization of the United Nations (FAO) reporting a 7.7% drop in bovine meat consumption and a 76.6% increase in poultry consumption from 1990 to 2009 (Henchion et al., 2014). These changes in protein consumption are not the result of nutritional outlook by consumers alone—price, availability, and convenience have also contributed—but consumer preference in protein has undoubtedly been influenced by health concerns.

Fat and cholesterol have been topics of particular importance regarding the nutrition of protein sources. Consumption of fat, saturated fat, and dietary cholesterol has been a concern since the 1950s when the American Heart Association first issued recommendations that intake should be limited to help reduce the risk of cardiovascular disease (Daniel et al., 2010). The *Dietary Guidelines for Americans* from the USDA and Department of Health and Human Services (HHS) have routinely recommended limited fat, saturated fat, and dietary cholesterol consumption since the inception of the program in 1980 due to concerns of obesity and chronic disease and have also included language recommending consumption of lean meats (HHS, n.d.). These public health concerns and nutritional recommendations resulted in an increased demand for lean-

er protein products. Consumer concerns resulted in the development of leaner protein by the food industry, accomplished through greater trimming of visible fat at the retail level and changes in production, as well as some substitution of red meat for poultry by consumers (Daniel et al., 2010; Scollan et al., 2006). It is noteworthy that the proportion of total fat and especially saturated fat in the American food supply provided by animal protein has slowly decreased even as overall meat consumption has increased, providing some evidence of success in changing practices by the food industry (Daniel et al., 2010). Low-fat/high-carbohydrate diets have not proven successful in reducing incidences of chronic disease, however, and a growing body of evidence suggests that the relationship between dietary and plasma lipids is more nuanced and complicated than previously believed and is reflected in the most recent *Dietary Guidelines for Americans* (Daniel et al., 2010; HHS, n.d.; Mozaffarian and Ludwig, 2015). The "War on Fat" thus greatly impacted the protein market as it responded to public health concerns and consumer demand, changing the relative trajectories of red and white meat consumption as well as pushing the food industry to provide leaner products.

The consumer demand for leaner protein has had noticeable impacts on the beef industry. Improved genetic selection and use of technology such as β-adrenergic agonists as well as other changes in production practices have allowed farmers to produce leaner beef to meet consumer demand (Johnson et al., 2014). For a completely trimmed sirloin steak, total fat content declined 34% from 1963 to 2010 and saturated fat content declined 17% from 1990 to 2010 (Cattleman's Beef Board and National Cattlemen's Beef Association, 2012); USDA-ARS, 1963, 1990, and 2010). Ground beef remains the most popular beef product due largely to its price and versatility in preparation, however, accounting for 63% of foodservice beef sales and 49% of retail beef sales by volume (Speer et al., 2015). This is convenient for the food industry since the fat content of ground beef can be easily reformulated to meet consumer needs. The consumer demand for leaner protein products has led to the advent of "Lean" and "Extra-Lean" ground beef labels, with fat content options dipping to as low as 4%, significantly leaner than the 30% legal limit established by the Food Safety and Inspection Service of the USDA (U.S. National Archives and Records Administration, 2014). Through improved production practices as well as changes in product processing, the beef industry has been able to respond to market demand for leaner products.

Producing leaner ground beef in order to compete with leaner proteins may have some drawbacks in terms of overall palatability, as fat is a driving factor in many quality characteristics in meat. Both trained and consumer panels have consistently found that increased fat content is associated with increased tenderness and juiciness and decreased fat content can substantially decrease palatability, flavor intensity, juiciness, and tenderness, with peak overall acceptability occurring at 20% fat (Cross et al., 1980; Huffman et al., 1991). Low fat blends can also develop a brittle texture upon cooking or become bland with a hard, rubbery texture (Brewer, 2012). Cooking to higher temperatures can exacerbate the quality differences between leaner and fatter ground beef blends as well, resulting in greater moisture loss and producing a drier cooked product (Keeton, 1994; Troutt et al., 1992). Lean products thus require more care during preparation to maximize potential palatability, which evidence suggests is consistently below that of fatter blends, in order to be an acceptable product for consumers from a taste standpoint—meaning fatter ground beef blends are more robust to preparation error and can yield acceptable cooked product under less ideal conditions. Knowing that consumer behavior is actively influenced by informational framing on labels, it is reasonable to conclude that the health trends and concerns about dietary fat intake drove the demand for leaner beef despite apparent losses in palatability—products with label claims of "lean" or "extra lean" are more acceptable to consumers in the grocery store, but are less acceptable on the plate (Levin, 1987; Levin and Geath, 1988). Consumer error in preparation of lean ground beef blends or preference of more well done beef can result in a product that, though initially attractive due to its lower fat content and perceived improvement in nutritional benefit, is unsatisfying or unacceptable.

Regardless of the fat content, ground beef is a nutrient-dense foodstuff. For less than 10% of the daily recommended caloric intake, 85 g (3 oz.) of lean beef can provide more than 10% of ten essential nutrients, vitamins, and minerals. Beef is an excellent source (>20% recommended daily value) of protein, selenium, zinc, vitamins B-6 and B-12, and niacin as well as a good source (>10% recommended daily value) of phosphorus, choline, iron and riboflavin (Cattleman's Beef Board and National Cattlemen's Beef Association, 2012; Institute of Medicine, 2006; USDA-ARS, 2011). Though routinely vilified for its saturated fat content, 85 g (3 oz.) of cooked beef actually has a fatty acid profile with a majority of heart-healthy unsaturated fatty acids (50.3% monounsaturated, 4.1% polyunsaturated) and 45.6% saturated fatty acids (USDA-ARS, 2007). Of the top 5 sources of monounsaturated fatty acids in children in the United States, beef is the only nutrient-dense food (Keast et al., 2013). Despite old concerns, new evidence is also beginning to show that at least unprocessed red meat is not significantly associated with increased risk of cardiovascular disease, stroke, or diabetes mellitus (McAfee et al., 2010; Micha, et al., 2010). As a nutrient powerhouse, beef has a place in a healthy diet and can deliver essential nutrients in a flavorful product.

Growing interest in food, including its nutritional value, as a determinant of overall well-being coupled with a hold-over nutritional orthodoxy that vilified fat has resulted in the advent of leaner protein products, including "lean" and "extra lean" ground beef. However, decreased fat content can potentially lead to a drier, less flavorful product, especially if cooked incorrectly by the consumer, thus making leaner beef less palatable. This potential discrepancy between perceived healthy and palatable beef choices can result in consumer dissatisfaction and decreased beef consumption, resulting in the dietary loss of all the nutrients that beef provides. By evaluating the difference in fat content and color characteristics of ground beef preferred by consumers uninfluenced by labels versus label-following, health-conscious consumers and comparing those results to the fat content of ideal palatability, it may be possible to bridge this gap in consumer preferences in the store and on the plate. This bridging of the healthy-or-palatable gap in protein options has immense possibilities in aiding the effort to curb obesity as well as in encouraging proper nutrition in Arkansas as well as nationally and internationally. A healthy product that is not palatable, and therefore not consumed, has no nutritional benefit in the diet. Thus this project attempts to identify an optimal ground beef composition that marries consumer palatability preferences with desired nutritional benefits.

Materials and Methods

Participants were recruited from the University of Arkansas main campus in Fayetteville, Arkansas to represent a sample of the college-aged millennial generation through mature consumers. Data collection was conducted on four days, 23–25 January 2017 and 14 February 2017. After consenting, participants were asked to complete two phases of the study: a display portion followed by a sensory taste sampling portion. A total of 91 participants completed the display portion of the study, and 88 participated in the sensory taste sampling portion—personal preference and religious beliefs regarding meat/beef consumption prevented three participants from completing the taste sampling portion. All product was purchased from a local grocery store to reflect ground beef blends commonly encountered by average consumers as well as the overall appearance, including grind coarseness, of typical ground beef readily available to consumers.

Display

Using simulated retail display cases with ground beef selections ranging from 4–27% fat, participants were asked as prospective consumers to select ground beef as they would for a typical family dinner. Packages were evaluated under conditions designed to simulate typical retail conditions, with a simulated display case as well as simulated retail lighting (deluxe warm white fluorescent lighting, 1620 lux). Participants selected two products, one from a selection of labeled products and one from a selection of unlabeled products. Both labeled and unlabeled sections contained three one-pound packages each of 4%, 10%, 20%, and 27% fat that were randomly placed in a 4 × 3 grid (Fig. 1). The two sections were grouped at opposite ends of a simulated retail case to allow independent selection. Both labeled and unlabeled selections contained a label with a product number in the upper left hand corner. Labeled product also contained a label in the upper right hand corner detailing percentage lean and percentage fat centered at the top of the label as well as weight and price at the bottom of the label. All packages were 0.45 kg (1 lb) and the price for each package was set at $3.98 to prevent selection based on price alone. Product was purchased as two-pound packages from the grocery store and partitioned into two one-pound portions, repackaged, and labeled each morning. Product was repackaged into 21.96 × 14.61 × 1.27 cm white polystyrene foam trays (Cryovac Food Packaging and Food Solutions, Duncan, S.C.) and wrapped with poly-vinyl chloride film (14,000 cc/mm^2/24 h/1 atm; Koch Supplies, Inc., Kansas City, Missouri, USA).

Fig. 1. Example of simulated retail display portion set up with randomly placed product in labeled and unlabeled sections at opposite ends of a display case.

Demographic data were collected and participants were asked about the relative importance of five traits in their purchasing decision as well as their view on the health impact of beef and the price differential for ideal ground beef. Participants were asked to report their age and gender. They were asked to identify how often they purchased ground beef from five options of Never, Once per month, Once per week, Twice per week, and >3 times per week. Participant views on the health impact of ground beef was determined by asking them to complete the phrase "Lean ground beef is…" from three answer choices of healthy for you, not healthy for you, has no impact on health. Willingness to pay for ideal ground beef was determined by asking participants how much more per pound they would be willing to pay for their ideal ground beef preference. Finally, the importance of common considerations when purchasing ground beef was determined by asking participants to mark a 15-cm line scale ranging from Not Important to Very Important for Color, Label, Fat Content, Company, and Price.

Fat content of preferred selections was recorded. Color characteristics were measured using a HunterLab MiniScan XE Spectrocolorimeter, Model 4500L and were evaluated using illuminant A, 10° observer for meat color values: CIE (L^*, a^*, and b^*) (L^*: 0 = black, 100 = white; a^*: +60 = red, -60 = green: b^*: +60 = yellow, -60 = blue). A reflectance ratio of 630/580 nm was used to approximate the proportion of oxymyoglobin (red form) of the myoglobin pigment in the samples. From these data, hue angle (shift from red to yellow) can be calculated $[\tan^{-1}(b^*/a^*)]$ as can chroma or saturation index (brightness/vividness of color) $[(a^{*2} + b^{*2})^{0.5}]$ (Baublits et al., 2005; Jimenez-Villarreal et al., 2003; Stivarius et al., 2003). The impact of label and visual appraisal on consumer preference was determined and analyzed for statistical significance using the Mixed Model Procedure of Statistical Analyses System software, v. 9.4 (SAS Institute, Inc., Cary, N.C.).

Taste Sampling

Participants were asked to evaluate samples of cooked ground beef patties with identical fat composition to blends in the display portion (4%, 10%, 20%, and 27% fat). Participants were blind to the composition of samples, and samples were presented in a complete block design in which each panelist received all treatments. Sample order was random for each participant, and presented samples were accompanied with a three-digit code later used for identifying sample composition. Patties were cooked using a gas griddle to an internal temperature of 71 °C as measured by a meat thermometer. Edges were trimmed from the cooked patties, then sectioned into 2.54 × 2.54 cm squares. Samples were kept covered and at serving temperature (60 °C) in a food warmer. Participants were asked to evaluate samples on five characteristics using a 15-cm line scale: Juiciness (Extremely Dry–Extremely Juicy), Bind (Extremely Fragile–Extreme Bind), Beef Flavor (Extremely Non-Beef Like–Extremely Beef Like), Off Flavor (Extreme Off Flavor–No Off Flavor), Overall Impression (Extremely Dislike–Extremely Like).

Samples were presented one at a time, and participants were instructed to cleanse their palate with a bite of unsalted cracker and a sip of water before tasting each sample. Sampling was conducted with no contact between participants in individual booths and under low pressure sodium color neutralizing light (48 W, 120 V; Trimblehouse lighting, Norcross, Georgia, USA) to avoid visual bias. Data

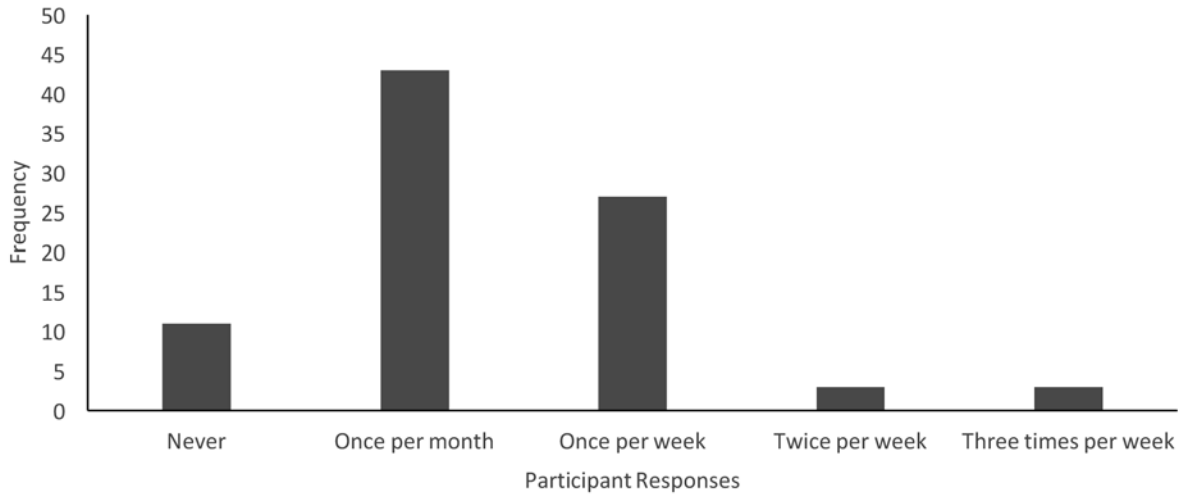

Fig. 2. Frequency of responses for lean ground beef purchasing behavior (n = 91).

were analyzed using the Mixed Model Procedure of Statistical Analyses System software, v. 9.4 (SAS Instutute, Inc., Cary, N.C.).

Results and Discussion

Results

The participant group was 65% female and 35% male with a mean age of 26 ± 11.5 years. The majority of participants (81%) believed that lean ground beef was healthy while 5% and 14% believed that lean ground beef was not healthy or has no impact on health, respectively. Frequency of ground beef purchase varied among participants: 49% reported purchasing ground beef once per month, 31% reported purchasing it once per week, 13% reported never purchasing it, and 3% reporting purchasing it either twice per week or three times per week (Fig. 2). The mean reported willingness to pay for ideal ground beef preference among participants was 2.61 ± 1.76 dollars.

Significant differences were found in the reported importance of common characteristics in ground beef selection. Least squares means for the length of the line (0 = Not Important, 15 = Very Important) along with standard errors for each characteristic are reported in Fig. 3. Company and label were significantly less important than price, fat, and color. Color was significantly more important than price and was not significantly greater ($P = 0.1878$) than fat content of ground beef.

The distribution of preferred fat content in ground beef package selection for labeled and unlabeled product is presented in Fig. 4. The 4% and 20% fat blends showed increases in the proportion of selected packages from labeled to unlabeled section (1.11% and 7.78% increases, respectively). The 10% and 27% fat blends showed decreases in the proportion of selected packages from labeled to unlabeled section (3.33% and 5.55% decreases, respectively). Interestingly, 62.64% of participants selected identical fat blends between labeled and unlabeled sections. However, 17.58% of participants selected a fatter blend in the unlabeled section compared to the corresponding selection in the labeled section while 19.78% selected a leaner blend. The preferred fat content, whether labeled or unlabeled, was 20%.

The L^* values in instrumental color data trended upward significantly with increasing fat content, corresponding to an increase in lightness of the ground beef with increasing fat proportion (Table 1). Values for a^* exhibited significant differences between the two leaner blends and each of the fatter blends, corresponding to differences in red-green values among samples. The highest fat content (27%), as might be expected, was less red in color than leaner ground beef treatments. Measurements for b^* value showed significant differences among treatments, corresponding to differences in yellow-blue values among samples. Chroma determinations yielded significant differences among blends, with 27% being less vivid in color than the three leaner blends. Determination of hue angle resulted in significant differences among treatments, with the 4% blend having a significantly lower hue value (hue angle) corresponding to a more red shift in instrumental color value. Determination of the oxymyoglobin proportion followed the trend in fat content, with leaner ground beef having higher estimates of oxymyoglobin and oxymyoglobin content decreasing as fat content increased.

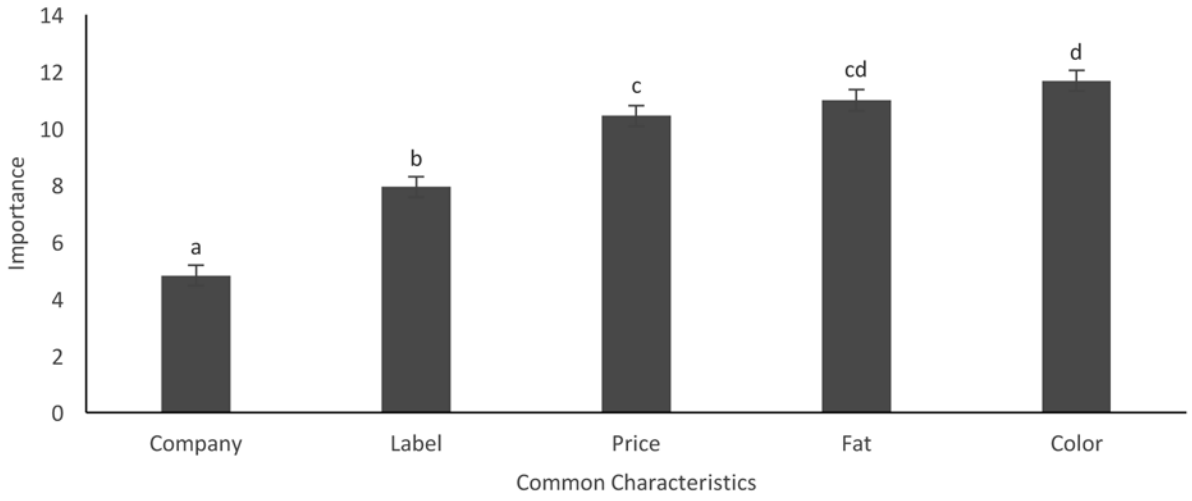

Fig. 3. Frequency of responses for lean ground beef purchasing behavior.
[a-d] Least squares means of columns with different superscripts differ ($P < 0.05$)
Characteristics scored on a 15-cm line scale (0 = Not Important, 15 = Very Important).

Results from the consumer taste panel are summarized in Table 2. The *P*-value for day as a covariant was above 0.05 for each trait. No trait showed statistically significant differences among treatments at the 95% confidence level, however the scores for the 20% blend were nearly significantly higher for off-flavor (less off flavor) and overall impression (*P*-values of 0.0681 and 0.0867, respectively).

Discussion

Participant responses about the healthiness of lean beef, with the majority agreeing that lean beef is healthy, initially seems to stand in contrast to prevailing trends of decreased red meat consumption due to nutritional concerns. The results of this question may be a reflection of recommendations to consume leaner meats, however, and helps explain the growing demand for lean ground beef. Comparisons of consumers' beliefs about the relative healthiness of lean and fatter ground beef cannot be made from the data collected, but this additional question could help further explore beliefs driving ground beef preferences. The belief among the majority of participants that lean ground beef is healthy is still an encouraging statistic to a market that has witnessed decreased consumption.

The frequency of ground beef purchase appears to be low, with nearly half of participants reporting purchasing ground beef only once per month. The next largest proportion of participants indicated purchasing ground beef once per week (31%), but the third most frequent response

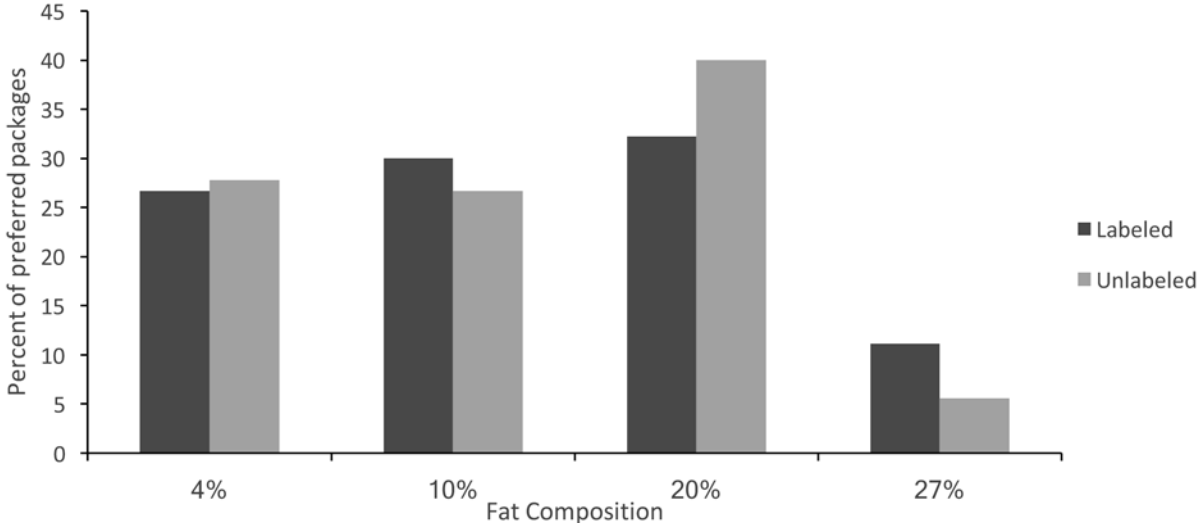

Fig. 4. Proportion of preferred product selected from labeled and unlabeled sections in a simulated retail display case.

Table 1. Impact of ground beef fat content on least squares means for instrumental color characteristics.

Treatment	$L^{*\dagger}$	$a^{*\ddagger}$	$b^{*\S}$	Chroma[¶]	Hue[#]	Oxymyoglobin Ratio[††]
4%	41.7846[a]	33.2925[b]	25.7746[a]	42.1050[b]	37.7437[a]	7.1946[d]
10%	47.2254[b]	32.9121[b]	26.9733[c]	42.5546[bc]	39.3329[c]	5.9375[c]
20%	50.3600[c]	33.7975[c]	26.4667[b]	42.9288[c]	38.0612[b]	5.6667[b]
27%	51.9908[d]	31.6517[a]	26.0325[a]	40.9821[a]	39.4379[c]	4.9846[a]

[abcd] Least squares means within a column bearing different superscripts differ ($P < 0.05$).
[†] L^*: 0=black, 100=white.
[‡] a^*: +60=red, -60=green.
[§] b^*: +60=yellow, -60=blue.
[¶] Calculated as $(a^{*2} + b^{*2})^{0.5}$
[#] Calculated as $\tan^{-1}(b^*/a^*)$.
[††] Calculated as 630 nm/580 nm.

(13%) indicated never purchasing ground beef. This distribution appears to agree more with trends of decreased red meat consumption (USDA-ERS, 2017). Purchasing frequency may not completely align with consumption, however, with bulk purchasing opportunities limiting visits to grocery stores. Additionally, comparison to purchasing and consumption habits of whole muscle beef cuts as well as other protein sources cannot be made from these data so it is difficult to evaluate the overall popularity of ground beef among consumers. Questions regarding ground beef consumption as well as other protein purchase frequency and consumption could help further elucidate the standing of ground beef in consumer protein preferences.

Participants indicated that color, fat, and price were most important when purchasing ground beef, and were significantly different from the importance of label and company. Among the three most important traits, color was significantly more important than price, indicating the importance of visual appraisal by consumers when purchasing ground beef. The quality of any fresh food, including fresh protein and produce, has visual indicators, and though price is important, consumers seem to be willing to pay more for a product they believe is higher quality as determined by visual inspection. Fat was the characteristic with the second highest least squares mean for importance, but it was not significantly less important than color or more important than price. It is not surprising that label and company were less important to participants than traits that indicated quality (color), nutrition (fat), and economics (price). The significant difference in the importance of label over company is nonetheless interesting given that commercial ground beef labels are frequently color coded to correspond with fat content. This study utilized identical white labels for consistency, but label color may play a subtle role in ground beef purchasing preferences.

Results of ground beef product selection indicate an overall preference for leaner blends of ground beef. Though the 20% fat blend exhibited the highest frequency of selection in both labeled and unlabeled groups, collectively the leaner two blends garnered a higher proportion of the preferred product selections than the two fatter blends (56.67% vs. 43.33%). Participants least preferred the 27% fat blend by a large margin in both labeled and unlabeled sections. This agrees with prevailing trends towards leaner protein sources (Daniel et al., 2010). There was no clear trend in change of frequency distribution towards fatter or leaner blends from labeled to unlabeled selection, however, with the majority of participants selecting the identical blend between sections. This indicates that consumers can evaluate ground beef packages reasonably well based upon visual appraisal alone. Previous history with the color characteristics of preferred ground beef may be informing participant choices without a label to help guide selection. The self-reported importance of color to consumers when purchasing ground beef may help explain participant success in replicating preferred package selection.

Instrumental color data revealed significant differences between fat blends for each measurement; however, only two measurements exhibited a trend that could potentially be used by participants in informing preference selections without a label. The L^* measurements increased as fat content increased, corresponding to the lightness of the ground beef. Increasing proportions of white fat in ground beef can logically be expected to increase the lightness of the product, and lightness is a simple visual indicator to evaluate (lighter samples tend to be higher in fat than darker samples). The decreasing oxymyoglobin ratio with increasing fat content provides another trend that may be useful in visually determining fat content without a label. Myoglobin is found in muscle, and

Table 2. Impact of ground beef fat content on least squares means for consumer panel sensory taste panel traits.

Trait	4%	10%	20%	27%	*P*-value
Juiciness[†]	6.19	6.12	6.48	6.28	0.9171
Bind[‡]	8.95	8.99	8.14	8.87	0.2435
Beef Flavor[§]	8.99	8.48	9.12	8.55	0.5311
Off Flavor[¶]	9.12	8.77	10.28	9.14	0.0681
Overall Impression[#]	8.07	7.23	8.57	7.91	0.0867

[†] Juiciness: 0=Extremely Dry, 15 = Extremely Juicy.
[‡] Bind: 0=Extremely Fragile, 15 = Extremely Bind.
[§] Beef Flavor: 0=Extremely Non-Beef Like Flavor, 15 = No Non-Beef Like Flavor.
[¶] Off Flavor: 0=Extreme Off Flavor, 15 = No Off Flavor.
[#] Overall Impression: 0=Extremely Dislike, 15 = Extremely Like.

decreasing the proportion of muscle by increasing fat content within a blend can be expected to decrease the overall myoglobin content of a sample. Under similar conditions among all samples, the ratio of oxymyoglobin, the oxygenated form of the myoglobin pigment, can be expected to similarly decrease with increasing fat content. Oxymyoglobin is bright cherry red, and decreasing redness with increasing fat content is easy to detect visually. The oxymyoglobin ratio then becomes a proxy for muscle content in a blend and its corresponding visual characteristics can be used to determine fat content visually.

A lack of statistically significant differences between samples in the tasting component of this study was surprising. These data indicate that consumers are less discerning of differences in palatability between various fat blends once cooked. Overall impression values peaked at 20% fat, agreeing with the literature, but a higher score for 4% fat disagrees with the consensus that acceptability decreases with decreasing fat content past 20% (Huffman et al., 1991). This may be the result of consumers' expectations of ground beef taste and texture changing as leaner ground beef is consumed more frequently. Therefore, general consumers of ground beef may have come to expect the eating experience of leaner blends as normal. Given that juiciness scores were similar among ground beef fat blend treatments, it may have been possible that cooking may have rendered more fat out of the higher fat treatments. Further, since patties in this study were cooked to a constant internal temperature as determined by a meat thermometer, the impact of cooking abuse on ground beef was not determined. Therefore, it may be possible that at higher degrees of doneness such as cooking abuse, higher fat contents may provide a buffer against cooking abuse. A lack of significant difference in individual traits or with overall impression points to consumers that are less discerning in differences in palatability between various fat blends. If consumers are satisfied with the eating experience of leaner ground beef, the decreased fat and energy consumption associated with leaner beef may prove to be attractive for many consumers.

Conclusions

Concerns about the nutritional value of food has driven demand for lean protein in the past few decades, resulting in the advent of lean and extra lean ground beef. The belief by consumers that lean ground beef is healthy may be tied to this nutritional orthodoxy that pushed for leaner foods. Despite overwhelming responses by participants indicating that lean ground beef is healthy, however, purchasing frequency of ground beef is low. Numerous factors may explain this discrepancy, and the relationship of ground beef consumption and purchasing frequency to whole muscle cuts and other proteins need to be further explored. Further, ground beef purchase activity may also be influenced by the number of meals prepared at home versus consumed outside the home.

When purchasing ground beef, participants place significant importance on color, fat, and price over label and company. These three important traits are tied to quality, perceived nutrition, and the economics of a product, respectively. It was hypothesized that concerns over nutrition drove preferences of lean ground beef and without labels consumers would select lean blends less frequently. However, the majority of participants were able to replicate preferred ground beef selection between labeled and unlabeled sections. This indicates a high level of visual appraisal by consumers aware of their preferences. When unlabeled, panels preferred 20% fat content 40% of the time. Trends in instrumental color data measurements suggest that either lightness or redness associated with oxymyoglobin content may play a role in this visual appraisal. Consumers have clear priorities when purchasing ground beef and can for the most part replicate decisions without a label.

Discerning differences between cooked ground beef samples of different fat blends, however, was more challenging for participants. No trait evaluated in the tasting portion of this study was significantly different among the various fat blends. This suggests that consumers are less able to differentiate the palatability of different fat blends once they are cooked.

Though consumers have priorities when purchasing ground beef that allow consistent selection of preferred fat content, they do not appear to be able to significantly differentiate among cooked product of different fat blends. Concerns about leaner beef being less palatable and turning away consumers, resulting in a loss of the nutrients all beef provides, may thus be exaggerated. If consumers are more comfortable purchasing leaner blends of ground beef and do not experience a significant decrease in palatability, they may continue to purchase the product. This may help explain the continued viability of lean ground beef and the development of extra lean blends.

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