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Consumer preferences for beef with improved nutrient profile[1]

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Abstract

Although beef is a nutrient-rich foodstuff excelling in protein, vitamins, and minerals, there is controversy regarding the fat content of beef and its healthfulness in the diet. Although much of the fatty acid (**FA**) content in beef is considered "healthy fats," many consumers are confused about the different classifications of FA. The objectives of this study were to determine consumers' knowledge about the nutritional value of beef and its importance in purchasing decisions, and to gain a better understanding about preferences for changes in FA composition. Objectives of the study were completed through 2 consumer studies: 1) an online survey and 2) a taste-panel auction. In the online survey, respondents were asked to choose between 2 steaks that varied in polyunsaturated and saturated FA levels, iron content, and price. Respondents were also asked to categorize "Monounsaturated Fat," "Polyunsaturated Fat," "Saturated Fat," and "Trans Fat," as either "healthy" or "unhealthy" both before and after an educational excerpt was provided. The results from the online survey indicated many consumers are unclear about the differences in beef nutritional value, specifically FA content. Initially, only 66.4%, 69.1%, 79.1%, and 79.2% of respondents correctly categorized the monounsaturated, polyunsaturated, saturated, and trans fat, respectively. However, more than 90% of respondents correctly categorized the various FAs after an educational excerpt was provided. After survey respondents better understood the healthfulness of FA in beef, they were also willing to pay a premium for a steak with improved FA composition. However, these premiums diminished when participants had to actually put forth a monetary value for a steak in the taste-panel auction. Research shows that there is variation among cattle for FA composition. This provides opportunity to identify cattle with a favorable composition and market this product to the increasing population of health-conscious consumers. Our results provide insight for beef promotion and marketing opportunities and indicate that relaying information about FA content is extremely important to collect a premium for healthier beef.

Key words: beef, consumer preference, fatty acid, nutritional value, willingness to pay

Introduction

A recent beef demand study (Schroeder et al., 2013) identified 7 factors as consequential for driving beef demand. Ranked in the order of their relevance to consumers, these factors were as follows: beef price, food safety, product quality, health, nutrition, social aspects, and sustainability. Given that the industry cannot control price, the report identified food safety, product quality, nutritional value, and healthfulness as the key attributes that the industry can and should address when marketing and

promoting beef. Beef consumption helps Americans fulfill daily-recommended dietary intake of protein, by providing 20 g of protein per 100 g of beef consumed (Williams, 2007; Wyness et al., 2011), while also providing many nutrients with positive effects on human health [MUFA, PUFA such as omega-3 and conjugated linoleic acid, iron, zinc, vitamin B6, etc.; Biesalski, 2005; Zevenbergen et al., 2009; McNeill and Van Elswyk, 2012]. However, beef is also associated with characteristics that are often perceived as negative, such as high levels of SFA and high caloric content. Consumers depend on the nutrition fact label to evaluate the healthfulness of a product. Taste and sensory attributes are relatively easy for consumers to evaluate after purchase; however, health claims are much less tangible (Urala and Lähteenmäki, 2004). Consumers who are more health conscious utilize information on the nutrition label more than those who are not as health conscious in making product-buying decisions (Rimal, 2005). Nutritional considerations of a product, such as saturated fat content and effect on cholesterol, affect consumer purchasing decisions of food products (Rimal, 2005). Specifically, for meat products, Rimal (2005) concluded that consumers' perceived importance of ingredient and nutrition information on food labels influenced consumer attitudes toward such labels. This highlights the importance of ensuring consumers understand what the nutrition information means and the implied effect on human health. Thus, communicating nutrition content and the associated health benefits are essential before attempting to market products with improved nutrient content at a higher price.

Previous studies examined the willingness to pay (**WTP**) along with the acceptance or likeliness of different beef attributes from various beef chuck muscles (Kukowski et al., 2005), marbling and tenderness (Platter et al., 2013), marbling and shear force of grass-fed beef (Xue et al., 2010), and welfare (Napolitano et al., 2010). Little or no information is available on the intention to buy and willingness to pay more for products with increased nutritional value.

The objectives of this study were to gain a better understanding about consumer knowledge of healthfulness benefits for different types of fats and increased iron content and to estimate consumers' WTP for beef with improved attributes. The objectives were completed by combining an online survey that included a hypothetical choice experiment with a taste panel that included a nonhypothetical auction. These studies determined consumers' general understanding of beef nutritional value, evaluated how much consumers' knowledge of beef nutritional value improved as information was provided, and determined the importance of nutritional content of beef on consumers' purchasing decisions.

Materials and Methods

Data Collection and Statistical Analyses—Online Survey

A survey was designed in Qualtrics Survey Software and distributed to a national online panel. A sample size of 1,000 U.S. respondents was the target, and participation restrictions were imposed to ensure the sample was representative of the U.S. population for age, education, income, and sex. A total of 1,021 participants were recorded and used in the subsequent analyses. The study was approved by the Institutional Review Board at the University of Florida (IRB201703127), and consent was obtained prior to a respondent completing the survey.

The survey began with a choice experiment, asking the respondents to choose between 2 steaks that varied by 3 attributes (i.e., fatty acid [**FA**] level, iron content, and price), and each attribute had 3 levels. Fatty acid levels were as follows: average polyunsaturated fat content and average saturated fat content, 50% more polyunsaturated fat than an average steak and 10% less saturated fat than an average steak, and 100% more polyunsaturated fat than an average steak and 20% less saturated fat than an average steak; iron content levels were as follows: average iron content, 35% more iron than an average steak, and 70% more iron than an average steak; and price levels were as follows: $10/0.45 kg, $13/0.45 kg, and $16/0.45 kg. Respondents were able to choose between 2 varying steaks or select "Neither." Each one of the 3 attributes included in the choice experiment had 3 varying levels; therefore, a full factorial design would have required 27 choice sets. Including 27 questions in the choice experiment block was suboptimal because of possible survey fatigue and as a result, a fractional factorial design was implemented to decrease the number of questions. A fractional factorial design selects a particular subset of questions, so that main effects can be estimated as efficiently as possible. The fractional factorial design (*D*-efficiency of 92.82) included a total of 7 choice sets, and an example of a choice set is shown in Fig. 1.

Following the 7 choice questions, respondents were asked to categorize "Monounsaturated Fat," "Polyunsaturated Fat," "Saturated Fat," and "Trans Fat" as either "healthy" or "unhealthy." Respondents were then provided an educational figure (shown in Fig. 2) with information from the Centers for Disease Control explaining the general classification of monounsaturated, polyunsaturated, saturated, and trans fats. Respondents were required to remain on the page displaying the educational figure for 20 s before moving on. The 7 choice sets and healthy/unhealthy fat categorization questions were repeated to determine the effectiveness of the educational figure. Respondents were also asked to categorize the 4 most important and 4 least important attributes of beef (out of 12 listed), excluding price, when making a purchasing decision (shown in Fig. 3).

Descriptive statistics from the survey were calculated using SAS (SAS Inst., Inc., Cary, NC), and the questions from the choice experiment were analyzed using NLogit 5. The choice experiment responses were analyzed using a random utility model (Bunch, 1977). The utility derived by person *i* from steak option *j* was represented by:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

where V_{ij} and ε_{ij} are the deterministic and stochastic portions of utility, respectively. If faced with *J* choice options, a respondent is assumed to choose option *j* if $U_{ij} > U_{il}$ for all $j \neq l$. Assuming the ε_{ij} are independent and identically distributed as a type 1 extreme value random variable, then the probability of individual *i* choosing option *j* is as follows:

$$\text{Prob}(\text{option } j \text{ is chosen}) = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{il}}}$$

For the choice experiment analysis, the deterministic portion of the utility for option *j* for respondent *i* was estimated as follows:

$$V_{ij} = \beta_0 + \beta_1 D_j^1 + \beta_2 D_j^2 + \beta_3 D_j^3 + \beta_4 D_j^4 + \delta \text{ Price}_j$$

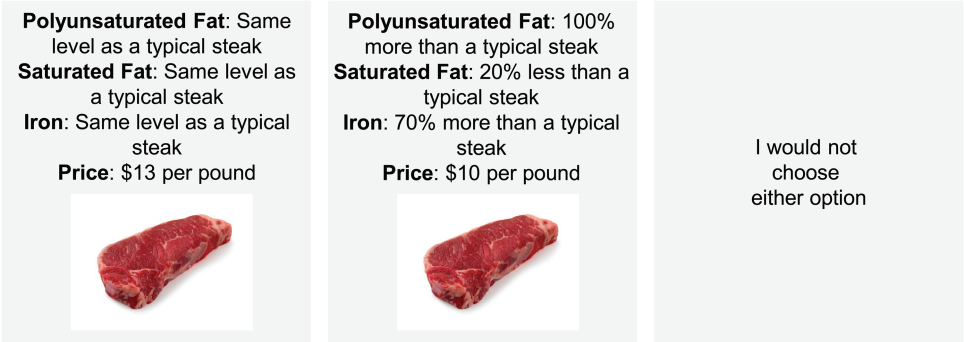

Figure 1. An example of a choice set in the online survey.

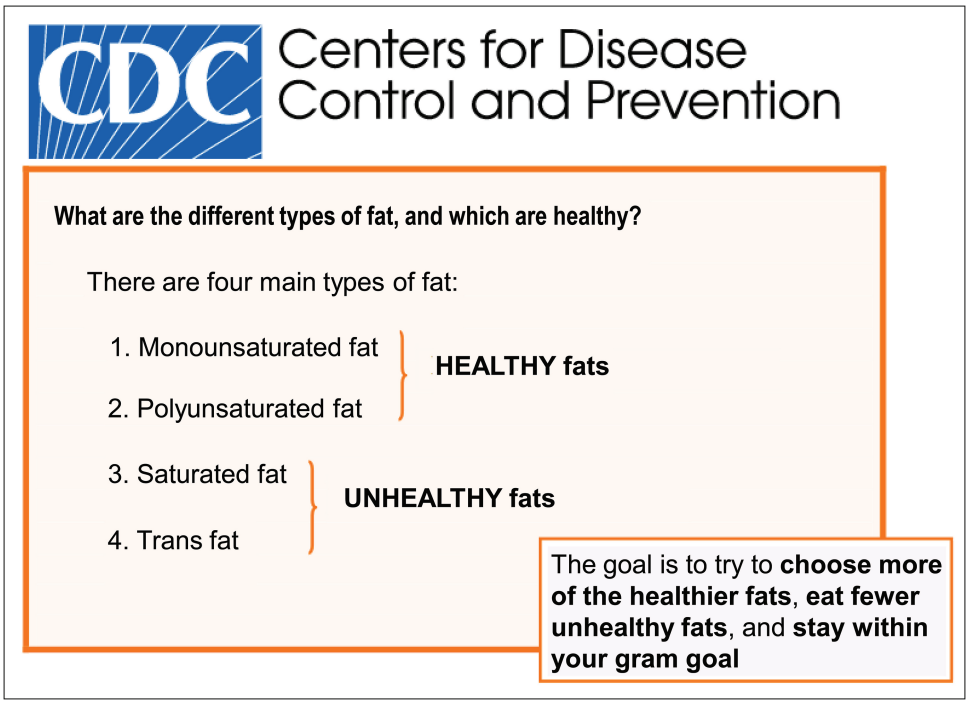

Figure 2. The educational excerpt in the survey used to inform respondents of the Centers for Disease Control and Prevention's classification of fats.

where D_j^1 is equal to 1 if option j changes the FA composition by a 10% decrease in saturated fat content and a 50% increase in polyunsaturated fat content, and D_j^2 is equal to 1 if option j changes the FA composition by a 20% decrease in saturated fat content and a 100% increase in polyunsaturated fat content, D_j^3 is an indicator equal to 1 if option j increases the iron content composition by 35%, D_j^4 is an indicator equal to 1 if option j increases the iron content composition by 70%, and Price_j is the price of option j. The model was used to estimate WTP for different attribute levels. For example, WTP for high iron content relative to baseline iron content, and holding other attributes fixed, is given by:

$$\text{WTP}^{\text{HighIron}} = -\frac{\beta_4}{\delta}$$

Data Collection and Statistical Analyses—Taste Panel

Taste panel was used as an experimental procedure to ensure capturing consumers' true WTP (Lusk et al., 2001; Umberger and Feuz, 2004). Steak samples with similar fat content and tenderness were selected for the taste panel to ensure no detectable differences between samples. A box of 6 strip loins (IMPS #180), merchandised under the Certified Angus Beef brand, were purchased from a major foodservice distributor. Each strip was identified with a number 1 to 6, and its identification number was tracked throughout the entire analysis. Each strip was cut into 2.5-cm-thick steaks. The most anterior steak from each strip was vacuum sealed, stored at 4 °C until reaching 21 d postmortem, then frozen at –40 °C. These reference steaks were used to evaluate cooked fat percentage and tenderness via slice shear force to determine which 4 strip loins had the most consistent, highly palatable steaks. The 3 next most anterior, medial, and posterior steaks were identified, vacuum packaged together then stored and frozen as described previously. The 3 consecutively removed steaks from the 4 strip loins chosen were used for each group of 10 panelists.

Steaks were thawed for 36 h at 4 °C prior to cooking. After thawing, steaks were cooked on an open-face electric grill (Hamilton Beach Brand, Washington, NC) and flipped once at

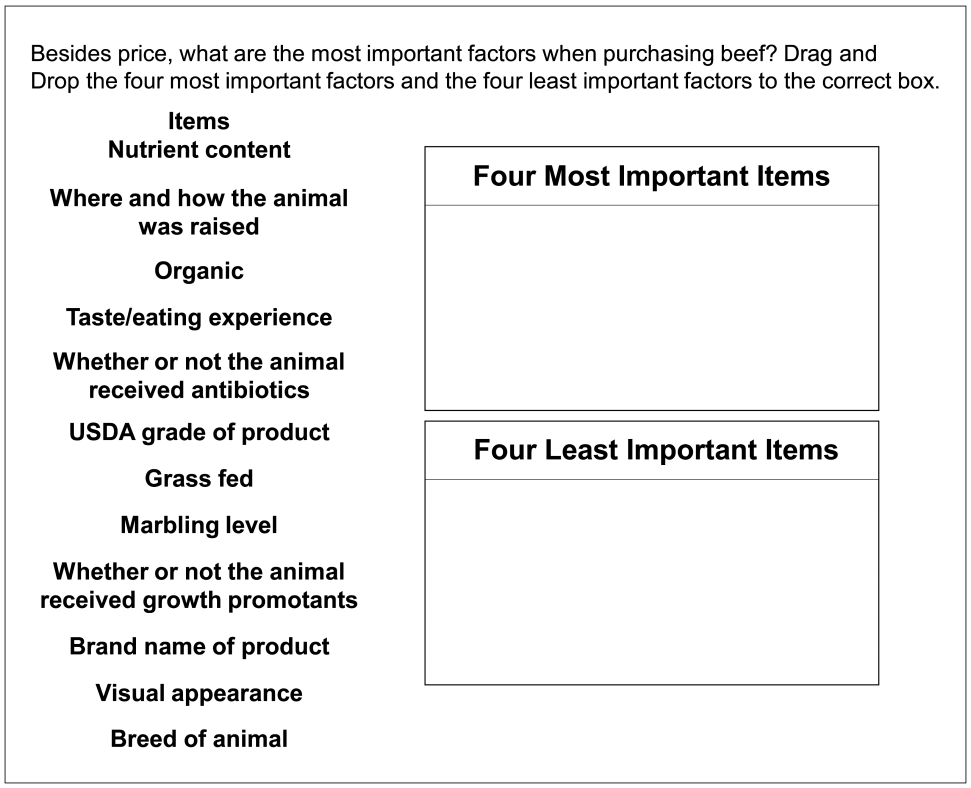

Figure 3. A question in the survey and in the willing-to-pay (WTP) taste-panel auction, which was used to understand the most important and least important factors to respondents' purchasing decisions of beef.

35 °C. Steaks were removed from the grill when they reached approximately 65 °C and allowed to rest. While resting, the heat within the steak continued to cook the steak to an ultimate temperature of 71 °C (approximately 5 min). Temperature was monitored throughout the cooking and resting process using a handheld thermocouple thermometer (Omega Engineering Inc., Stanford, CT) placed in the geometric center of each steak. One 1-cm-thick, 5-cm-long slice was taken parallel to the muscle fibers (Shackelford and Wheeler, 2009). Each sample was sheared within 2 min of the steak being removed from the grill to ensure the sample was still hot. Each slice was sheared once perpendicular to the muscle fibers using a slice shear head attached to an Instron Universal Testing machine (Model 3343; Instron Corporation, Canton, MA) with a cross-head speed of 500 mm/min. Once the machine sheared the sample, the force in kilograms was recorded.

The remainder of each cooked steak was trimmed free of any exterior/subcutaneous fat and then ground. A 1- to 2-g duplicate sample was inserted into labeled filter bags (W1), then heat sealed and placed into a 105 °C oven to dry for 3 h. Samples were cooled in a desiccant pouch and weighed (W2). Using hexane in an Ankom XT15 Extractor, samples were placed in the carousel to run the extraction process. Once the extraction process was complete, samples were placed in a drying oven for 15 to 30 min. Samples were then cooled in a desiccant pouch and the final weight of sample was recorded (W3). The percentage of cooked fat was calculated using the following equation: % Crude fat = [100 × (W2 – W3)]/W1. Moisture percentage was calculated using the following equation: [(filter bag wt. + W1) – W2]/W1.

The crude fat percentage and slice shear force values from the reference steaks are included in Table 1. Slice shear force values of 20.0 kg or less are considered "Certified Tender" (Society for Testing and Material Standards, 2013). Considering that 4.6 kg is the difference slice shear force that an average consumer can detect when eating meat at home (Miller et al., 1995), strips 3 and 6 were eliminated for use in the consumer WTP panel. The variation in slice shear force for the remaining strips (1, 2, 4, and 5) was under the level in which the average consumer can detect a difference in tenderness. The eliminated strips 3 and 6 also had the lowest crude fat percentage. The crude fat percentage of the remaining strips ranged between 6.84% and 7.68%. Crude fat percentage for beef quality grading average choice or high choice ranges from 5.34% to 8.55%; therefore, all products used for the taste portion of the WTP taste panel would be graded upper 2/3 choice quality grade (Drake, 2004).

Table 1. Slice shear force (SSF) values and crude fat percentages of 6 strip loins purchased for the taste-panel auction

Strip loin	SSF, kg	Crude fat, %
1	9.49	7.58
2	13.31	7.68
3	13.71	4.17
4	8.85	6.90
5	10.53	6.84
6	16.35	5.76

Steaks from strips 1, 2, 4, and 5 (Table 1) were used for consumer sensory. All 9 steaks from each of strips 1, 2, 4, and 5 were labeled in groups of 3, in order of most anterior to most posterior to ensure uniformity across 3 steaks. A different set of 3 steaks from the same strip was cooked for each consumer panel. Steaks from strip loins 3 and 6 were used as rewards for panelists who won each individual auction session. All steaks

(strips 1 to 6) were removed 36 h prior to consumer taste-panel evaluation and thawed at 4 °C. Steaks used for auction winners were individually vacuum sealed, whereas steaks used for consumer taste panel were cooked as described previously. After the steaks rested and reached an internal temperature of 71 °C, all external fat was cut from each side of the steak. This resulted in a square piece of steak absent of any external fat. The remaining piece of steak was placed in a 10 cm × 10 cm grid. A knife was used to cut the steak using the slots as a guide to create 1.3 cm^3 cubes. This was repeated for all sets of 3 steaks prepared for one set of ~10 panelists. The pieces were randomly sorted into 4 different cardboard food containers labeled Sample 1, Sample 2, Sample 3, and Sample 4. The samples were held under a food warmer, whereas panelists arrived and completed the questionnaire. As panelists requested the next sample according to their questionnaire, staff members would take 2 pieces from the respective sample container and provide it to the panelists.

The taste panel was conducted at the University of Florida Food Science and Human Nutrition Lab, and the study was approved by the Institutional Review Board at the University of Florida. Prior to the day of the panel, participants were selected from a diverse population based on typical demographics and required to be normal beef consumers. The panel consisted of 95 participants who were separated into groups of approximately 10. Consent was obtained from participants prior to beginning the taste panel, and participants were notified they would receive a $20 beef certificate as compensation for participation.

On arrival, participants entered a room with cubicles equipped with a computer that displayed a questionnaire, a chair, a piece of paper to record WTP, and a pencil. Participants read the directions on the computer screen and were then instructed to open a sliding window to signal they were ready for the first sample. The directions informed participants they would taste 4 samples of beef strip steak that differed only in nutritional value. The order of the steak samples was randomized across groups of participants. Participants were informed the average price for a retail strip steak is $10/0.45 kg (USDA, 2017) and instructed to take a bite of an unsalted cracker and a sip of water before each sample to cleanse their palate. After consuming each sample, participants gave a bid for the per 0.45-kg price they would pay for the current steak. Panelists were informed that at the end of the experiment, one of the steaks would be chosen for purchase and the 2 participants (in the respective group of approximately 10 participants) who bid the highest prices would be required to purchase the steak at the third-highest bid price. This method follows the second-price Vickrey auction style of WTP studies (Vickrey, 1961).

Participants were asked to rate each sample for overall likeness and texture, and both questions were answered using a 9-point scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely). Participants were asked demographic questions and questions to determine typical fat and beef consumption. Respondents were also asked to categorize the 4 most important and 4 least important attributes of beef (out of 12 listed), excluding price, when making a purchasing decision (Fig. 3).

The top 2 bids for the "Average" sample were used and determined the 2 highest bidders who would be required to purchase a steak for the third-highest bid price out of their $20 beef certificate. The top 2 bidders purchased an individually vacuum packaged steak from their $20 beef certificate according to the third-highest bid price and were provided the appropriate change. The change provided was in cash; however, participants were not made aware of this prior to bidding.

Descriptive statistics from the survey were calculated using SAS (SAS Inst., Inc., Cary, NC). PROC ANOVA was used to determine whether there was a difference in the liking, texture, or WTP between the 4 steak samples. Significant differences were determined with a post hoc Tukey test.

Demographic attributes and the association with WTP for the 4 steak samples were analyzed using PROC GLM in SAS. The linear models estimated can be mathematically represented by:

$$\begin{aligned} WTP_{ij} = {} & \beta_0 + \beta_1 Age_j + \beta_2 Sex_j + \beta_3 Education_j \\ & + \beta_4 Income_j + \beta_5 R_j^1 + \beta_6 R_j^2 + \beta_7 R_j^3 + \beta_8 Employed_j \\ & + \beta_9 Household_j + \beta_{10} Consumption_j \\ & + \beta_{11} Preferred\_Cooking_j + \beta_{12} Liking_j + \beta_{13} Texture_j \end{aligned}$$

where WTP_{ij} is the WTP for steak i and participant j; Age, Sex, Education, and Sex are the self-reported age, sex, education, and income level for participant j; R^1, R^2, and R^3, are indicator variables for race that equal to 1 if a participant self-identified as white, black, or African America, and Spanish, Hispanic, or Latino; Employed is an indicator variable equal to 1 if a participant is currently employed; Household is a participants household size; and Consumption is self-reported consumption of beef. The variables Preferred_Cooking, Liking, and Texture were included in the estimation to control for a participant preferred cooking level of a steak, and the overall liking and texture of a strip of steak provided in the taste panel. Additionally, correlations were estimated for liking, texture, and WTP, both between and across the 4 steak samples, using PROC CORR in SAS.

Results and Discussion

Lower consumption of saturated and trans FA in favor of polyunsaturated fat has been the recommendation of public health authorities in most developed countries with the goal of decreasing the incidence of cardiovascular and metabolic diseases (Higgs, 2000; Lunn and Theobald, 2006; Clifton and Keogh, 2017). In response, the nutritional value of beef has become increasingly important to specific groups of consumers, some of whom are willing to pay a premium for low rather than high marbling in beef (Killinger et al., 2004). The natural variation in beef products (Garmyn et al., 2011) offers the opportunity to develop different marketing strategies based on nutritional value to respond to the demand of healthier diets without substantive changes in consumer eating habits. The nutritional value of meat products is a complex concept given the multitude of individual FA and, as a consequence, the majority of information is presented in terms of major FA groups. In addition, the inconclusive and even contradictory messages from the scientific literature regarding the effects of different individual FA or groups of FA relative to the human health add to the complexity of the topic. In this study, information about the health properties of different groups of FA was provided to both the online and taste-panel participants in a very succinct manner and from a source (Center for Disease Control, CDC), which is recognized by most consumers as trusting and unbiased.

Respondent and Participant Demographics and Eating Preferences

Detailed summaries of the demographic profile and socioeconomic characteristics of the online national survey

Table 2. Demographic information of online survey respondents (n = 1,021) and taste-panel participants (n = 95)[1]

Item	% of online survey respondents	% of taste-panel participants
Age		
18 to 24 yr old	18.6	22.1
25 to 34 yr old	16.3	48.4
35 to 44 yr old	14.2	8.4
45 to 54 yr old	13.0	9.5
55 to 64 yr old	20.0	10.5
65 to 74 yr old	13.9	1.1
75 yr or older	4.1	0.0
Sex		
Male	49.0	47.4
Female	51.0	52.6
Race		
White	79.8	63.2
Black or African American	10.9	9.5
American Indian or Alaska Native	0.6	0.0
Asian	4.0	12.6
Native Hawaiian or Pacific Islander	0.1	0.0
Spanish, Hispanic, or Latino	3.7	14.7
Other	1.0	0.0
Education level		
Less than high school degree	1.8	0.0
High school graduate	21.7	2.1
Some college but no degree	30.4	11.6
Associate degree in college (2-yr degree)	15.8	9.5
Bachelor's degree in college (4-yr degree)	19.5	49.5
Master's degree	8.2	22.1
Doctoral degree	1.8	5.3
Professional degree (JD, MD)	0.9	0.0
Employment status		
Full-time employed	38.0	51.6
Part-time employed	17.5	6.3
Self-employed	16.0	0
Retired	28.5	42.1
Income		
Less than $10,000	7.1	11.6
$10,000 to $19,999	7.0	15.8
$20,000 to $29,999	10.6	34.7
$30,000 to $39,999	9.7	9.5
$40,000 to $49,999	5.8	9.5
$50,000 to $59,999	5.0	11.6
$60,000 to $69,999	10.3	1.1
$70,000 to $79,999	12.8	2.1
$80,000 to $89,999	6.7	1.1
$90,000 to $99,999	7.2	2.1
$100,000 to $149,999	12.2	1.1
$150,000 or more	5.8	0.0
Household size		
1	17.3	32.6
2	36.7	36.8
3	18.9	14.7
4	14.9	10.5
5	8.2	3.2
6 or more	4.0	2.1

[1]Chi-square tests were estimated to determine the relationship between the 2 samples. The 2 samples were significantly different (at an alpha level of at least 0.01) for all measurements with the exception of sex.

Table 3. Consumption habits of online survey respondents (n = 1,021) and taste-panel participants (n = 95)[1]

Item	% of online survey respondents	% of taste-panel participants
How often respondents consume beef		
Never	3.8	0
At least 1/yr	4.3	0
At least 1/mo	10.9	2.1
1/every other week	11.3	2.1
1/wk	26.2	26.3
2 to 3/wk	38.8	57.9
Daily	4.7	11.6
Cooking level		
Rare	3.6	11.6
Medium rare	25.8	43.2
Medium	27.9	22.1
Medium well done	20.6	20.00
Well done	22.1	3.2
Milk fat level		
Skim	11.4	
1%	10.9	
2%	36.5	
Whole	22.1	
I do not drink milk	18.2	
I do not know	1.0	
Fat type		
Lard	1.3	
Olive oil	54.2	
Vegetable oil	35.3	
Other	9.2	

[1]Chi-square tests were estimated to determine the relationship between the 2 samples. The 2 samples were significantly different (at an alpha level of at least 0.01) for beef consumption and preferred cooking level.

respondents and the participants in the taste-panel auction are presented in Table 2. Approximately half of the survey respondents and auction participants were females (50.98% and 52.63%, respectively) with a high percentage reporting their ethnicity as White (79.8% and 63.16%, respectively) followed by Black or African American (10.86%) for the survey respondents and Spanish, Hispanic, or Latino (14.74%) for the auction participants. The age of the survey respondents was balanced across the 6 age categories, whereas 70.53% of the auction participants were between 18 and 34 yr old. A high percentage (75.56%) of the survey respondents had some form of postsecondary education, whereas 49.47% and 27.37% of the auction participants had a bachelor's degree or Master/Doctoral degree, respectively. There was a relatively uniform distribution of the survey respondents across all income classes, whereas a relatively higher percentage (34.74%) of auction participants had a total household income between $20,000 and $29,999/yr with about 93% of the total auction participants having an income lower than $60,000/yr.

Consumption and eating preferences of survey respondents and auction participants are presented in Table 3. Approximately 70% of the survey responders and 96% of the auction participants indicated that consumed beef at least once a week. The higher percentage of frequent beef consumers among the auction participants was expected because the participants

were selected from a diverse population but required to be normal beef consumers. On the other hand, the online survey was designed to capture a representative sample of the national distribution. Only 3.82% of the survey respondents said they never consumer beef, which is slightly higher than reported vegetarian and vegan prevalence rates of 2.4% to 3.3% in the United States (The Vegetarian Resource Group, 2013; Jaacks et al., 2016). Although not consuming beef could also be a result of other factors (e.g., religious avoidance). More than half of the survey responders (58.53%) preferred 2% or whole milk, whereas 18.24% did not drink milk. Olive oil was the most preferred type of fat for cooking (54.22%) followed by vegetable oil (35.29%). The preferred level of cooking was different among the survey responders and auction participants, reflective of the underlying design of these 2 population samples. Among the survey responders who are representative of the U.S. population, only a smaller percentage (3.63%) preferred the beef cooked rare, whereas relatively similar percentages ranging from 20.59% to 27.94% preferred a level of cooking between medium rare and well done. Among the auction participants who were selected to be regular consumers of beef, 43.16% preferred a medium-rare level of cooking and only 3.16% preferred well-done cooked beef.

Online Survey

Respondents were asked to classify which 4 attributes, besides price, are most important when purchasing beef. The top 3 most important attributes by percentage of respondents who placed the attribute in their top 4 were grade, taste, and appearance, with percentages of 64.15%, 54.36%, and 46.43%, respectively. Respondents were also asked to classify which 4 attributes, besides price, are least important and the top 3 least important attributes by percentage of respondents who placed the attribute in their bottom 4 were brand, breed, and organic, with percentages of 71.20%, 62.68%, and 44.07%, respectively. The complete ranking of most important and least important characteristics to respondents' purchasing decisions is presented in Table 4. These results agree with a study conducted by Watson et al. (2011) that showed Appearance was ranked in the top 2 most important beef purchasing attributes among their respondents and Brand was ranked in the 2 least important.

The results from the survey indicated that many consumers were unclear about differences in beef nutritional value, specifically FA content. Initially, only 66.40%, 69.05%, 79.14%, and 79.24% of respondents correctly categorized the monounsaturated, polyunsaturated, saturated, and trans fat, respectively. However, a favorable shift occurred and more than 90% of respondents correctly categorized the various FA once provided the educational figure (Table 5). Before the educational excerpt, only 46.13% of the respondents were able to correctly characterize all fats, and this percentage increased to 88.44 after the educational excerpt was provided.

After better understanding the differences in "healthy" and "unhealthy" of FA in beef, respondents were willing to pay a premium for a product of improved FA composition (Table 6). It is interesting to note that prior to information regarding FA healthfulness, respondents preferred improved iron content over improved FA composition, but these preferences reversed after the educational figure was provided. This could be a result of a better public knowledge regarding the iron deficiency as a serious public health problem, with negative consequences on maternal and child mortality, cognitive and physical development of children, and physical performance and work capacity in adults (Geissler and Singh, 2011; Phillips, 2012; Cashman and Hayes, 2017). Another contributing factor to the discount placed on steaks with higher fat content could be the attributed to the "framing effect," which has been shown to have important implications for consumer behavior. Because of public perceptions of health advantages associated with low-fat diets and in the absence of information regarding the nutritional and health benefits of the monounsaturated and polyunsaturated fat, the survey responders associated the choice options of steaks with higher fat level as unhealthy. After respondents better understood FA composition, they were WTP $3.13 and $4.35 more for increased healthful fat content. These results are comparable to the mail survey of Lusk and Parker

Table 4. Proportion of respondents who ranked a factor as "most important" or "most unimportant"[1]

	Proportion of respondents who ranked attribute as "most important"		Proportion of respondents who ranked attribute as "least important"	
Factor	Online survey respondents	Taste-panel participants	Online survey respondents	Taste-panel participants
Brand name of product	12.4	10.5	69.7	62.1
Breed of animal	11.6	6.3	59.9	64.2
Marbling level	29.7	47.4	37.1	21.1
Nutrient content	33.2	33.7	21.4	25.3
Taste/eating experience	50.2	80.0	14.1	3.2
USDA grade of product	60.1	57.9	11.5	11.6
Visual appearance	42.9	70.5	27.7	11.6
Where and how the animal was raised	24.7	21.1	37.7	35.8
Whether or not the animal received growth promotants	36.9	21.1	25.2	30.5
Whether or not the animal received antibiotics	41.6	21.1	24.4	31.6
Grass fed	31.7	20.0	27.8	39.0
Organic	24.6	10.5	43.1	64.2

[1]Chi-square tests were estimated to determine the relationship between the 2 samples. The 2 samples were significantly different (at an alpha level of at least 0.01) for most and least important attributes of beef.

(2009) where consumers were WTP up to $3.48 for beef reduced in saturated fat content. In their study, they also observed a strong interaction between total fat content and saturated fat content, where consumers were willing to pay more for reducing the saturated fat content from 50% to 30% when the total fat content was 10% compared with the same reduction in saturated fat when the total fat content was 20%. This would indicate that products from leaner carcasses, for example, from *Bos indicus*-influenced cattle, which are characterized by lower saturated fat percentage and higher polyunsaturated fat percentage due to relatively lower marbling (Flowers et al., 2018), might present an advantage with consumers who tend to regard these products as more nutritionally desirable.

The importance of providing relevant information regarding the nutritional and healthfulness benefits of a product on the willingness to pay a premium, which we demonstrated in this study is similar to results presented by Bower et al. (2003). Nutritional information, once provided, changed respondents' perceptive value of the product and altered their WTP. Xue et al. (2010) observed from their study's knowledge scoring scale, that a one-point knowledge score increase resulted in a $0.19 increase in participant's WTP for grass-fed beef (Xue et al., 2010). Similar findings were presented by Barreiro-Hurle et al. (2010) who pointed out that the responses to food labels differ both with respect to the way information is presented and with the type of information provided. In a study conducted by Rimal (2005), 85% of respondents who said food labels help in their purchasing behavior of beef also stated that it was very important for such labels to include nutrition information. For meat products, Rimal (2005) concluded that consumers' perceived importance of ingredient and nutrition information on food labels influenced their attitude toward such labels, therefore providing nutritional information results in consumers purchasing and consuming a product more frequently.

Table 5. Percentage of survey respondents able to correctly identify different categories of fat as healthy or unhealthy before and after reading an educational excerpt from Centers for Disease Control.

Fat category	Before, %	After, %
Monounsaturated	66.4	94.3
Polyunsaturated	69.1	93.5
Saturated	79.1	91.7
Trans	79.2	94.4

Table 6. The premiums/discounts (in U.S. dollars) survey respondents were willing to pay (WTP) per 0.45 kg of steak before and after the educational excerpt

Nutritional value	WTP[1] before information	WTP[1] after information
50% more favorable fat composition	–$1.00 (–1.34, –0.66)	$3.13 (2.64, 3.61)
100% more favorable fat composition	–$1.42 (–1.85, –1.00)	$4.35 (3.76, 4.95)
50% iron content increase	$0.12 (–0.12, 0.36)	$0.14 (–0.08, 0.36)
100% iron content increase	$1.33 (0.99, 1.67)	–$0.48 (–0.88, –0.088)

[1]TPs were computed at the mean of variables and the 95% confidence intervals, presented in parentheses, were computed using the Krinsky–Robb method and 5,000 draws.

Taste-Panel Auction

The WTP was measured through an experimental procedure that reflects the consumers' true WTP (Lusk et al., 2001; Umberger and Feuz, 2004) and avoids the hypothetical nature of surveys where consumers tend to overestimate their WTP. No palatability differences are expected between steaks with the proposed nutritional properties, and steak samples were chosen in such a way to ensure no detectable differences between samples. In this way, differences in the WTP measured through the taste-panel approach should reflect the value of different nutritional properties.

Similar to the online survey, the taste-panel auction participants were asked to classify which attributes, besides price, are most important to their beef purchasing decisions. The top 3 attributes by percentage of respondents were Taste, Appearance, and Grade with percentages of 80.00%, 70.53%, and 57.89%, respectively. Participants were asked to classify which attributes, besides price, are least important to their beef purchasing decisions and the top 3 attributes by percentage of participants were Breed, Organic, and Brand with percentages of 64.21%, 64.21%, and 62.11%, respectively. The overall ranking of most important and least important characteristics to participants' purchasing decisions can be seen in Table 4. The top 3 characteristics ranked in Most Important and the top 3 characteristics ranked in Least Important were the same in both the online survey conducted and the WTP panel, only with differing percentages.

Table 7 shows the WTP for each of the 4 samples: Average (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, average iron), Better Fat (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, average iron), More Iron (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, increased iron), Better

Table 7. Participants' average willingness to pay (WTP) in dollar price per 0.45 kg, average overall liking, and average texture liking for each of the 4 steak samples

Sample[1]	WTP price per 0.45 kg	Overall liking	Texture liking
Average	$8.26 (2.07)	6.71 (1.19)	6.51 (1.46)
Better Fat	$8.99 (2.70)	7.00 (1.18)	6.80 (1.38)
More Iron	$8.49 (2.15)	6.74 (1.39)	6.53 (1.51)
Better Fat + More Iron	$8.85 (2.51)	6.82 (1.35)	6.56 (1.63)

[1]Steaks were categorized as Average (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, average iron), Better Fat (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, average iron), More Iron (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, increased iron), Better Fat + More Iron (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, increased iron content). SD are in parentheses. Participants evaluated their "overall liking" and "texture liking" of each sample from 1 to 9 (1 = dislike extremely; 9 = like extremely).

Table 8. Linear regression models for the effect of consumer demographic information, overall liking, and texture liking attributes on willingness to pay (WTP) for Average (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, average iron), Better Fat (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, average iron), More Iron (average healthy fat-polyunsaturated fat, average unhealthy fat-saturated fat, increased iron), Better Fat + More Iron (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, increased iron content) steaks

	Average steak		Better Fat steak		More Iron steak		Better Fat + More Iron steak	
Variable	Effect (SE)	*P*-value	Effect (SE)	*P*-value	Effect (SE)	*P*-value	Effect (SE)	*P*-value
Age	−0.11 (0.03)	<0.0001	−0.11 (0.03)	0.002	−0.08 (0.03)	0.004	−0.09 (0.03)	0.008
Sex	0.49 (0.51)	0.342	0.96 (0.66)	0.151	1.01 (0.55)	0.071	0.28 (0.62)	0.654
Education level	−0.15 (0.20)	0.463	0.07 (0.27)	0.794	0.11 (0.21)	0.611	0.11 (0.25)	0.650
Income level	0.39 (0.16)	0.018	0.28 (0.21)	0.186	0.27 (0.17)	0.116	0.19 (0.20)	0.347
White	−0.39 (0.74)	0.604	−1.14 (0.96)	0.241	−1.26 (0.76)	0.103	−0.78 (0.90)	0.385
Black or African American	1.25 (1.00)	0.218	0.66 (1.32)	0.622	0.84 (1.06)	0.427	1.20 (1.27)	0.347
Spanish, Hispanic, or Latino	0.52 (0.86)	0.545	−0.70 (1.13)	0.535	−0.30 (0.90)	0.737	0.35 (1.04)	0.737
Employment status	−0.10 (0.56)	0.860	0.37 (0.74)	0.712	0.49 (0.68)	0.472	−0.20 (0.58)	0.733
Household size	−0.15 (0.19)	0.436	−0.13 (0.26)	0.602	−0.15 (0.20)	0.463	−0.21 (0.24)	0.386
Consumption frequency	−0.57 (0.30)	0.058	−0.70 (0.39)	0.072	−0.57 (0.31)	0.066	−0.70 (0.36)	0.055
Preferred cooking level	0.02 (0.23)	0.940	0.04 (0.30)	0.889	0.09 (0.24)	0.711	0.23 (0.28)	0.413
Overall liking	0.57* (0.30)	0.064	1.15 (0.40)	0.005	0.40 (0.27)	0.140	0.89 (0.36)	0.016
Overall texture	0.25 (0.25)	0.315	0.37 (0.33)	0.256	0.27 (0.24)	0.263	0.24 (0.28)	0.396

Table 9. Pearson correlations between the willingness to pay (WTP) for the 4 different steaks and the Overall Liking and Texture Liking attributes

	WTP, Better Fat steak	WTP, Better Fat + More Iron steak	WTP, More Iron steak	Overall Liking	Texture Liking
WTP, Average steak	0.73 (<0.0001)	0.69 (<0.0001)	0.75 (<0.0001)	0.33 (0.001)	0.27 (0.007)
WTP, Better Fat Steak		0.84 (<0.0001)	0.80 (<0.0001)	0.50 (<0.0001)	0.47 (<0.0001)
WTP, Better Fat + More Iron steak			0.80 (<0.0001)	0.48 (<0.0001)	0.44 (<0.0001)
WTP, More Iron steak				0.32 (0.002)	0.33 (0.001)

Fat + More Iron (increased healthy fat-polyunsaturated fat, decreased unhealthy fat-saturated fat, increased iron content). Table 7 also shows participants' Overall Liking and Texture Liking of each of the samples. There were no significant differences between Overall Liking, Texture Liking, or WTP among the 4 samples. There was, however, a significant effect of Overall Liking on WTP for both the Better Fat and the Better Fat + More Iron samples (Table 8). For a 1-unit increase in Overall Liking, WTP for the Better Fat and the Better Fat + More Iron samples increased by $1.15/0.45 kg and $0.89/0.45 kg, respectively. The lower premiums the auction participants were willing to pay for products with increased nutritional value compared with respondents in the online survey were not surprising. Values elicited from hypothetical surveys tend to not reflect consumer's true WTP as responders do not use real money at the time of the survey (Umberger and Feuz, 2004). Another factor contributing to the lack of statistical difference in the WTP for the taste-panel auction compared with the online survey could be a framing effect (Levin and Gaeth, 2002). The framing effect influences the judgment of a product by the consumer as a function of verbal labels used to define specific attributes. Although the same verbal attributes were used for both the online survey and the taste-panel auction, the WTP was larger in the online survey. This is similar to the findings of Levin and Gaeth (2002) when studying the impact of the framing effect on consumers of ground beef, where the information provided had a weaker impact when consumers actually tasted the meat. In addition, consumers in the taste-panel auction were regular consumers of beef, but not necessarily of steaks. Given the higher cost associated with this type of product, we expect that the panelists who are regular consumers of cheaper beef products (hamburgers) would be reluctant to pay an additional cost for improved healthfulness for a product they would consider already at the upper end of their budget.

Among all demographic and socioeconomic characteristics, only Age and Income had a significant effect (Table 8). Age was significant across all 4 steak samples, whereas Income had a significant effect only for the Average sample. The WTP decreased anywhere from $0.08/0.45 kg (More Iron steak) to $0.11/0.45 kg (Average and Better Fat steaks) for every category (10 yr) increase in age. For one category ($10,000/yr) increase in income, WTP for the Average steak sample increased by $0.39/0.45 kg. These results are comparable to those of Xue et al. (2010) who observed age as the only significant demographic variable for preferring grass-fed beef vs. conventional beef (Xue et al., 2010).

Pearson correlations estimates between the WTP among the 4 steaks and between the WTP and the Overall Liking and Texture Liking attributes are presented in Table 9. The WTP across all 4 types of steaks were strongly correlated and ranged from 0.67 to 0.84, indicating an individual had a similar WTP regardless of the steak attribute. Weak correlations ranging from 0.27 to 0.33 were detected between the WTP for both the Average and More Iron steaks and the Overall Liking and Texture Liking attributes. Stronger correlations (0.44 to 0.50) with the Overall Liking and Texture Liking attributes were identified for the Better Fat and Better Fat + Iron steaks. These correlations between Overall Liking and WTP, and Texture Liking and WTP suggest that

individuals would perceive a difference in the liking and texture between samples; however, this did not influence their WTP for the different samples.

Conclusions

In the past, much controversy surrounding fat content of red meat and its role in the diet led to many health professionals recommending cutting such food from the diet. In recent years, research on different FA categories supports the idea that not all fat is bad. Our results indicate that relaying this information to consumers is extremely important to their purchasing decisions and willingness to pay for beef. WTP was much higher with varying nutritional value in the online survey than in the taste-panel auction. This is in line with previous research indicating that consumers are willing to pay higher premiums in a hypothetical survey scenario compared with an experimental auction, which can reveal a consumer's true WTP (Lusk et al., 2001; Umberger and Feuz, 2004).

Our study provides insight for beef promotion and marketing opportunities to the increasing population of health-conscious consumers. When marketing a product based on health attributes, to receive a premium for such a product, will be essential for information to be provided in a clear way such that the consumer can easily realize the health benefits of the product. Future studies should target the different beef consumer populations (regular consumers of hamburgers vs. steak) separately to be able to quantify the WTP more accurately.

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