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Consumer Preferences for Amount and Type of Fat in Ground Beef

Jayson L. Lusk and Natalie Parker

Scientists and beef industry participants are investigating ways to improve the healthiness of beef. We report results of a nationwide mail survey developed to determine consumers' preferences for fat content in ground beef and identify how consumers would most like to improve the healthiness of beef. The results from a choice-based conjoint experiment indicate that consumers place significant value on reducing saturated fat and the Omega 6:3 ratio in ground beef, but were relatively unconcerned about conjugated linoleic acid. The relatively new method of best-worst scaling was used to further identify which methods consumers most preferred producers use to improve fat content in beef. The results indicate consumers preferred feeding cattle a grass-fed diet as opposed to supplementing cattle feed with fish-meal or flaxseed to improve the fatty acid content in beef. Although consumers were receptive to the idea of using genetic testing to breed only those cattle with improved fatty acid content, using cloning to achieve this end, was viewed as very undesirable.

Key Words: beef, best-worst scaling, cloning, conjoint, fat, maximum-difference scaling, omega 3 fatty acid

JEL Classifications: M31, Q13

Although beef demand has been on the rise in recent years (see Mintert), participants in the beef industry are continually interested in improving the competitive position of beef relative to other protein sources. One area where beef has faced a competitive disadvantage relative to pork and especially poultry is in regards to fat and cholesterol content. Several studies have linked beef demand to health concerns and fat content. For example, Boetel and Liu (p. 324) found “increased food health concerns for fat and cholesterol have resulted in a 6% reduction in the consumption of beef per capita per quarter since 1987, and an 18% increase in the poultry consumption.” Kinnucan et al.

also found that health information related to cholesterol had a significantly larger effect than relative price elasticities and advertising on beef demand. They found that health information greatly benefited poultry and harmed beef demand while leaving demand for pork and fish unaffected. There is also some evidence from Europe that television publicity had a negative impact on expenditures for beef (Verbeke and Ward). Furthermore, Ward has found that households with higher stated levels of concern for fat and cholesterol consume significantly less beef than households with lower fat and cholesterol concerns.

To counteract the negative health perception associated with beef, steps are being taken to find ways to improve the amount and type of fat in beef by increasing levels of omega 3 fatty acid and conjugated linoleic acid (CLA) while reducing saturated fat. The goal is to create a

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“heart healthy” beef product. Scientists and beef industry participants have at their disposal several avenues to improve fat content in beef including altering feeding methods to include grass or fish meal, selective breeding to creating genetic stock with healthier fat profiles either through traditional methods or by cloning, or simply by offering premiums and discounts in the current market for fat profiles that are more desirable. Improving the fat content may be one way to improve the competitiveness of beef relative to poultry and pork.

Of course, improving the fat content of beef is costly, and as such, producers are in need of information to determine whether the benefits of improving fat content exceed the costs. Indeed, producers have a multitude of opportunities to improve beef demand, and it is important to determine how the demand for fat and fat content compares to demand for other beef attributes. The purpose of this research is to determine consumers’ willingness to pay for beef with improved fat content, to determine how consumers prefer the fat content of beef be improved, and finally to determine the importance of fat content in beef relative to other beef attributes.

Background

Several studies have investigated methods of modifying cattle production systems to improve the composition of beef fat. Efforts have focused on investigating the effects of various feed additives and on the effects of genetics. Gillis, Duckett, and Sackman, for example, investigated the effects of supplemental corn oil on fatty acid composition. They found that short term lipid supplementation in feedlot cattle increased CLA concentrations; however these increases were only marginally effective. Mandel et al. investigated the effect of feeding fish meal on fatty acid composition of beef steaks. They found that feeding cattle 10% fish meal for 168 days improved the levels of omega 3 fatty acids in beef steak. They also found that higher levels of fish meal in the diet generated higher omega 3 fatty acid levels.

French et al. examined the fatty acid composition of grass-fed steers. They found that

increasing the amount of grass intake (relative to concentrated feed) decreased intramuscular saturated fatty acids. They also found that a higher grass diet also increased the omega 3 fatty acid concentration and decreased the omega 6 to omega 3 ratio.¹ Maddock et al. examined the effects of feeding flax (also known as linseed), which is an oilseed, on fatty acid composition. They found that feeding flax decreased the omega 6:3 ratio and increased the amount of omega 3 fatty acid in beef. Their results revealed that feeding flax also increased the number of carcasses grading USDA choice. They further found that feeding flax improved the performance and efficiency of the cattle (e.g., average daily gain) as well as improving the intramuscular fatty acid composition of the beef, suggesting feeding flax may have advantages over feeding grass.

Scollan et al. reviewed the extant literature regarding nutritional approaches to change the fatty acid composition of beef. They concluded that feeding a diet rich in fresh grass and silage results in higher concentrations of omega 3 acids compared with a diet with concentrates. They also concluded that feeding supplementary fatty acids to the cattle also altered the fatty acid composition. Their review of the literature suggested that feeding linseed oil had the biggest positive effect on the fatty acid composition. Feeding sunflower seed oil and fish oil also improved fatty acid composition, but to a lesser extent than linseed oil. The authors, however, pointed out that altering the fatty acid composition of beef might change the product’s taste in a way that is unappealing to consumers. Indeed, Umberger et al. have shown that the majority of U.S. consumers prefer the taste of corn-fed beef to grass-fed beef.

In addition to feeding approaches, Knight et al. studied the heritability of fatty acid composition

¹ Research has shown that it is not necessarily the level of omega 3 fatty acids that is important to human health, but rather the ratio of omega 6 to omega 3 fatty acids in the diet. Because the intake of omega 6 fatty acids is relatively high in the U.S., increased intake of omega 3 serves to lower the ratio, with lower ratios being associated with better health outcomes.

and found that it is indeed heritable and can be improved by identifying and selecting for natural genetic differences that exist between animals. The authors found that traditional breeding selection programs can be used to improve the fatty acid composition of beef and suggested that DNA markers can be used to select breeding stock to create a healthier product.

A few papers have attempted to measure consumers' preferences for fat content in beef. Several studies have investigated the effect of total fat content in ground beef using hedonic analysis. For example, Brester et al. found that a 1% increase in the leanness of ground beef was associated with a price premium of \$0.02/lb. More recently, Parcell and Schroeder found that a 1% increase in leanness was associated with a \$0.039/lb premium in ground beef, and Ward, Lusk, and Dutton found that ground beef that exhibited at least 96% leanness sold at price premiums of \$0.18, \$0.89, \$1, and \$1.39 over products that were, respectively, 90–95%, 85–89%, 80–84%, and less than 80% lean. Unnevehr and Bard found, studying table cut beef, that consumers significantly discounted external and seam fat, but did not place a consistent value on intramuscular fat content.

To our knowledge, only two previous studies have explicitly investigated consumer preferences for type of fat in beef. Lusk, Fields, and Prevatt conducted nonhypothetical purchasing experiments with consumers in grocery stores to determine the value they placed on “pasture-raised” beef. They found that explicitly informing consumers about the link between pasture-raised beef and improved levels of Omega 3 fatty acids increased willingness-to-pay for pasture-raised steaks by about a dollar; however, such information did not have a significant effect on willingness-to-pay for pasture-raised ground beef.

McCluskey et al. administered an in-person survey in several grocery stores in Spokane, WA, and utilized a choice-based conjoint questionnaire to determine relative preferences for beef price, fat and calories, and level of omega 3 fatty acids. They found that respondents were willing to pay a premium for beef steaks with

lower fat content and higher levels of omega 3 fatty acids. Their results reveal a willingness-to-pay of \$2.82 to move from “high” to “low” fat and calories and willingness-to-pay of \$1.71 to move from “low” to “high” omega 3 fatty acid content in beef steaks. Because of the similarity of this study with the present analysis, several comments are in order. First, almost half the data collected by McCluskey et al. were from a “specialty” natural food store. Clearly, consumers in such an outlet are not likely to be representative of the general population and are likely to be more willing to pay for healthier products. Second, the survey method employed by McCluskey et al. simply used the words “high” and “low” when referring to total fat and fatty acid content, making precise predictions about the effects of improving fat content unavailable. Finally, McCluskey et al. only investigated consumer preferences for one method of improving the fatty acid content of the beef, feeding grass, and as previously discussed, there are many alternative methods for improving fat content.

Methods

A mail survey was developed and mailed to random sample of 2,000 households throughout the United States in April of 2007. In designing the mail survey, the advice offered by Dillman was closely followed. In particular, the survey instrument was designed to address the research objectives, but in a way that respondent could easily and accurately respond to the survey questions. As suggested by Dillman, survey questions were written in bold font on gray background and response categories were in white. The survey was printed and stapled in booklet form with an attractive cover page. The questionnaire was mailed out with a personalized cover letter including the each individual's name and address. The cover letter explained the purpose of the survey and asked participants for their help in the research project. A prepaid return envelope was included in the mailing and respondents were encouraged to contact the survey administrators if they had any questions or comments about the survey. One week after the survey was mailed out, a

reminder/thank you post card was sent to all respondents.

The survey began with four general questions regarding the respondents’ past purchases of ground beef. Following the first four questions, information about different types of fat and associated health effects was presented. The exact information given to respondents is as follows.

On the next page, you will be asked several repeated questions about your preferences for beef products with different amounts and types of fat. Although some types of fat in beef may have adverse health consequences, some types of fat may have health benefits. The following information is provided to assist you in answering these questions.

- People who consume diets high in saturated fat tend to have higher levels of “bad” cholesterol, which increases the risk of heart disease.
- In a typical package of ground beef, saturated fats normally comprise about 40% of the total fat content
- In contrast to saturated fats, medical studies indicate that the ingested ratio of omega-6 to omega-3 polyunsaturated fatty acids is important in maintaining cardiovascular health and preventing heart disease.
- Most health experts suggest diets should have an omega-6 to omega-3 fatty acid ratio of about 1:1–2:1; however, most

Americans consume these fatty acids in a ratio of about 16:1.

- A typical package of ground beef has an omega-6 to omega-3 ratio of about 5:1.
- Medical studies suggest consumption of conjugated linoleic acid—CLA, a polyunsaturated fat, may lower body weight, reduce cancer risk, and improve cardiovascular health.
- In a typical package of ground beef, CLA normally comprises about 0.5% of the total fat content.

Choice-Based Conjoint Questions

Immediately following the information about the types and amount of fat in ground beef, nine choice questions were presented. In each question, the respondent was asked to choose which of two ground beef options they would purchase (or neither), where each ground beef option varied according to the amount and type of fat and the price of the product. Each ground beef option was described by the five attributes shown in Table 1.

As shown in Table 1, each attribute was varied at two levels. Thus, there are $2^5 = 32$ different ground beef options that could be described. In each choice option, people chose between two ground beef options and a third “neither” option. Thus, the full factorial design consisted of $2^5 \times 2^5 = 1024$ possible choices. From this full factorial, 18 choice tasks were

Table 1. Attributes and Attribute Levels in the Choice-Based Conjoint Questions

Attribute	Definition	Levels
Price	Price in dollars for a package of ground beef.	\$1.99
		\$3.99
Fat %	Percent total fat in the ground beef.	10%
		20%
Saturated Fat %	Percent of saturated fat measured as a percent of total fat content (note: health experts suggest consuming products low in saturated fat).	30%
		50%
Omega 6:3 ratio	Omega 6 to Omega 3 fatty acid ratio (note: health experts suggest a smaller ratio is better).	6:1
		2:1
CLA %	Conjugated linoleic acid, a polyunsaturated fat, measured as a percent of total fat content (note: health experts suggest consuming higher levels of CLA to have health benefits).	0.3%
		0.7%

selected such that all main and two-way interaction effects were uniquely identified. The 18 choice tasks were selected by choosing choice options out of the full factorial design to minimize a D-efficiency criterion. Lusk and Norwood have shown that such an approach yields reliable willingness-to-pay estimates. The resulting design had a D-efficiency score of 94.2 (out of 100) indicating that each attribute exhibits only a very low correlation with each other attribute within and across choice options. It was felt that it would be too burdensome to present all 18 choice questions to each individual, and as such, the 18 questions were blocked into two sets of nine, and two survey versions were created—each with nine choice questions. An example choice question is shown in Figure 1.

As can be seen in Figure 1, rather than indicating the percent fat, choice options were presented as the percent lean to be consistent with the way most ground beef is marketed in grocery stores. However, when estimating the model and defining the variables in the survey, fat content is defined as the percent fat (i.e., 80% lean = 20% fat and 90% lean = 10% fat).

Responses to the choice questions can be analyzed using the random utility framework of McFadden, where the systematic portion of the utility function is assumed to depend on the attributes of the choice option. In addition to this systematic portion, the utility function is assumed to contain a stochastic error term representing the fact that the analyst cannot observe people's preferences with certainty. It is assumed that the consumer chooses the option that generates the highest utility given available choice options and constraints. More formally, a random utility function may be defined by

a deterministic (V_{ij}) and a stochastic (ϵ_{ij}) component:

$$(1) \quad U_{ij} = V_{ij} + \epsilon_{ij}$$

where U_{ij} is the i th consumer's utility of choosing option j , V_{ij} is the systematic portion of the utility function determined by ground beef attributes in alternative j , and ϵ_{ij} is a stochastic element. The probability that a consumer chooses alternative j from a choice set with J possible choice options is

$$(2) \quad \text{Prob} \{V_{ij} + \epsilon_{ij} \geq V_{ik} + \epsilon_{ik} \text{ for all } k \neq j\} *$$

If the random errors in equation (1) are independently and identically distributed across the j alternatives and N individuals with a type I extreme value distribution, McFadden, shows that the probability of alternative j being chosen is

$$(3) \quad \text{Prob} \{\text{option } j \text{ is chosen}\} = \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}}$$

In this research, the consumers' utility function for alternative j is assumed to be a function of total amount of fat, type of fat, and price:

$$(4) \quad \begin{aligned} V_j = & \alpha_j + B_1(\% \text{fat})_j + B_2(\text{Saturated fat } \%)_j \\ & + B_3(\text{Omega 6 to Omega 3 ratio})_j \\ & + B_4(\text{Conjugated Linoleic Acid } \%) \\ & + B_5(\text{Price})_j \end{aligned}$$

where α_j is an alternative specific constant that indicates the utility of option j that is not attributable to fat content and price, and where B_k represents marginal utilities of each of the attributes.

In addition to this linear specification, we also considered interactions between total fat

Of the packages of ground beef shown below, which would you choose to purchase?
(please check only one of the three options below)

80% lean	90% lean	I would not purchase either option
saturated fats comprise 30% of total fat content	saturated fats comprise 30% of total fat content	
Omega 6 to Omega 3 ratio is 6:1	Omega 6 to Omega 3 ratio is 2:1	
CLA comprises 0.7% of total fat content	CLA comprises 0.3% of total fat content	
\$3.99	\$1.99	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 1. Example Choice Question Presented to Survey Respondents

content and the other nonprice attributes. Including such interactions allows people's preferences for total fat content, for example, to depend on the type of fat present. We expect that people are less averse to higher levels of total fat content if the type of fat present is healthier (i.e., lower in saturated fat). The nonlinear utility specification is given by:

$$\begin{aligned}
 V_j = & \alpha_j + B_1(\% \text{ fat}) + B_2(\text{Saturated fat } \%) \\
 & + B_3(\text{Omega 6 to Omega 3 ratio}) \\
 & + B_4(\text{Conjugated Linoleic Acid } \%) \\
 (5) \quad & + B_5(\text{Price}) + B_6(\% \text{ fat} * \text{Saturated Fat}) \\
 & + B_7(\% \text{ fat} * \text{Omega 6.3 ratio}) \\
 & + B_8(\% \text{ fat} * \text{CLA}).
 \end{aligned}$$

In equation (5), the marginal utility of, and thus willingness-to-pay for, saturated fat, for example, now depends on the amount of total fat.

Measuring Preferences for Methods of Improving Fat Content with Best-Worst Questions

In addition to identifying consumers' preferences for fat type and content in ground beef, we also sought to determine which methods consumers most preferred producers use to improve the fat content in ground beef. A typical approach taken in marketing and psychology literature to measure the level of importance or relative preference is simply to ask people to rate several items on a scale of, say, 1–5 where 1 equals "not at all important" and 5 equals "very important." A difficulty with such methods is that they do not force people to make trade-offs and it is common for people to rate all items as "very important." Further, with such ratings, different people are likely to use the scale differently, with a "5" for one person possibly representing a "4" for another. Finally, the results have no natural interpretations. That is a score of "3" has no meaning outside the survey context.

To sidestep some of these problems and investigate people's relative preferences for different methods to improve fat content, we turned to the use of "best-worst" or "maximum difference" scaling originally introduced by Finn and Louviere. Marley and Louviere have further identified the theoretical properties of

probabilistic, best-worst choice models. This method is rapidly gaining popularity in business-marketing research (e.g., Sawtooth Software) and has been recently been applied to health care issues (Flynn et al.). Best worst scaling, as developed by Finn and Louviere, involves asking the respondent to simultaneously choose their "most" and "least" preferred options out of a set of several competing options. Obviously, by asking people to indicate the "best" and "worst," provides much more information than asking the respondent to choose only the "best" or "most important" or "most preferred." Two key advantages of the best-worst methods over Likert-type scaling methods are (i) they force people to make trade-offs between levels of concern, and (ii) the measured level of "concern" or "importance" can be placed on a ratio scale, where one can legitimately say that issue X is, for example, twice as important as issue Y. Potential downsides to the best-worst method over the Likert-type scaling methods are (i) the responses are more difficult to analyze and results are more difficult to convey to "lay" audiences, and (ii) answering the best-worst questions is likely more challenging for survey respondents than answering simple Likert scale questions.

Respondents in our survey were asked to answer eight questions to determine preferences for the method used to improve the fat content of the beef. In particular, respondents were asked to pick the most preferable and least preferable method of improving the fatty acid content out of the competing methods given to them. Figure 2 illustrates an example of one of the best-worst questions. The six methods shown in Figure 2 correspond to the methods of improving fat content that have been studied in the animal science literature along with a few other issues that may be utilized by the industry: grass feeding, sorting and labeling, genetic testing, feeding flaxseed oil, feeding fish meal, and cloning.

Given the strong interaction between alternative feeding methods and product taste (e.g., see Umberger et al.), it is worth considering how meaningful it is to ask people to evaluate beef alternatives when they are likely unaware of how flavor might change. In this regard, it is

What is the most preferable and least preferable option to improve the fatty acid content of beef (check one option as the most preferable and one option as the least preferable)

Most Preferable		Least Preferable
<input type="checkbox"/>	cattle fed a diet primarily consisting of grass or green-leafy hay	<input type="checkbox"/>
<input type="checkbox"/>	supplement cattle diets with fish meal	<input type="checkbox"/>
<input type="checkbox"/>	supplement cattle diets with flaxseed oil	<input type="checkbox"/>
<input type="checkbox"/>	use genetic testing to breed only those cattle with improved fatty acid content	<input type="checkbox"/>
<input type="checkbox"/>	sort existing cattle and label those with improved fatty acid content	<input type="checkbox"/>
<input type="checkbox"/>	clone cattle with improved fatty acid content	<input type="checkbox"/>

Figure 2. Example Best-Worst Question Related to Methods for Improving Fat Content

important to recognize that product taste is not all that matters when people make decisions of whether and which brand of beef to buy, and perceptions about quality, safety, and so on, play a prominent role. It is true in repeat purchases that taste will ultimately feed back into the decision making process, but people's perceptions about alternative approaches of changing fat content are important too.

Figure 2 illustrates the case where respondents were asked to choose the most and least preferred method from all six methods studied. To present competing choice options to respondents, a main-effects fractional factorial design was utilized. In particular, a 2^6 full factorial design was constructed that indicated whether each of the six attributes was present or absent in the choice set (i.e., the two levels for each issue are present or absent), and nine choice sets were selected from this full factorial such that the presence or absence of each issue was independent of the presence or absence of each of the other issues. Because two survey versions were employed to accommodate the 18 choice experiment questions discussed in the previous subsection, one half of the survey respondents received the original nine best-worst choice sets and the other half received the fold-over of the original design (note: the fold-over design is created by replacing all "present" with "absent" and vice versa). This design ensures that each of the six issues

appears an equal number of times (four to be precise) across all eight choice sets. This means that the maximum number of times an issue can be picked as "best" or "most preferred" by an individual is four, whereas the maximum number of times an issue can be picked as "worst" or "least preferred" by an individual is also four.

Consumers can be conceptualized as choosing the two items that maximize the difference between two items on an underlying scale of preference. If a choice set has J items, then there are $J(J - 1)$ possible best-worst combinations a person could choose. The particular pair of items chosen by the consumer as best and worst (or least and most preferable), then, represents a choice out of all $J(J - 1)$ possible pairs that maximizes the difference in preference.

Formally, let λ_j represent the location of item j on the underlying scale of preference/importance and let the true or latent unobserved level of preference for individual i be given by $I_{ij} = \lambda_j + \varepsilon_{ij}$, where ε_{ij} is a random error term. The probability that the consumer chooses, say, item j and item k , as the best and worst, respectively out of a choice set with J items, is the probability that the difference in I_{ij} and I_{ik} is greater than all other $J(J - 1) - 1$ possible differences in the choice set. If the ε_{ij} are distributed iid type I extreme value, then this probability takes the familiar multinomial-logit form:

Prob(*j* is chosen best and *k* chosen worst)

(6)
$$= \frac{e^{\lambda_j - \lambda_k}}{\sum_{l=1}^J \sum_{m=1}^J e^{\lambda_l - \lambda_m} - J}$$

The parameters in equation (6), λ_j , can be estimated by standard maximum likelihood techniques.

One useful feature of the estimates obtained from this model is that they can be used to determine the relative preference consumers have for each of the methods on a ratio scale. In particular, the estimated coefficients can be substituted back into the typical multinomial logit formula to determine the “share of preference” for each issue. These shares of preferences must sum to 100% and correspond the frequency of people in the population that would be expected to pick each issue as most preferable. If one method has a “share of preference” score twice that of another method, then, because the measurement lies on a ratio scale, one can properly interpret the result as saying the former method is twice as preferable as the latter method.

Measuring Relative Importance of Ground Beef Attributes with Best-Worst Questions

Of course, fat content is not the only attribute consumers may consider when purchasing beef.

As such, it is important to determine how important fat content is relative to other attributes that industry groups could focus on to improve demand. To determine which attributes, including fat content, were most important when consumers purchased ground beef, we again utilized the best-worst scaling approach.

Eight additional best-worst questions were asked regarding the importance the respondents place on several attributes when making a decision to purchase ground beef. These attributes were expiration date, food safety, price, fatty acid composition, total amount of fat and package size. Because there were six attributes, we simply used the same experimental design described in the previous subsection. The respondent was asked to answer these in the same manner as the preference questions regarding improving the fat content in ground beef, but the underlying measurement scale was changed from “most preferable/least preferable” to “most important/least important.” Thus, the best-worst results will indicate the position of each of the attributes on the underlying scale of importance. An example best-worst question involving all six attributes is shown in Figure 3. The same data analytic approach described in the preceding subsection is used to analyses the responses to these best-worst questions as well.

When you purchase beef steaks, which of the following attributes is the most important and which is the least important? (check only one attribute as the most important and one attribute as the least important)

Most Important		Least Important
<input type="checkbox"/>	expiration date	<input type="checkbox"/>
<input type="checkbox"/>	price	<input type="checkbox"/>
<input type="checkbox"/>	food safety	<input type="checkbox"/>
<input type="checkbox"/>	total amount of fat	<input type="checkbox"/>
<input type="checkbox"/>	package size	<input type="checkbox"/>
<input type="checkbox"/>	fatty acid composition	<input type="checkbox"/>

Figure 3. Example Best-Worst Question Related to Relative Importance of Beef Attributes

Results

Overall there were 241 surveys returned. After accounting for undeliverable addresses, this implies a 12.7% response rate. The sample size was further reduced to 220 people who answered all choice-based conjoint questions. Because each person answered eight choice questions, this implies that 1,760 choices are available for analysis, which implies a low level of sampling error. In particular, we can be 95% confident that the true proportion of people predicted to choose option A or B for a conjoint question is within plus or minus 2.4% of the true proportion in the population. Sampling error, however, is not the only concern in surveys, and one must be concerned with the potential for nonresponse bias—that the respondents to the survey differ systematically from the population. To address this issue, Table 2 reports summary statistics of our sample of respondents as compared with data from the most recent Current Population Survey of the U.S. Census Bureau. Although our sample matches the population reasonably well on some characteristics (e.g., education, gender, and location), it differs from the population in terms of age and income. Thus, following common practice in survey research, we created sample weights using iterative proportional fitting

techniques based on all variables shown in Table 2. As can be seen in the last column of Table 2, this procedure forces the sample proportions, when weights are applied, to match the population proportions in terms of age, education, gender, location, and income. The calculated weights are used in all the remaining regression analyses to ensure that the estimated models and willingness-to-pay values are representative of the population—at least in terms of age, education, gender, location, and income.

Table 3 reports estimates of the multinomial logit model fit to the choice-based conjoint questions. The first column of results corresponds to the linear model without interactions and the last column includes interaction effects between total fat and the other nonprice attributes.

Overall, results are consistent with *a priori* expectations. People dislike increases in total fat, saturated fat, the Omega 6:3 ratio, and price. All coefficients are statistically significant except that related to CLA. Apparently consumers' choices were not significantly influenced by this type of fat. The hypothesis that the interaction effects are zero is rejected at the $p = 0.01$ level according to a likelihood ratio test, suggesting that model 2 is the appropriate specification.

Table 2. Characteristics of Survey Respondents ($n = 220$)

Category	U.S. Census	Unweighted Sample	Weighted Sample
18–34 years	30.7% ^a	7.7%	30.7%
35–44 years	19.2%	15.0%	19.2%
45–54 years	19.5%	24.6%	19.5%
55–64 years	14.5%	26.4%	14.5%
65+ years	16.2%	26.4%	16.2%
No Bachelor's degree	73.8%	70.9%	73.8%
Bachelor's degree or higher	26.2%	29.1%	26.2%
Female	51.6%	49.6%	51.6%
Northeast U.S. Census Region	18.1%	15.5%	18.1%
Midwest U.S. Census Region	22.0%	26.4%	22.0%
South U.S. Census Region	36.6%	38.2%	36.6%
West U.S. Census Region	23.2%	20.0%	23.2%
Annual HH income less than \$25,000	25.3%	6.8%	25.3%
Annual HH income \$25,000 to \$99,999	55.6%	65.5%	55.6%
Annual HH income \$100,000 or more	19.1%	27.7%	19.1%

^a Percent of respondents falling in the respective category.

Table 3. Results from Choice-Based Conjoint Questions: Multinomial Logit Model Estimates

Variable	Model 1	Model 2
Intercept	5.939 ^a (0.270) ^b	8.721* (0.808)
Fat	−0.056* (0.007)	−0.230* (0.047)
Saturated Fat	−0.056* (0.004)	−0.107* (0.012)
Omega 6:3 Ratio	−0.178* (0.017)	−0.336* (0.054)
CLA	0.025 (0.173)	−0.526 (0.807)
Price	−0.423* (0.042)	−0.431* (0.042)
Fat*Saturated Fat		0.003* (0.001)
Fat* Omega 6:3		0.010* (0.004)
Fat* CLA		0.036 (0.055)
Number of Respondents	220	220
Number of Choices	1980	1980
Log Likelihood	−2744.48	−2734.61
Chi-Square Statistic ^c	854.38*	874.11*
McFadden’s LRI	0.135	0.138

^a One (*) asterisk represent 0.01 level of statistical significance.
^b Numbers in parentheses are standard errors.
^c Chi-square statistic associated with a test of the hypothesis that all model parameters are zero.

Tables 4 and 5 report willingness-to-pay (WTP) estimates for various levels of total fat, saturated fat, and Omega 6:3 ratios. Because the interaction effects between attributes were statistically significant, willingness-to-pay for total fat depends on saturated fat and vice versa. To determine WTP from model 2 in Table 3, we calculated total WTP for a one pound package of ground beef with 10% total fat and 30% saturated fat holding CLA and omega 6:3 ratio constant at the values of 0.7% and 2:1, respectively. Noting that the utility of the “none” or “neither” option has been normalized to zero, total WTP for a package of ground beef with 10% total fat and 30% saturated fat, using the notation from equation (5), is:

$$\begin{aligned} \text{Total WTP} = & -[\alpha_j + B_1(10) + B_2(30) + B_3(6) \\ & + B_4(0.07) + B_6(10*30) \\ & + B_7(10*6) + B_8(10*0.7)]/B_5 \end{aligned}$$

This is the dollar amount that, when taken from a person, would make them indifferent to having the package of ground beef and choosing the “neither” option. Because package size (or weight) is not one of the explanatory variables included in the experimental design, WTP for a change in fat content does not depend on size. Thus, theoretically, the unit of measurement associated with WTP is dollars per choice. Nonetheless, because people were told that they were evaluating 1 lb packages, it tempting to interpret the measures on a per-pound basis;

Table 4. Total and Marginal Willingness-to-Pay (\$/choice) for Total Fat and Saturated Fat from Nonlinear Model

	Total Fat		WTP Reduce Total Fat from 20% to 10%
	10%	20%	
Saturated Fat			
30%	\$8.29 [7.40, 9.61] ^a	\$6.23 [5.55, 7.14]	\$2.06 [1.35, 2.93]
50%	\$4.81 [4.27, 5.51]	\$4.23 [3.65, 4.93]	\$0.58 [−0.18, 1.32]
WTP to reduce saturated fat from 50 to 30% of total fat	\$3.48 [2.79, 4.41]	\$2.00 [1.44, 2.66]	

Note: Omega 6:3 ratio and CLA and held constant at 2 and 0.7%, respectively.
^a Numbers in brackets are 95% confidence intervals determined by parametric bootstrapping.

Table 5. Total and Marginal Willingness-to-Pay (\$/choice) for Total Fat and Omega 6:3 from Nonlinear Model

Omega 6:3 Ratio	Total Fat		WTP Reduce Total Fat from 20% to 10%
	10%	20%	
2	\$8.29 [7.40, 9.61] ^a	\$6.23 [5.55, 7.14]	\$2.06 [1.35, 2.93]
6	\$6.09 [5.43, 7.08]	\$4.93 [4.32, 5.69]	\$1.15 [0.46, 2.04]
WTP to reduce Omega 6:3 ratio from 6 to 2	\$2.21 [1.73, 2.82]	\$1.30 [0.81, 1.90]	

Note: Saturated fat and CLA are held constant at 30% and 0.7%, respectively.
^a Numbers in brackets are 95% confidence intervals determined by parametric bootstrapping.

however, the theoretically correct interpretation is dollars per choice between one pound packages. After the total WTP value was determined as above, WTP for a package of ground beef was estimated again holding everything constant at the values used above except changing percent saturated fat to 50%. Subtracting the two numbers then causes WTP to change from 50% saturated fat to 30% saturated fat when total fat is held constant at 10%. This same procedure was repeated by changing select variables to cause WTP to change from 20% to 10% fat and WTP to change from an Omega 6:3 ratio of 6:1–2:1.

Table 4 shows consumers are willing to pay \$2.06 to reduce total fat from 20% to 10% when saturated fat is 30% of total fat, but only \$0.58 when saturated fat is 50% of total fat.

The value consumers place on reducing saturated fat from 50 to 30% is \$3.47 when total fat is 10%, but only \$2.00 when total fat is 20%. As illustrated in Figure 4, these results imply a strong interaction effect between total fat content and saturated fat content. As suggested by Louviere, Hensher, and Swait, these interaction effects can be interpreted as attributes having complement/substitute relationships. That a reduction in saturated fat is valued more highly when total fat content is low suggests the two attributes are complements, that is, consumers prefer having low saturated fat and low total fat *together* more than the linear extrapolation of these values would imply. That is, WTP for low saturated fat and low total fat is superadditive.

The estimates in Table 4 imply that consumers are willing to pay roughly \$0.21 and

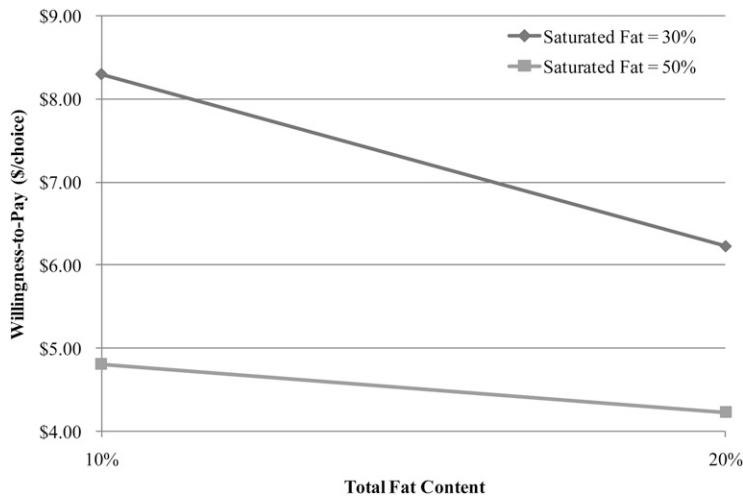


Figure 4. Willingness-to-Pay (\$/choice) for Beef of Differing Fat Contents

\$0.06, respectively for each additional percentage reduction in total fat, given that saturated fat is 30% and 50% of total fat, respectively. This latter result (a value of \$0.06 for each unit of leanness) is reasonably close to Parcell and Schroeder's estimate from a hedonic study of actual transactions of about \$0.04/lb. The figure is also similar to the estimate from the hedonic study conducted by Ward, Lusk, and Dutton, who found that the price premium for ground beef packages between 5 and 10% fat to be about \$0.82/lb greater than price premiums for ground beef packages between 16 and 20% fat—implying a marginal value of about \$0.078/lb. Furthermore, given that the dollar amounts reported in Table 4 are economically large, one might question whether they are “too large.” As just mentioned, our calculated WTP for a 1% change in total fat content is very similar to two previous hedonic studies, which used actual price differences observed in the marketplace, suggesting a reasonable level of validity. Further, as shown in these hedonic studies, there are often economically and statistically significant differences in ground beef prices. For example, Ward, Lusk, and Dutton found market premiums for ground beef (in \$/lb) of \$0.94 for beef with a “special label,” \$0.74 for beef with a “raised without added antibiotics” claim, \$0.82 for beef with an expiration date vs. beef without, and \$1.96 for ground beef sold in “specialty” stores vs. discount stores. These market premiums are additive, suggesting that a product with a special label sold in a specialty store with a “no antibiotics” claim and an expiration date would command a $\$0.94 + \$0.74 + \$0.82 + \$1.96 = \$4.46/\text{lb}$ premium over an alternative product without such characteristics. Given the magnitude of these observed price differences, it is difficult to naively conclude that the values shown in Table 4 are somehow out of line with observed premiums in the market place.

Table 4 also shows that consumers place significant values on changes in saturated fat, ranging from \$3.48 to \$2.00 depending on total fat content, as compared with the value of changes in total fat, which ranges from \$2.06 to \$0.58 depending on saturated fat levels. Similarly,

Table 5 also shows that consumers place significant value on reductions in the Omega 6:3 ratio: ranging from \$2.21 to \$1.30 depending on total fat content. These results suggest people place significant value the *type* of fat in ground beef. Indeed, WTP for marginal changes in fat type are generally higher than WTP for marginal changes in total fat. This suggests that consumers believe the type of fat in ground beef to be as important or more important than the total amount of fat.

The question now becomes how consumers would prefer that the type of fat be improved. Table 6 reports results from the best-worst choices made in regard to preferences for competing methods of improving the fat content in ground beef. Results reveal that the most preferred method of improving fat content in the ground beef is to feed the cattle a diet primarily consisting of grass, whereas the least preferred method is to clone cattle. The relative desirability of the competing methods is illustrated in Figure 5. The estimated share of preferences suggest that almost 40% of people would most prefer grass feeding as the method to improve fatty acid content in ground beef. Sorting and labeling was also relatively desirable, but only half as desirable as grass feeding. Virtually no one believes cloning is the most preferable method to improve fatty acid content of beef.

Table 7 reports the results of the multinomial logit model fit to the best-worst questions related to what consumers believe to be the most and least important attributes when purchasing ground beef. Results indicate the most important factor when purchasing ground beef is food safety. The next most important attribute was found to be the expiration date of the beef which is also a factor related to food safety. The attribute that was of least important was package size. Fatty acid composition was found to be the next least important, ranked 5th in importance. Although fat type was not rated as very important, total amount of fat in the ground beef was the third most important attribute that consumers consider when purchasing ground beef. This result somewhat contradicts the findings from the choice-based estimates, which suggested changes in

Table 6. Results from Best-Worst Question Related to Methods for Improving Fat Content: Multinomial Logit Estimates

Method	Definition	Multinomial Logit Estimates	Share of Preference
Grass feeding	Feed cattle a diet primarily consisting of grass or green leafy hay	2.916 ^{*,a} (0.103) ^b	40.33%
Sorting and labeling	Sort existing cattle and label those with improved fatty acid content	2.193* (0.097)	19.59%
Genetic testing	Use genetic testing to breed only those cattle with improved fatty acid content	1.680* (0.093)	11.73%
Feeding flaxseed oil	Supplement cattle diets with flaxseed oil	1.789* (0.087)	13.09%
Feeding fish meal	Supplement cattle diets with fish meal	1.789* (0.091)	13.08%
Cloning	Clone cattle with improved fatty acid content	0	2.19%
Number of respondents		193	
Number of choices		1374	
Log likelihood		-2601.45	
Chi-square statistic ^c		1368.0*	
McFadden's LRI		0.208	

^a One (*) asterisk represent 0.01 level of statistical significance.

^b Numbers in parentheses are standard errors.

^c Chi-square statistic associated with a test of the hypothesis that all model parameters are zero.

saturated fat and the Omega 6:3 ratio had larger influence in utility than changes in total fat. The difference in results is perhaps attributable to the use of the phrase “fatty acid composition” in the best-worst importance questions. Had the words “saturated fat” or “Omega 6:3 ratio” been as in the choice-based conjoint question, a more consistent result may have been obtained. Another possible reason for the

difference is that in the best-worst questions, consumers were asked which attributes were most/least important when currently buying beef. However, consumers cannot easily ascertain fat composition when currently purchasing beef due to the lack of labels providing such information. The absence of such information may have resulted in consumers rating “fatty acid composition” as of low importance

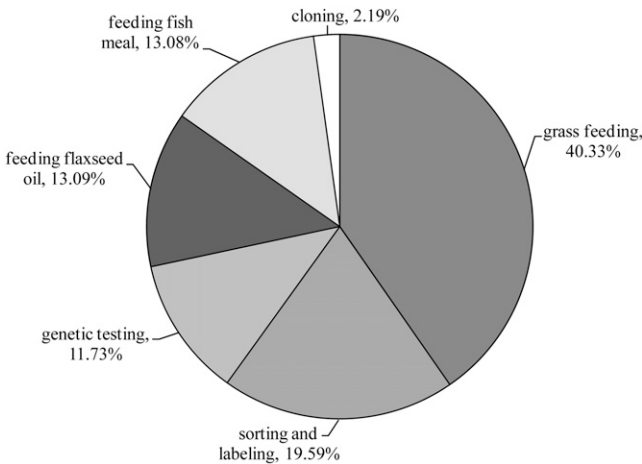
**Figure 5.** Relative Desirability of Methods for Improving Fat Content in Ground Beef

Table 7. Results from Best-Worst Question Related to Importance of Beef Attributes: Multinomial Logit Estimates

Attribute	Multinomial Logit Estimates	Share of Preference
Food safety	1.868 ^{*,a} (0.085) ^b	32.82%
Expiration date	1.464* (0.080)	21.92%
Total fat	1.256* (0.079)	17.79%
Price	0.890* (0.078)	12.34%
Fatty acid composition	0.686* (0.076)	10.06%
Package size	0	5.07%
Number of respondents	193	
Number of choices	1374	
Log likelihood	−2873.74	
Chi-square statistic ^c	1368.01*	
McFadden’s LRI	0.125	

^a One (*) asterisk represents 0.01 level of statistical significance.
^b Numbers in parentheses are standard errors.
^c Chi-square statistic associated with a test of the hypothesis that all model parameters are zero.

to them currently; of course, such a finding need not hold if such information was readily available. Another issue to consider when interpreting the important measures shown in Table 7 is that the best-worst approach does not mention anything to consumers about the current levels of safety or fat content. In conjoint-type studies, for example, the level of importance is measured by calculating the utility difference in the best and worst levels within an attribute (or issue), but in the best-worst approach, no specific attribute levels are mentioned. Thus, the calculated importance scores in Table 7 can be interpreted as being measured at the levels that endogenously come to mind for the consumer.

Implications and Conclusions

This study investigated consumer preferences for the amount and type of fat in ground beef. Results from choice-based conjoint questions revealed that consumers place significant values on the amount of saturated fat and the Omega 6:3 ratio, but that choices were unaffected by the level of conjugated lineolic acid. Overall, willingness-to-pay for changes in amount of saturated fat and the Omega 6:3 ratio were as large or larger than willingness-to-pay for changes in the total amount of fat. These results suggest it may be profitable for industry participants to market and sell beef products that

are healthier for the consumer. Current ground beef labeling is restricted only to indications of total fat content, but results from the choice-based conjoint questions suggest consumers may be just as interested in the type of fat in ground beef.

Producers have at their disposal several alternatives to improve the fat composition of ground beef. Results reveal that consumers most prefer improving the type of fat in ground beef by feeding a diet of grass. Even if agribusinesses were able to achieve improved fat content by selective breeding and sorting, such an approach is viewed as relatively desirable to consumers. When one takes into consideration that grass feeding is likely to change the taste of ground beef in ways that may be undesirable to consumers (i.e., see Umberger et al.), this suggests that looking for animals that have a genetic predisposition to produce lower levels of saturated fat and Omega 6:3 ratios may be a more promising direction. Consumers found the use of flaxseed oil and fish meal supplements to improve fatty acid content to be less desirable than grass-feeding and genetic testing/sorting, but such methods were strongly preferred to cloning.

Finally, the survey sought to identify the importance of fat type and content relative to other attributes consumers may consider when purchasing ground beef. Results reveal consumers find food safety to be of more concern

than fat content. However, the total amount of fat in ground beef was found to be more important than price or package size. If one combines the relative importance of total fat content and fatty acid composition, fat-related issues were only second in importance to food safety.

The next step in this research program is to compare the estimated benefits to costs of improving fatty acid content. The estimates of the marginal value of reductions in total fat content obtained from our survey compared well with previous hedonic studies on the issue, but additional work should focus on determining whether the estimated values for saturated fat and Omega 6:3 ratios hold up in nonhypothetical settings with real food and real money. The results presented in this paper provide a much needed first step in determining the market potential for what would historically have been seen as an oxymoron: heart healthy beef.

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