Nutrition Knowledge, Sensory Characteristics and Consumers' Willingness to Pay for Pasture-Fed Beef

Hong Xue
Department of Agricultural Economics and Applied Economics
Virginia Tech
hxue@vt.edu

Denise Mainville
Department of Agricultural Economics and Applied Economics
Virginia Tech

Wen You
Department of Agricultural Economics and Applied Economics
Virginia Tech

Rodolfo M. Nayga, Jr
Department of Agricultural Economics and Agribusiness
University of Arkansas

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, WI, July 26-28, 2009.

Abstract

Nutritional value is an important attribute of foods whose benefits can only be experienced by repetitive consumption in long run. Consumers' knowledge about the importance and usefulness of specific nutrients in a food product may influence their subjective expectation of the product's health benefits which in turn is translated into their perception of the product's value. At the same time, the sensory characteristics of food products affect consumers' immediate consumption gratification. This study makes a unique contribution to the literature by exploring the roles that nutrition knowledge and sensory evaluation play in shaping consumers' pasture-fed beef purchasing behavior through economic experiments. Our results suggest that beef products' sensory characteristics play a central role in determining consumers' preferences and willingness to pay. Nutrition knowledge significantly influences consumers' willingness to pay and different types of nutrition knowledge influence consumers' willingness to pay in distinct ways. The significant impact of consumers' health status on their willingness to pay is identified.

The study advances the literature by providing empirical evidence of the relationship between nutrition knowledge, sensory evaluation, and consumers' purchasing behavior observed right at the point of purchase. It can help policy makers better understand consumers' food behavior and make initiatives to improve diet and health.

Nutritional value is an important attribute of foods whose benefits can only be experienced by repetitive consumption in long run. Consumers' knowledge about the importance and usefulness of specific nutrients in a food product may influence their subjective expectation of the product's health benefits which in turn is translated into their perception of the product's value. Using pasture-fed beef (PFB) as a vehicle, this study intends to offer empirical evidence of the influence of consumers' nutrition knowledge on their food behavior. Enhanced nutritional value is one of the favorable quality attributes of PFB compared to feedlot conventional beef. Consumers obtain the information about PFB's nutritional attributes from government, advertisements, food labels, and other sources and assess the anticipated health benefits from PFB consumption based on subjective means. Consumers' nutrition knowledge determines the effectiveness of such information processing which influences their valuation of the nutritional attributes of PFB. Previous studies have identified the correlation between consumers' nutrition knowledge and food choice (e.g. Elbon 1996; Harnack 1997; ERS 2000; Wardle et al. 2000), indicating that knowledge is significantly associated with healthy food choice. However, eating healthier foods usually costs more (Monsivais and Drewnowski 2007). This raises a question of whether consumers with higher levels of nutrition knowledge are willing to pay more for food with better nutrition quality. Existing literature does not provide a satisfying answer to this question. To address this research gap, this study uses experimental economics tools to explore the associations between nutrition knowledge and consumers willingness to pay (WTP) for PFB. We develop two sets of survey questions to measure consumers' nutrition knowledge. One set measures consumers' familiarity with the function of four

specific nutrients --- Vitamin A, Vitamin E, Omega 3 and CLA each of which is present in greater amount in pasture-fed beef than they are in conventionally produced beef. The other set probes consumers' knowledge of the main food sources of these nutrients. When consumers process the nutritional information, their knowledge about the nutrient functions affects their expected utility from consuming PFB while their knowledge about the nutrient sources influences their purchasing decisions for alternative nutritious food. The net effect of these two types of knowledge is reflected in the value that they perceive for PFB. Thus, the hypothesis we test is that nutrition knowledge has significant impact on consumers' WTP for PFB.

Perception of the sensory characteristics of food products are key indicators of consumers' food preference since they are determinants of the immediate consumption experience. For beef products, these characteristics include the visual appeal and the taste quality. Pasture-fed cattle are generally marketed as "free range," living in a more natural way than those confined in factory farms and feedlots. The natural diets of pasture-fed cattle consist of only grasses, hay, or grass silage. As a result, the meat characteristics of PFB are different from conventional beef in terms of the tenderness, juiciness, flavor, color, meat texture, etc. According to Melton et al. (1996) study, appearance and tasting experience are important predictors for consumer perceptions and WTP for fresh food. In this study, a sensory evaluation is performed to analyze how and to what extent that these sensory characteristics can influence consumers' choices and WTP.

While the main effects of the sensory characteristics on consumers' beef preference and WTP are expected to be significant, consumers with different levels of

nutrition knowledge may tend to value these characteristics in their purchasing decisions differently. High knowledge consumers may place greater importance on the health benefits from consuming healthier beef products; low knowledge consumers may be more likely to respond to the eating satisfaction. For this reason, we assess the interaction effects between nutrition knowledge and sensory evaluation on consumers PFB preference and WTP treating nutrition knowledge as a moderator. We attempt to test if the sensory characteristics of PFB and nutrition knowledge interactively impact consumers' WTP for PFB.

In our study, we conduct in-store experiments to examine consumers' preference and WTP for pasture-fed beef (PFB) using the Becker-DeGroot-Marshak (BDM) auction. In our experiments, we first collect the participants' background information, including their beef consumption habits, experience with PFB, health related information, and demographic information. Then at the sensory evaluation stage we conduct a visual test and a palatability test to study consumers' perception of the sensory characteristics of PFB. In the visual test, participants rate the lean meat color, fat color, and meat texture of PFB and conventional beef. In the palatability test, participants rate the PFB and conventional beef in terms of beef's tenderness, juiciness, and flavor. After the tests, participants who prefer PFB are given a pound of conventional beef as well as an opportunity to bid to upgrade their conventional beef to PFB under the BDM auction rule. A nutrition information shock is randomly introduced before the sensory evaluation stage or before the auction stage to examine the information impact on consumers' WTP.

The remainder of the article proceeds as follows: in section II, we discuss the conceptual framework; in section III, we explain the experimental design; in section IV, we present summary results of the experimental data; in section V, we discuss the empirical model and estimation results; section VI concludes the article.

Conceptual Framework

Consumers obtain utility from a bundle of attributes of beef products, such as nutritional benefits and taste. The nutritional value is different from other attributes in the sense that, at the point of purchase, its effects can only be perceived under expectation. The difference in consumers' the expected utility of consuming PFB and the expected utility of consuming conventional beef determines their WTP for PFB. Based on this assumption, we derive consumers' WTP for PFB under Von Neumann and Morgenstern's (1944) random utility framework.

We assume a consumer's expected utility of consuming one pound of PFB is of the form:

$$(1) \qquad EU_1 = \pi^1 u_c(m, X, Z, S; 1) + (1 - \pi^1) u_{nc}(m, X, Z, S; 1)$$

Where m denotes the consumer's income. X is a vector of observable characteristics of the choice and Z is a vector of the unobservable attributes of the choice. The socio-economic characteristics of the consumer are denoted by a vector S. The number 1 denotes that the consumer decides to purchase one pound of PFB. To factor the nutritional information effect into the model, we let this representative consumer face two states: the occurrence or nonoccurrence of the positive health outcome from purchasing PFB. u_c, u_{nc} denote the state-dependent utility of occurrence and nonoccurrence

respectively. The probabilities attached to the two states when the consumer chooses to purchase PFB are: π^1 for occurrence and $1-\pi^1$ for nonoccurrence. These probabilities do not indicate the occurrence/ nonoccurrence of positive health outcomes from one-time PFB consumption; rather they reflect the cumulative outcomes from repeated consumption. Note the fact that consumers are offered numerous alternatives by the market and they can gain possible health benefits by choosing to consume other products, we therefore set the probabilities the consumer faces when he chooses not to purchase PFB as: π^0 for occurrence of a positive health outcome and $1-\pi^0$ for nonoccurrence. Similarly, the expected utility of choosing not to consume PFB is:

(2) $$EU_0 = \pi^0 u_c(m, X, Z, S; 0) + (1-\pi^0) u_{nc}(m, X, Z, S; 0)$$

Incorporating the monetary cost of purchasing PFB, the consumer's expected utility of consuming one pound of PFB is

(3) $$EU_1 = \pi^1 u_c(m - WTP, X, Z, S; 1) + (1-\pi^1) u_{nc}(m - WTP, X, Z, S; 1)$$

WTP is the consumer's willingness to pay for PFB. In our experiment, consumers' nutrition knowledge is categorized as the knowledge of nutrient function and the knowledge of the nutritious food sources, denoted as k_f and k_s. We hypothesize that a consumer's knowledge of the nutrient functions assists the consumer to process the nutritional information of PFB more effectively and thus the consumer will hold more positive attitudes about consuming PFB; at the same time, if a consumer has good knowledge of the food sources of the nutrients emphasized in the nutrition information of PFB, he will be aware of the alternative food choices in the market and thus be less

positive about consuming PFB. We thus assume that the consumer's nutrition knowledge k favorable to PFB is a function of both nutrient function knowledge and food source knowledge $k = \alpha k_f + \beta k_s$ and hypothesize that $\alpha > 0$ and $\beta < 0$. We assume that the knowledge k and new information I provided enter the model via probability, i.e. π^0 and π^1 are functions of $k(k_f, k_s)$ and I. Differentiating equation (3) with respect to WTP and information k, we have

$$(4) \qquad \frac{dWTP}{dk} = \frac{\pi^1{}' u_c - \pi^1{}' u_{nc}}{\pi^1 u_c{}'} > 0$$

The sign is deterministic because the utility of the occurrence of the desired state is assumed to be greater than the utility of the nonoccurrence state. If we disentangle the effects of the nutrient function knowledge and food source knowledge, under our hypothesis, equation (4) suggests that

$$(5) \qquad \frac{dWTP}{dk_f} = \frac{dWTP}{dk}\alpha > 0$$

$$(6) \qquad \frac{dWTP}{dk_s} = \frac{dWTP}{dk}\beta < 0$$

Hanemann (1984) shows a utility maximization based approach to obtain the utility-theoretical measure of the money value of a permit to the individual hunter. Using the similar method, we set the expected utility as

$$(7) \qquad EU_d = EV_d(m, X, Z, S, \pi^d; d) + \varepsilon_d$$

Where

$$(8) \qquad E[EU_1] = EV_1(m, X, Z, S, \pi^1; 1)$$

(9) $E[EU_0] = EV_0(m, X, Z, S, \pi^0; 0)$

d is a state variable: d = 1 if the individual chooses to purchase PFB; d = 0, otherwise. $\varepsilon_0, \varepsilon_1$ are iid random variables with zero means. A money value of the individual's maximum WTP for one pound of PFB should satisfy

(10) $EV_1(m - WTP, X, Z, S, \pi^1; 1) + \varepsilon_1 = EV_0(m, X, Z, S, \pi^0; 0) + \varepsilon_0$

we can set

(11) $\Delta EV = EV_1(m - WTP, X, Z, S, \pi^1; 1) - EV_0(m, X, Z, S, \pi^0; 0)$

Then

(12) $\Pr\{\eta < \Delta EV(WTP)\} = F_\eta[\Delta EV(WTP)\ ]$=p

Where $\eta = \varepsilon_0 - \varepsilon_1$, $F(\cdot)$ denotes the CDF of η. p is the probability that we perceive the consumer will purchase PFB. Thus,

(13) $\Delta EV(WTP) = F_\eta^{-1}(p)$

If we postulate some functional form of the expected utility function EV and chose a specific form of F_η which is ensured to have an inverse representation, we can solve equation (8) to get the individual's WTP for one pound of PFB

(10) $\text{WTP} = \Delta EV^{-1}(WTP \mid F_\eta^{-1}(p)) = w(m, X, k_f, k_s, I, S, Z)$

Experimental Design

Our experiment intends to answer questions such as: How do quality attributes and health information of PFB affect the value of PFB perceived by consumers? What kinds of consumers are more likely to prefer PFB to conventional beef? How much more are

consumers willing to pay for PFB than conventional beef? Visual test and palatability test are conducted to measure consumers' evaluation of the sensory characteristics of PFB, nutrition information is presented to participants to test the information influence, and Becker-DeGroot-Marshak (BDM) auction is employed to simulate the PFB purchasing situation that consumers face in real world.

Visual Tests and Palatability Tests

In the visual test, unlabeled samples of conventional New York strip steaks and Pasture-fed New York strip steaks are presented to the participant. The participants rate these attributes of the beef samples: (a) lean meat color: the color of beef muscle; (b) fat color: the color of intramuscular and marbling fat; and (c) meat texture: fineness or coarseness of the cut surface. We index each attribute on a discrete scale of 1 to 7, ranging from very pale (1) to very dark (7) for lean meat color, very white (1) to very yellow (7) for fat color, and very fine (1) to very coarse (7) for meat texture: Overall acceptability is rated from strongly like (1) to strongly dislike (7) (see Appendix A).

In the palatability test, the participants taste the two unlabeled steak samples and rate the tenderness, flavor, and juiciness of each sample. Again, we index each attribute on a discrete scale of 1 to 7, ranging from very tender (1) to very tough (7) for tenderness, very juicy (1) to very dry (7) for juiciness, and very intense (1) very bland (7) for flavor. Overall acceptability is also rated from strongly like (1) to strongly dislike (7).

Information Shock

Enhanced nutritional value is an important intrinsic attribute of PFB. Studies have found that PFB has high (a) the concentration of natural vitamin E[1] in PFB is 2 - 4 times higher than that found in conventional beef (Arnold et al., 1992); (b) pasture-fed cattle incorporate significantly higher amounts of β-carotene[2] into muscle tissues as compared to grain-fed cattle (Descalzo et al., 2005); (c) PFB has approximately 60% more Omega-3[3] fatty acids than conventional beef (Duckett et al. 1993); and (d) Pasture-fed cattle produce 2 to 3 times more CLA[4] than grain-fed cattle (Duckett et al. 1993). The impact of nutrition information on consumers WTP has been inadequately addressed in previous studies though it is critical to understanding how consumers' food purchasing behavior is affected by nutrition information. Therefore, we randomly introduce a nutrition information shock in our experiments to assess its effect on consumers WTP for PFB. The information shock consists of the provision of information describing the unique

[1] *Vitamin E supplementation may help prevent or delay coronary heart disease, block the formation of nitrosamines, and protect against the development of cancers by enhancing immune function.*

[2] *β-carotene is a safe dietary source for vitamin A supplementation. Vitamin A is a critical fat-soluble vitamin that is important for normal vision, bone growth, reproduction, cell division, and cell differentiation.*

[3] *Omega-3 fatty acids are essential fatty acids but cannot be produced by human body and they must thus be obtained from food. A proper balance of Omega-6/Omega-3 ratio helps maintain and improve health.*

[4] *Animal tests results have suggested that numerous health benefits can be attributed to CLA, including actions to reduce carcinogenesis, atherosclerosis, onset of diabetes, and fat body mass.*

nutrition attributes of PFB relative to conventional beef, including the high concentration of ß-Carotene, Vitamin E, Omega 3 and Conjugated Linoleic Acid (CLA) (see Appendix B). We use two sets of questions to measure consumers' nutrition knowledge. One measures consumers' familiarity with the function of the four nutrients: Vitamin A, Vitamin E, Omega 3 and CLA. The other probes consumers' knowledge of the main food sources of these nutrients. To ensure credibility of the information, we use research-based information which is excerpted from a research paper by Daley, et al. (2006).

Treatment Groups

We randomly assign subjects to three treatment groups numbered A, B, C. Group A is the control group in which a visual test and a palatability test are conducted first to measure consumers' perception of the physical quality of PFB, and then the BDM auction is conducted to elicit consumers' WTP for PFB for those for prefer it. This group is labeled as V+P group. In group B, we introduce the information shock first. Then the visual and palatability tests are conducted, and the auction is conducted following the tests. This group is labeled as I+V+P group. In group C, we conduct the visual and palatability tests, then introduce the information shock, and the auction is conducted last. This group is labeled as V+P+I group. This design provides a clear structure to disentangle treatment effect and sequencing effects. We randomly assign treatments during the experiment by drawing a group for each participant at the outset of the experiment.

Experimental Protocol

1. In the supermarket, we approach each potential participant randomly chosen from shoppers. We ask her/him if s/he is a beef consumer and if s/he is over the age of 18. If

s/he responds affirmatively to both questions, we then ask if s/he is the primary person who purchases food for her/his household and if s/he is the primary person who prepares food for her/his household. If s/he answers yes for either of the questions, then s/he is qualified for our experiment. We invite her/him to take the survey, and offer a $10 store gift for participating in the research.

2. After agreeing to participate, the participant completes the written survey portion of the experiment. The written survey is designed to collect the participant's beef consumption behavior, prior-experience with and expectations about PFB, health status, nutrition knowledge and demographic information (See Appendix C).

3. After the participant finishes the survey questions, the investigator randomly chooses one of the three group numbers as A, B, or C and treats the subject with corresponding treatments. We treat subjects with health-related information by letting subjects read the information card.

4. Following step 3, the participant is asked which sample s/he prefers and is then told which sample is which. If the participant is indifferent between two beef samples, then we terminate the experiment and give her/him $10 gift card for participating in the research. If the participant prefers conventional beef, the participant is also given $10 gift card and is asked a hypothetical question: how much would the pasture-fed beef have to be discounted compared to the price of conventional beef for you to buy it instead of conventional beef? No real transaction is made in this case. Finally, if the participant prefers pasture-fed beef, we give her/him $10 gift card and a pack of conventional beef. Then we explain to him that s/he can use part of the $10 gift card to upgrade her/his

conventional beef to PFB and we will play a simple game to determine the trade price. The game is explained as following: we give you $10 gift card and a pound of conventional beef. You tell us how much more you are willing to pay to trade your beef with one pound of pasture-fed beef. We then draw a sale price from a sealed box which contains possible prices. If the price we draw is lower than or equal to the price you offer, you purchase one pound of pasture-fed beef at the price we draw and can keep the rest of the $10 gift card; otherwise you can't buy the beef but can keep the $10 gift card (see Appendix D).

Data

The experiments were conducted in three supermarkets in Knoxville, TN, Middlesboro, KY and Bluefield, WV during September and October 2008. These experimental sites were chosen because they have relatively large and diverse populations within an easily accessible distance from researchers' university. The availability of the chain supermarket stores where we were allowed to conduct in-store experiments was another factor determining site selection. Therefore, generalizing the results from this study to a broader population should be made with conditions. Previous studies on shopping behavior show that different types of consumers have different shopping frequencies during a week (Kahn and Schimittlein 1989) and that consumers are more likely to shop on Thursday, Friday, and Saturday (East et al. 1994). The experiments thus were conducted in both weekday and weekend periods at each experimental site, throughout the morning, afternoon and evening hours to capture a broad range of consumers.

Table 1 summarizes the socio-demographic characteristics of our sample. Table 2 provides comparative data for each area. In general, the participants are predominately white, female, and middle aged. Most participants have some college education or above and are in the middle income category. Participants who are identified as householders living alone only comprise a small portion of the sample (30%, 10%, and 13% for Knoxville, Middlesboro and Bluefield respectively). In direct contrast with the population in each area, female consumers and non-single living consumers seem to be over-represented in our sample. However, this should not be treated as sampling bias but rather reflects the fact of disproportionate composition of primary food shoppers in terms of gender and living status, which may suggest the target group for PFB marketing.

Table 3 reports the participants' preferences for PFB solely based on visual examination, solely based on palatability test, or based on both. The results show that the majority of the participants preferred PFB if the judgment was based on the visual comparison between PFB and conventional beef only. The proportion is 58%, 50%, and 58% for Knoxville, Middlesboro, and Bluefield respectively. However, the trend reverses when the participants choose the beef samples based on palatability. Only 38%, 39% and 35% of the participants at each site preferred PFB over conventional beef. Combining the visual and palatability impression, the proportion of the participants who preferred PFB remain almost the same with 38%, 40%, and 38% for Knoxville, Middlesboro, and Bluefield respectively. This table indicates that consumers generally possess positive attitudes towards the visual appearance of PFB but not towards its taste. Based on the evaluation of the visual attributes and palatability attributes of PFB jointly, the

participants tend to choose conventional beef over PFB, which implies the influential role of palatability in consumers' beef choice.

Table 4 reports the participants' auction bid results by experimental location. Only the observations from participants who preferred PFB to conventional beef are included. Knoxville has the highest mean bid of $2.07 while Bluefield has the lowest mean bid of $1.66. We observe the similar trend in participants' household annual income level in thee experimental sites, implying the income effect on consumers' WTP for PFB. Table 5 reports the auction results by treatment groups. Participants in group B and group C exhibit higher mean bids than participants in group A. A nonparametric Wilcoxon- Mann-Whiteney U test is applied to test the significance of these bid differences because it is robust to outliers and efficient when the underlying distributions are far from normal (Hollander and Wolfe, 1999). Table 6 and table 7 provide the comparison results of mean bids between participants by location and by treatment group. The results from table 6 indicate that the mean bids are not significantly different from each other in three experimental sites. Geographic variation does not seem to have influence on participants' WTP. In contrast, table 7 indicates that the bids in treatment group A are significantly different from the bids in treatment group B and treatment group C, with high possibilities that bids in group A are smaller than bids in group B and group C. Nevertheless, solely based on this finding, we cannot conclude that the hypothesis that the health benefit information has significant impact on increasing participant's WTP for PFB is supported by the data, since we don't control for the other

potentially influential factors across different treatment groups. The confounded effect may be attributed to a set of factors which will be explored in the regression analysis.

Figure 1 presents the means of WTP at different levels of nutrition knowledge (nutrient function knowledge and food source knowledge) and sensory evaluation (visual attributes and palatability attributes) scores. The scores are obtained by subtracting the overall visual/palatability acceptance rank for PFB from the overall visual/palatability acceptance rank for conventional beef, representing the level of consumers' preference for PFB to conventional beef. Means connected by line represent the groups with same level of nutrition knowledge. Since we did not observe WTP in all sub-groups, some of the group means were missing. The WTP changing trends, however, are still instructive in these graphs. As the figure suggests, consumers' WTP for PFB increase as consumers' preference for the palatability of PFB increases. Nevertheless, the increase in their WTP does not appear to be influenced by the visual appeal of PFB. In contrast, consumers with high level of nutrient function knowledge tend to offer higher prices for PFB. The effect of the food source knowledge on consumers' WTP does not show a clear opposite tendency as we expected. However, we do observe from the graphs that consumers with highest level of such food source knowledge tend to offer lower prices for PFB than these with lower levels of knowledge. In general, the main effects of nutrition knowledge and sensory evaluation are obvious in the graphs. Furthermore, all the graphs suggest that there are interaction effects between nutrition knowledge and sensory perception on consumers' WTP for PFB since all the lines intercept with each other. Nevertheless, the graphs only provide a rough idea of the effects of nutrition knowledge and sensory

evaluation on consumers' WTP for PFB. Further analysis should be performed within the regression framework.

Empirical Model and Estimation Results

We now turn to the discussion of the econometric analysis results. Estimates from Probit model and Tobit model are presented to explain consumers' preference and WTP for PFB respectively.

Sensory Evaluation and Consumer Choice

Previous studies suggest that color of lean muscle tissue and visible fat content, flavor and tenderness are important cues for consumers to make beef purchasing choice (e.g. Feldkamp, Schroeder, and Lusk 2003; Huffman et al. 1996; Lusk et al. 2001). In our experiments, to determine consumers' preference for the visual appeal and palatability characteristics of the beef products, we had the participants evaluate six sensory traits of beef samples. These traits included: lean meat color, fat color, meat texture, juiciness, tenderness, and flavor. The following Probit model is estimated to analyze the explanatory capability of these sensory characteristics on consumers' beef choice behavior:

$$\begin{aligned} &Probability(consumer\ i\ chooses\ PFB) \\ &= f(Dlcolor, Dfcolor, Dtexture, DTender, DJuicy, Dflavor, D2, D3) \end{aligned}$$

The explanatory variables are the differences of the valuation scores of lean meat color, fat color, meat texture, tenderness, juiciness, and flavor between conventional beef sample and PFB sample, i.e. conventional beef sample score minus PFB sample score. Location dummies are D2 and D3. D2= 1 if location =Middlesboro, 0 otherwise; D3=1 if

location =Bluefield, 0 otherwise. Observations with missing responses or with "don't know" answers are dropped from the sample, hence 407 observations is used in the analysis. Table 8 presents the Probit estimates. After the estimation, we use the model to predict consumers' choices using the sample data. The high percentage of the correct predictions indicates that our model performs well in explaining the impact of sensory attributes on consumer purchasing choice.

The estimates suggest that four of the six attributes significantly influence consumers' preference and carry the expected signs. The more that a consumer rates the PFB beef sample favorably in terms of its meat texture, tenderness, juiciness, and flavor, the more likely she/he will prefer PFB to conventional beef. Only one of these attributes is a visual cue; the other three are palatability attributes and have a relatively greater impact on the consumers' choice. It seems that consumers are more likely to base their choice of beef products on eating satisfaction than appearance. Considering the influence of geographic difference, the significant coefficients of the location dummies suggest that these intrinsic attributes of beef products do have discernable different impact on consumers across different locations. Specifically, the results suggest that the likelihood of consumers' choosing PFB decreases from Middlesboro to Bluefield and to Knoxville. This may indicate that consumers living in more urban area are less likely to choose PFB over conventional beef.

WTP Model

Previous studies suggest that consumers are willing to pay a premium for food perceived as natural, organic or environment friendly (e.g. Gil et al. 2000; Loureiro and Hine 2002;

Wandel and Bugge 1996). Harper and Henson (2001) show that consumers may claim high levels of concern about farm animal welfare, however, such concerns are not necessarily translated into price that they actually are willing to pay. According to Melton et al. (1996) study, appearance and taste experience are important to predict consumer perceptions and WTP for fresh food. The effect of sensory attributes on consumer food behavior has been identified by many studies. For example, Alfnes et al. (2006) show that consumers color are willing to pay significantly more for salmon fillets with normal or above-normal redness, as compared with paler salmon fillets, and Lusk et al. (2001) show that consumer are willing to pay extra for more tender steaks. It has also been shown that health concerns and nutritional knowledge are influential factors in consumer WTP for food products with proven health benefits (Bower et al., 2003). With respect specifically to PFB, Evan (2007) study indicates that the frequency of in-home steak preparation, grass-fed purchasing experience, and gender all have significant impacts on consumers preferences for PFB. Based on these previous findings, we include consumers' beef consumption habit, prior consumption experience of PFB, expectation of PFB(on human health, environment, animal welfare), health status, nutrition knowledge level, demographic characteristics, and the sensory evaluation scores as explanatory variables in our empirical model. We hypothesize that: 1) consumers who consume beef more frequently are more aware of the risk/health benefits of the beef they consume and thus are willing to pay more for healthier beef products; 2) consumers' prior experience of PFB affects their attitudes towards PFB which will be translated into their WTP; 3) consumers who possess positive expectation of PFB's impact on human health,

environment and animal welfare are expected to be willing to pay a premium for PFB; 4) consumers' health status is negatively associated with their WTP for nutritious food; 5)sensory characteristics largely determine consumers' WTP for PFB. Regarding the nutrition knowledge, consumers who are knowledgeable on nutrition should be more capable of processing nutrition information and put more value on PFB's nutrition claims. At the same time, however, these consumers may be also aware of the substitutes available in the market which can provide equal or better nutrition than PFB does but at a lower cost. To disentangle these two effects on WTP, we include two nutrition knowledge variables in the empirical model. They measure consumers' nutrition knowledge in terms of consumers' knowledge on the functions of the four nutrients (Vitamin A, Vitamin E, CLA, Omega 3) and the best food sources for these nutrients. With respect to nutrition knowledge, we hypothesize that 6) nutrition function knowledge has positive impact on consumers' WTP for PFB while food source negatively impact consumers' WTP for PFB. Thus, the representation of our empirical model of consumers WTP for PFB is given by the following equation:

$$\begin{aligned} WTP = f(&Tb, Tc, Freq, Experience, Eeph, Eepe, Expa, Disease, Kf, Ks, \\ &Gender, Age, Single, Householdsize, Ethnicity, Edu, Income, \\ &\mathrm{D}lcolor, Dfcolor, Dtexture, DTender, DJuicy, Dflavor, D2, D3) \end{aligned}$$

The description and the summary statistics of the variables in the model are reported in Table 9.

The observations with missing responses in written survey questions and in auction sessions are dropped. Therefore, we use a sample of 404 observations from the three experimental sites in the estimation. We assume that consumers who preferred

conventional beef to PFB have negative or zero WTP for PFB. Hence, all hypothetical negative WTP are treated as censored and thus scaled up to zero. Before estimating this base model, we tested the interactive mode which controls for the same variables as the base model and included all possible interactions between nutrient function knowledge and sensory evaluation, and food source knowledge and sensory evaluation. Likelihood ratio test suggests, however, the interactions do not significantly increase the explanatory power of base model (test statistic LR chi-square (12) = 11.40) .Therefore, our discussion is restricted to the base model.

Table 10 presents the estimates of the WTP equation from Tobit analysis. The Likelihood-Ratio test suggests a significant joint effect of all the explanatory variables with large LR values as 205.11 (d.f.=25). Tobit models heavily rely on the normality assumption, and the MLE will be inconsistent if the underlying distribution is nonnormal, thus, the conditional moment test (Skeels and Vella 1999) using a bootstrap approach (Drukker 2002) is used to test the null that the underlying distribution of the error term is normal. The value of the conditional moment test statistic is 12.95, with the critical value of 15.22 and 13.30 at 10% level under the 500 and 1000 replications respectively. Thus, there is no statistical evidence indicating the violation of the normality assumption. By plotting the residuals from WTP equation, we also diagnose the potential heteroskadasticity problem but detect no obvious heteroskedasticity either.

Coefficients from the Tobit estimation cannot be directly interpreted as the marginal effects of the independent variables on WTP since these independent variables have distinct effects on the dependent variable for cases with zero value and for cases

with non-zero value of the dependent variable. McDonald and Moffitt (1980) provide a formula for the expected value of the dependent variable for all cases $Ey = X\beta \times F(z) + \Sigma \times f(z)$,where F(z) is the normal CDF, f(z) is the normal density function and Σ is the standard deviation of the error term. The marginal effect of an independent variable on Ey is given by

$$\frac{\partial Ey}{\partial X_i} = F(z) \times \frac{\partial Ey^*}{\partial X_i} + Ey^* \times \frac{\partial F(z)}{\partial X_i}$$

Where $\frac{\partial Ey^*}{\partial X_i}$ measures the change in expected value above the censoring limit and $\frac{\partial F(z)}{\partial X_i}$ measures the possibility change of being above the limit. McDonald and Moffitt (1980) show that

$$\frac{\partial Ey^*}{\partial X_i} = \beta_i \times [1 - (z \times \frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2}]$$

$$\frac{\partial F(z)}{\partial X_i} = \beta_i \times \frac{f(z)}{\Sigma}$$

Table 10 reports the Tobit coefficient estimates, the marginal effects on unconditional expected value, $\frac{\partial Ey}{\partial X_i}$ and the marginal effects conditional on being uncensored, $\frac{\partial Ey^*}{\partial X_i}$.

An interesting finding is the impact of consumers' nutrition knowledge on WTP. The coefficients of nutrient function knowledge and food source knowledge are significant and carry the expected signs. As we hypothesized, these two sets of nutrition knowledge influence consumers' WTP and have opposite effects. The coefficient of

nutrient function knowledge is positive and strongly significantly different from zero. The marginal effect estimates suggest that each point increase in the nutrient function knowledge score induces a $0.18 increase in all participants' WTP. For those who are willing to pay a positive premium for PFB, each point increase in the nutrient function knowledge score induces a $0.15 increase in WTP. For food source knowledge, the effect is significantly negative since consumers with higher such knowledge are more aware of the substitutes they can purchase in the market, which in turn reduces their valuation for the nutritious attributes of PFB. The magnitude of the food source knowledge effect is smaller than nutrient function knowledge effect, with a marginal effect of -$0.12 on unconditional expected WTP and -$0.10 on uncensored WTP. Each point increase in the food source knowledge score thus reduces WTP about $0.12 for all participants and about $0.10 for participants who hold positive WTP for PFB. The relative magnitude of the effects of this two sets of nutrition knowledge suggest a positive overall influence of the nutrition knowledge on consumers' WTP for PFB: the more knowledgeable a consumer is, the more she/he is willing to pay for the nutrition attributes of PFB. These findings strongly support our hypothesis that nutrition knowledge has significant impact on consumers' WTP for PFB, with positive impact of nutrient function knowledge and negative impact of food source knowledge.

As expected, we find that sensory characteristics of PFB are important determinants of consumers' WTP. The results show that the coefficients of the difference of meat texture, tenderness, juiciness, and flavor evaluation between PFB and conventional beef are positive and significant, implying that these attributes are

particularly valued by beef consumers. Specifically, if a consumer perceives that PFB is finer than conventional beef in terms of meat texture, each rank difference increases her/his WTP for PFB about $0.09; regarding the palatability attributes, if a consumer perceives that the PFB tastes more tender, juicier and more intense than conventional beef, each rank increase in tenderness, juiciness and flavor generates about $0.18, $0.14 and $0.08 increase in her/his WTP for PFB respectively. In contrast to the effects of other sensory attributes, tenderness exhibits the largest magnitude on consumers' WTP. This is in line with previous studies' results (e.g. Feldkamp, Schroeder, and Lusk 2003; Lusk et al. 2001). However, our results imply a smaller impact of flavor than Huffman et al.(1996), who found that flavor accounts for most of the variation in palatability of beef steaks. Over all, the impact of palatability attributes is much larger than the visual attributes, which indicates that consumers are more likely to base their value perception of beef products on the palatability than on the visual appearance, and the actual eating satisfaction largely determines how much they are willing to pay for beef products.

The influence of consumers' beef consumption habit on their WTP for PFB is also confirmed by the estimates. The results in table 10 suggest that consumers who consume beef at home more frequently are willing to pay more for PFB. For example, if a consumer eats beef at home 3 or more times a week, she/he will be willing to pay about $0.14 more to purchase PFB than consumers who eat beef at home only 1-2 times a week. The prior PFB consumption experience, however, has no impact on consumers' WTP. One possible explanation is that PFB is a relatively novel product; while consumers may have PFB consumption experience, they do not consume it regularly and thus the

experience only provides vague guide in their valuation process, which impacts little on their WTP.

The estimation results lend little support to our hypotheses that consumers' expectation of PFB on human health, environment, and animal welfare impact consumers' WTP for PFB. None of the coefficients corresponding to these variables are statistically significant from zero. This could be attributed to several factors. For example, although consumers may hold positive impression of these impacts of PFB, it does not necessarily translate into WTP since other concerns may dominate the decision process. These concerns could include a wide range of factors, such as the immediate consumption satisfaction, budget constraints, etc. Further research need be conducted to reveal the nature of the insignificant impact of these variables.

An important finding is that a consumer's or family members' health status is associated with her/his WTP for PFB. The parameter estimate suggests that if a consumer or any of his family members has diabetes, heart disease, high blood pressure, high cholesterol, or obesity, she/he is willing to pay more for PFB. Our finding indicates that consumers now are aware of the linkage between food consumption and health. They are willing to pay more to reduce the negative impact of beef consumption by consuming more nutritious beef products. However, our results suggest a much smaller WTP compare to what McCluskey et al. (2005) found. Their study reported that a low fat and calorie steak could sell for $5.65 more per pound than the high fat and calorie steak, and steak with high levels of omega 3 fatty acids could sell $3.45 more. The high estimates from McCluskey et al.study may be due to the hypothetical nature of the choices that

participants made in the experiments, which may upwardly bias the estimates. Also, as the authors themselves noted, it may be because about half of the participants were natural food store shoppers who usually pay more for nature foods.

Regarding the socio-demographic characteristics, only living status and household size have a significant influence on consumers WTP for PFB. The results suggest that, in general, the consumers who live alone are less willing to pay about $0.36 than consumers who do not live alone when purchasing PFB. We may infer from this result that consumers who do not live alone are more concerned with the heath of the household members and thus are willing to pay more for healthier food. However, there is a negative relationship between household size and WTP in non-single living household. The negative coefficient of household size in the WTP equation suggests that consumers from larger households are less willing to pay for PFB than these from smaller households. This may reflect the fact that larger households usually face a tighter budget constraint than smaller households. In this case, economizing on food expenditure may dominate in food purchase decision, reducing consumers' WTP for PFB as household size increases. Finally, according to the Tobit estimates, other demographic variables do not exhibit significant influence in WTP model.

Conclusion

As a novel product in beef market, PFB is a new option for beef consumers, most of whom have never been exposed to PFB. Our analysis shows that consumers' impression of PFB products' impact on human health, environment and animal welfare do not necessarily translate into WTP. Beef products' sensory characteristics play a central role

in determining consumers' preferences and WTP. However, the visual attributes and the palatability attributes do not exert their influence to the same extent. Actual eating satisfaction plays a more important role in consumers' purchasing choice. As the first time in the literature, this study reveals that nutrition knowledge can significantly influence consumers' WTP. Furthermore, different types of nutrition knowledge can express such influence in sensible distinct ways. We find that consumers with more nutrition knowledge on the functions of the four nutrients (Vitamin A, Vitamin E, CLA, Omega 3) are willing to pay more for PFB, while consumers with better knowledge on the main food sources for these nutrients tend to express lower WTP for PFB. This may be because those consumers who are more knowledgeable on the nutrient function are more capable of processing the nutrition information of PFB and thus put more value on PFB's nutrition attributes; at the same time, however, consumers with better food source knowledge are more knowledgeable of the food substitutes available in the market which can provide equal or better nutrition than PFB does but at a lower cost, as a result, we observe that consumers' WTP is negatively associated with their food source knowledge. The significant impact of a consumer's or any of his family members' health status on her/his WTP suggests that consumers with health concerns are aware of the linkage between food consumption and health. They are willing to pay more for perceived healthier food. With respect to the impact of consumers' socio-demographic characteristics on their WTP for PFB, only consumers' living status and household size have significant impact on consumers' WTP , implying that consumers living along or from large size household are less willing to pay for PFB.

The findings in this article can be applied generally to the whole U.S. population considering the sampling limitation of our experiments. However, our study does provide PFB producers and marketers with practical guidelines to improve the quality traits of PFB products in favor of consumers' preference and to design effective marketing strategies. It can also help policy makers better understand consumers' food behavior and make initiatives to improve diet and health.

References

Alfnes, F., A.G. Guttormsen, G. Steine, and K. Kolstad. 2006. "Consumers' Willingness to Pay for the Color of Salmon: A Choice Experiment with Real Economic Incentives." *American Journal of Agricultural Economics* 88:1050-61.

Alan D, B. O'Brien, and A. Gafni. 1998. "Health Care Contingent Valuation Studies: a Review and Classification of the Literature." *Health Economics* 7: 313-326.

Alberini, A. and J. R.Kahn. 2006. "Handbook on Contingent Valuation". Northhampton, MA, USA: E. Elgar Pub

Arnold, R.N., N. Scheller, K. K . Arp, S.C. Williams, D.R. Beuge, and D.M. Schaefer. 1992. "Effect of Long or Short-term Feeding of α-tocopheryl acetate to Holstein and Crossbred Beef Steers on Performance, Carcass Characteristics, and Beef Color Stability." *Journal of Animal Science* 70:3055-3065.

Areni, C. S. 2002. "The Proposition-probability Model of Argument Structure and Message Acceptance." *Journal of Consumer Research* 29(2):168-187

Bishop, R. C. and T. A. Heberlein. 1979. "Measuring Values of Extramarket Goods: Are Indirect Measures Biased?" *American Journal of Agricultural Economics* 61(5): 926-930.

Bohm, P., J. Lindén, and J. Sonnegard. 1997. "Eliciting Reservation Prices: Becker-DeGroot-Marschak Mechanisms vs. Markets." *The Economic Journal* 107(443): 1079-1089.

Bower, J.A., M.A. Saadat, and C. Whitten. 2003. "Effect of liking, information, and consumer characteristics on purchase intention and willingness to pay more for a fat spread with a proven health benefit." *Food Quality and Preference* 14: 65–74.

Buchinsky, M. 1994. "Methodological Issues in Quantile Regression." Ph.D. Dissertation, Department of Economics, Harvard University, Cambridge.

Carlsson, F. and P. Martinsson. 2001. "Do Hypothetical and Actual Marginal Willingness to Pay Differ in Choice Experiments? Application to the Valuation of the Environment." J*ournal of Environmental Economics and Management* 41(2): 179-192.

Carlsson, A, F. and P. MartinssonB. 2004. "Willingness to Pay among Swedish Households to Avoid Power Outages - A Random Parameter Tobit Model Approach." Working Papers in Economics no. 154.

Chow, G. C. 1960. "Tests of Equality between Sets of Coefficients in Two Linear Regressions." Econometrica 28: 591-605.

Cooper, J. C., M. Hanemann, and G. Signorello. 2002. "One-and-One-Half-Bound Dichotomous Choice Contingent Valuation." *The Review of Economics and Statistics* 84: 742-750.

Cohen J. 1998 "Statistical Power Analysis for the Behavioral Sciences" 2nd ed. Hillsdale, NJ: Lawrence Erlbaum

Crawford, C. M. 1977. "Marketing Research and the New Product Failure Rate." *Journal of Marketing* 41(2): 51-61.

Crowley, A. E. and W. D. Hoyer. 1994. "An Integrative Framework for Understanding Two-Sided Persuasion." *The Journal of Consumer Research* 20(4): 561-574.

Davis, C. G. and L. Biing-Hwan. 2005. "Factors Affecting U.S. Beef Consumption." Electronic Outlook Report, USDA

Davis, D. and C. Holt. 1993. "Experimental Economics." NJ: Princeton University Press.

Davis, O. A., M. H. DeGroot and M. J. Hinich. 1972. "Social Preference Orderings and Majority Rule" *Econometrica* 40(1):147-157

Descalzo, A.M, E. M. Insani, A. Biolatto and A. M. Sancho, P.T. Garcia, N. A. Pensel, J. A. Josifovich. 2005. "Influence of pasture or grain-based d iets supplemented with vitaminE on antioxidant/oxidative balance of Argentine beef." *Meat Science* 70:35-44.

Desu, M. M. and D. Raghavarao. 1990. "Sample Size Methodology." Academic Press, Boston.

Diamond, P. A. and J. A. Hausman. 1994. "Contingent Valuation: Is Some Number better than No Number?" The Journal of Economic Perspectives 8(4): 45-64.

Duckett, S.K, D.G. Wagner, L.D.Yates, H.G. Dolezal, S.G. May. 1993. "Effects of time on feed on beef nutrient composition." *Journal of Animal science* 71:2079-2088

Drukker, D. M. 2002. "Bootstrapping a conditional moments test for normality after tobit estimation." *The Stata Journal* 2(2):125-139

East, R., W. Lomax, G. Willson, and P. Harris. 1994. "Decision making and habit in shopping times." *European Journal of Marketing* 28(4):56-71

Efron, B., H. Trevor, I. Johnstone and R. Tibshirani. 2004. "Least Angle Regression" *The Annals of Statistics* 32(2):407-451

Eisend, M. 2006. "Two-sided advertising: A meta-analysis." *International Journal of Research in Marketing* 23(2): 187-198.

Elbon, S.M., M.A. Johnson, J.G. Fischer. 1996. "Developing an instrument to measure the influence of knowledge, behaviors, and attitudes on milk consumption patterns in older participants of a community wellness group: a pilot study." *Journal of nutrition for the Elderly* 15: 21–37.

Evans, J. R., C. Brown, A. R. Collins, G. E. D'Souza, E. B. Rayburn, and M. Sperow. 2008. "Determining Consumer Perceptions of and Willingness to Pay for Appalachian Grass-fed Beef: An Experimental Economics Approach." Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29.

Feldkamp, T., T. Schroeder, and J. Lusk. 2003. "Consumer valuation of steaks with different quality attributes."In *Cattleman's Day*, Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Report of Progress No. 908: 1-4.

Foster, W. and R. E. Just. 1989. "Measuring welfare effects of product contamination with consumer uncertainty." Journal of Environmental Economics and Management 17(3): 266-283.

Fox, J. A., J. F. Shogren, D.J. Hayes, and J.B. Kliebenstein. 1998. "CVM-X: Calibrating contingent values with experimental auction markets." *American Journal of Agricultural Economics* 80(3): 455-465.

Gil, J.M., A. Gracia, and M. Sanchez. 2000. "Market segmentation and willingness to pay for organic products in Spain." *International Food and Agribusiness Management Review* 3(2):207-226

Green, P. E., A. M. Krieger, and Y. Wind. 2001. "Thirty years of conjoint analysis: reflections and prospects." *Interfaces* 31(3): S56-S73.

Green, P. E. and V. Srinivasan. 1978. "Conjoint Analysis in Consumer Research: Issues and Outlook." The Journal of Consumer Research 5(2): 103-123.

Green, P. E. and V. Srinivasan. 1990. "Conjoint Analysis in Marketing: New Developments with Implications for Research and Practice." *Journal of Marketing* 54(4): 3-19.

Green, S. B. 1991. "How many subjects does it take to do a regression analysis?" *Multivariate Behavioral Research* 26: 499-510.

Hammitt, J. K. and J. D. Graham. 1999. "Willingness to Pay for Health Protection: Inadequate Sensitivity to Probability?" *Journal of Risk and Uncertainty* 18(1):33-62

Hanemann, W. M. 1984. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." *American Journal of Agricultural Economics* 66(3):332-341

Hanemann, W. M. 1994. "Valuing the Environment through Contingent Valuation." *The Journal of Economic Perspectives* 8(4): 19-43.

Harnack L, G. Block, A. Subar, S. Lane, R. Brand. 1997. "Association of cancer prevention-related nutrition knowledge, beliefs and attitudes to cancer prevention dietary behavior." *Journal of the American Dietetic Association* 97: 957–965.

Harrison, G. W., R. M. Harstad, and E.E. Rutström. 2004. "Experimental Methods and Elicitation of Values." Experimental Economics 7(2): 123-140.

Heller, E. and C. S. Areni. 2004. "The effects of conditional indicative language on the comprehension and acceptance of advertising claims." *Journal of Marketing Communications* 10(4): 229-240.

Herring, J. L., J. M. Martin, M. D. Hudson, L. L.Nalley and R.W. Rogers. 2007. "Consumer Acceptance of "Farm Raised" Precooked Roast Beef." *Journal of Food Quality* 30: 403-412.

Hoffman, E., D. J. Menkhaus, D. Chakravarti, and R.A. Field. 1993. "Using Laboratory Experimental Auctions in Marketing Research: A Case Study of New Packaging for Fresh Beef." *Marketing Science* 12(3): 318-338.

Hollander, M. and Wolfe, D. Nonparametric Statistical Methods, (1999) 2nd edn , NY Wiley.

Howe, C. W., B.J. Lee, and L.L. Bennett. 1994. "Design and Analysis of Contingent Valuation Surveys Using the Nested Tobit Model." *The Review of Economics and Statistics* 76(2): 385-389.

Huffman, K., M. Miller, L. Hoover, C. Wu, H. Brittin, and C. Ramsey. 1996. "Effect of beef tenderness on consumer satisfaction with steaks consumed in the home and restaurant." *Journal of Animal Science*, 74: 91-97

Ippolito, P. M. and A. D. Mathios. "Information and Advertising: The Case of Fat Consumption in the United States." *The American Economic Review* 85(2):91-95

Shuster, J. J. 1990. CRC Handbook of Sample Size Guidelines for Clinical Trials, CRC Press, Boca Raton.

Kinnucan, H.W., H. Xiao, C.J. Hsia, and J. D. Jackson 1997. "Effects of Health Information and Generic Advertising on U.S. Meat Demand."*American Journal of Agricultural Economics* 79(1): 13-23.

Joshi, A. W. and S. Sharma. 2004. "Customer Knowledge Development: Antecedents and Impact on New Product Performance." *Journal of Marketing* 68(4): 47-59.

Kahn, B. E. and David C. 1989. "Schmittlein Shopping trip behavior: An empirical investigation." *Marketing Letters* 1(1):55-69

Knetsch, J. L. and J. A. Sinden. 1984. "Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value." *The Quarterly Journal of Economics* 99(3): 507-521.

Kraemer, H. C. and S. Thiemann. 1987. How Many Subjects? Statistical Power Analysis in Research. Sage Publications, Newbury Park, CA.

Krupnick, A., A. Alberini, M. Cropper, N. Simon, B. O'Brien, R. Goeree, and M. Heintzelman. 2002. "Age, Health and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents." *Journal of Risk and Uncertainty* 24(2): 161-186.

List, J. A. and J. F. Shogren. 1999. "Price Information and Bidding Behavior in Repeated Second-Price Auctions." *American Journal of Agricultural Economics* 81(4): 942-949.

Loureiro, M. L., and S Hine. 2002. "Discovering Niche Markets: A Comparison of Consumer Willingness to Pay for Local (Colorado Grown), Organic, and GMO-Free Products." *Journal of Agricultural and Applied Economics* 34(3): 477-487

Loureiro, M. L., W. J. Umberger, and S. Hine. 2003. "Testing the Initial Endowment Effect in Experimental Auctions." *Applied Economics Letters* 10(5): 271-275.

Lozier,J., E. Rayburn, and J. Shaw. 2005. "Growing and Selling Pasture-Finished Beef: Results of a Nationwide Survey." *Journal of Sustainable Agriculture* 25(2):93–112.

Lusk, J. L., M. S. Daniel, D.R. Mark, and C.L. Lusk. 2001. "Alternative calibration and auction institutions for predicting consumer willingness to pay for nongenetically modified corn chips." *Journal of Agricultural and Resource Economics* 26(1): 40-57.

Lusk, J. L., T. Feldkamp, and T.C. Schroeder. 2004. "Experimental Auction Procedure: Impact on Valuation of Quality Differentiated Goods." *American Journal of Agricultural Economics* 86: 389-405.

Lusk, J. L., J. A. Fox, T. C. Schroeder, J. Mintert, and M. Koohmaraie. 2001. "In-Store Valuation of Steak Tenderness." American Journal of Agricultural Economics 83(3): 539-550.

Lusk, J. L., F. B. Norwood, and J.R Pruitt. 2006. "Consumer Demand for a Ban on Antibiotic Drug Use in Pork Production." *American Journal of Agricultural Economics* 88: 1015-1033.

Lusk, J. L. and T. C. Schroeder. 2004. "Are choice experiments incentive compatible? A test with quality differentiated beef steaks." *American Journal of Agricultural Economics* 86(2): 467(16).

Lusk, J. L. and T. C. Schroeder (2004). "Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks." *American Journal of Agricultural Economics* 86(2): 467-482.

Davis, D.D, and C.A. Holt. 1993. "Marschak Mechanisms vs. Markets." *The Economic Journal* 107(443): 1079-1089.

McCabe, K. A., S. J. Rassenti, and V. L. Smith. 1990. "Auction Institutional Design: Theory and Behavior of Simultaneous Multiple-Unit Generalizations of the Dutch and English Auctions." *The American Economic Review* 80(5): 1276-1283.

McCluskey, J., T. Wahl, Q. Li, and P. Wandschneider. 2005. "U.S. Grass-fed beef: Marketing health benefits." *Journal of Food Distribution Research* 36(3): 1-8.

McDonald, J. F. and R. A. Moffitt. 1980. "The Uses of Tobit Analysis." *The Review of Economics and Statistics* 62:318-21.

Melton, B. E., W. E. Huffman, J.F. Shogren, and J.A. Fox.1996. "Consumer preferences for fresh food items with multiple quality attributes: evidence from an experimental auction of pork chops." American Journal of Agricultural Economics 78(4): 916-923.

Mitchell, R. C. and R. T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Press: Resources for the Future. ISBN:0915707322

Moeltner, K. and D. Layton. 2002. "A Censored Random Coefficients Model for Pooled Survey Data with Application to the Estimation of Power Outage Costs." *Review of Economics and Statistics* 84: 552-561.

Monsivais, P., A. Drewnowski. 2007. "The Rising Cost of Low-Energy-Density Foods." *Journal of the American Dietetic Association* 107(12): 2071-2076).

Moon, C.G. 1989. " A Monte Carlo comparison of semiparametric Tobit estimators." *Journal of Applied Econometrics* 4: 361–382.

Nayga Jr., R.M. 1997. "Impact of sociodemographic factors on perceived importance of nutrition in food shopping." *Journal of Consumer Affairs* 31 (1):1–9

Nunnally, J. 1978. Psychometric theory (2nd ed.). New York: McGraw-Hill.

Neumann, John von and O. Morgenstern. 1944. "Theory of games and economic behavior." Princeton University Press.

Park, J. and G. Davis. 2001. "The Theory and Econometrics of Health Information in Cross-Sectional Nutrient Demand Analysis." *American Journal of Agricultural Economics* 84(840-51).

Paarsch, H.J. 1984. “A Monte Carlo comparison of estimators for censored regression models.” *Journal of Econometrics* 24, pp. 197–213.

Payan, J. M. and R. G. McFarland. 2005. “Decomposing Influence Strategies: Argument Structure and Dependence as Determinants of the Effectiveness of Influence Strategies in Gaining Channel Member Compliance.”*Journal of Marketing* 69(3): 66-79.

Pentina, I. and D. Strutton. 2007. “Information Processing and New Product Success: a Meta-analysis.” *European Journal of Innovation Management* 10 (2): 149 - 175

Portney, P. R. 1994. “The Contingent Valuation Debate: Why Economists Should Care.” *The Journal of Economic Perspectives* 8(4): 3-17.

Powell, J.P.1984. “ Least Absolute Deviations Estimation for the Censored Regression Model.”*Journal of Econometrics* 25: 303-325.

Pratt, J. W. and R. J. Zeckhauser. 1996. “Willingness to Pay and the Distribution of Risk and Wealth.” *The Journal of Political Economy* 104(4): 747-763.

Rousu, M. 2005. “European Consumers' Willingness to Pay for U.S. Beef in Experimental Auction Markets: Comment.” *American Journal of Agricultural Economics* 87(1): 255-257.

Rousu, M., W. Huffman, J.F. Shogren, and A. Tegene. 2002. “The Value of Verifiable Information in a Controversial Market: Evidence from Lab Auctions of Genetically Modified Food.” Department of Economics Working Papers Series, Iowa State University.

Rows, R. D. and L. G. Chestnut. 1983. "Valuing Environmental Commodities: Revisited." Land Economics 59(4): 404-410.

Russell, J. B., F. Diez-Gonzalez, and G.N. Jarvis 2000. "Potential Effect of Cattle Diets on the Transmission of Pathogenic Escherichia Coli to Humans." *Microbes Infect* 2(1): 45-43.

Schmidt, F. L. 1971. "The relative efficiency of regression in simple unit predictor weights in applied differential psychology." *Educational and Psychological Measurement* 31: 699-714.

Schnedler, W. 2005. "Likelihood Estimation for Censored Random Vectors." *Econometric Reviews* 24(2): 195-217.

Shogren, J. F., M. Margolis, C. Koo, and J.A. List. 2001. "A random nth-price auction." *Journal of Economic Behavior & Organization* 46: 409-421.

Shogren, J. F., S. Y. Shin, D. J. Hayes, and J. B. Kliebenstein. 1994. "Resolving Differences in Willingness to Pay and Willingness to Accept." *The American Economic Review* 84(1): 255-270.

Skeels, C. L. and F. Vella. 1999. "A Monte Carlo investigation of the sampling behavior of conditional moment tests in Tobit and Probit models." *Journal of Econometrics, Elsevier* 92(2): 275-294

Smith, V. K. and W. H. Desvousges. 1987. "An Empirical Analysis of the Economic Value of Risk Changes." *The Journal of Political Economy* 95(1): 89-114.

Tegene, A., W. E. Huffman, M. Rousu, and J. Shogren. 2003. "The Effects of Information on Consumer Demand for Biotech Foods: Evidence from Experimental Auctions." ERS Research Briefs.

Teisl, M. F., N. E. Bockstael and A. Levy. 2001. "Measuring the Welfare Effects of Nutrition Information." *American Journal of Agricultural Economics* 83(1): 133-149.

Umberger, W., D. Feuz, C. Calkins, and K. Killinger-Mann. 2002. "U.S. consumer preference and willingness to pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction." *Agribusiness* 18(4): 491-504.

US Department of Agriculture Economic Research Service. 2000. "Mother's nutrition knowledge is key influence on the quality of children's diets." *Journal of the American Dietetic Association* 100: 155.

USDA. Grass (Forage) Fed Marketing Claim Standard (October 16,2007, Federal Register Notice (72 FR 58631)).

Viscusi, W. K. and W. N. Evans. 1990. "Utility Functions That Depend on Health Status: Estimates and Economic Implications." *The American Economic Review* 80: 353-374.

Walsh, R. G., N. P. Miller, and L.O. Gilliam. 1983. "Congestion and Willingness to Pay for Expansion of Skiing Capacity." *Land Economics* 59(2): 195-210.

Wampold, B. E., and Freund, R. D. 1987. “Use of multiple regression in counseling psychology research: A flexible data-analytic strategy.” *Journal of Counseling Psychology* 34: 372-382.

Wandel, X., and X. Bugge. 1996. “Environmental concern in consumer evaluation of food quality.” *Food Quality and Preference* 8(1):19–26.

Wertenbroch, K., B. Skiera. 2002. “Measuring Consumers' Willingness to Pay at the Point of Purchase.” Journal of Marketing Research (JMR) 39(2): 228.

Appendix A

Visual Evaluation

Definitions of Visual Traits of Beef
Lean meat color: the color of beef muscle
Fat color: the color of intramuscular and marbling fat
Meat texture: fineness or coarseness of the cut surface
Overall acceptability: overall like/dislike of the sample visually examined

Please evaluate the visual traits of beef samples when you examine each sample that is displayed in the retail cases, and mark the boxes that indicate how you feel about the visual attributes of each sample.

(1) Visual Evaluation: Beef sample # 1

Lean Meat Color	□ Very pale	□ Pale	□ Pink	□ Neutral	□ Red	□ Dark	□ Very dark	Don't Know ○
Fat color	□ Very white	□ White	□ Somewhat white	□ Neutral	□ Somewhat yellow	□ Yellow	□ Very yellow	Don't Know ○
Meat Texture	□ Very fine	□ Fine	□ Somewhat fine	□ Neutral	□ Somewhat coarse	□ Coarse	□ Very coarse	Don't Know ○
Overall Acceptability	□ Strongly like	□ Like	□ Somewhat like	□ Neutral	□ Somewhat dislike	□ Dislike	□ Strongly dislike	Don't Know ○

(2) Visual Evaluation: Beef sample # 2

Lean Meat Color	□ Very pale	□ Pale	□ Pink	□ Neutral	□ Red	□ Dark	□ Very dark	Don't Know ○
Fat color	□ Very white	□ White	□ Somewhat white	□ Neutral	□ Somewhat yellow	□ Yellow	□ Very yellow	Don't Know ○
Meat Texture	□ Very fine	□ Fine	□ Somewhat fine	□ Neutral	□ Somewhat coarse	□ Coarse	□ Very coarse	Don't Know ○
Overall Acceptability	□ Strongly like	□ Like	□ Somewhat like	□ Neutral	□ Somewhat dislike	□ Dislike	□ Strongly dislike	Don't Know ○

Which sample of beef do you prefer?
□ Sample 1 □ Sample 2 □Indifferent

Palatability Evaluation

Definitions of Palatability Traits of Beef

Tenderness: the force required to bite through a piece of beef
Flavor: the taste of beef
Juiciness: the perception of moistness
Overall acceptability: overall like/dislike of the sample tasted

Please evaluate the palatability traits of beef samples when you taste each sample, and mark the boxes that indicate how you feel about the palatability attributes of each sample.

(1) Palatability Evaluation: Beef sample # 1

Tenderness	□ Very tender	□ Tender	□ Somewhat tender	□ Neutral	□ Somewhat tough	□ Tough	□ Very tough	Don't Know ○
Juiciness	□ Very juicy	□ Juicy	□ Somewhat juicy	□ Neutral	□ Somewhat dry	□ Dry	□ Very dry	Don't Know ○
Flavor	□ Very intense	□ Intense	□ Somewhat intense	□ Neutral	□ Somewhat bland	□ Bland	□ Very bland	Don't Know ○
Overall Acceptability	□ Strongly like	□ Like	□ Somewhat like	□ Neutral	□ Somewhat dislike	□ Dislike	□ Strongly dislike	Don't Know ○

Please cleanse your palate with a sip of water between samples.

(2) Palatability Evaluation: Beef sample # 2

Tenderness	□ Very tender	□ Tender	□ Somewhat tender	□ Neutral	□ Somewhat tough	□ Tough	□ Very tough	Don't Know ○
Juiciness	□ Very juicy	□ Juicy	□ Somewhat juicy	□ Neutral	□ Somewhat dry	□ Dry	□ Very dry	Don't Know ○
Flavor	□ Very intense	□ Intense	□ Somewhat intense	□ Neutral	□ Somewhat bland	□ Bland	□ Very bland	Don't Know ○
Overall Acceptability	□ Strongly like	□ Like	□ Somewhat like	□ Neutral	□ Somewhat dislike	□ Dislike	□ Strongly dislike	Don't Know ○

Which sample of beef do you prefer?
□ Sample 1 □ Sample 2 □Indifferent

Appendix B

Nutritional Facts about Pasture-Fed Beef[5]

Compared to the conventional beef*, pasture-fed beef has:

- **Higher concentrations of ß-carotene (also called ProVitamin A)**

Pasture-fed steers incorporate higher amounts of β-carotene into muscle tissues as compared to grain-fed animals. β-carotene is a safe dietary source for vitamin A supplementation. Vitamin A is a critical fat-soluble vitamin that is important for normal vision, bone growth, reproduction, cell division, and cell differentiation.

- **Higher concentrations of vitamin E**

The concentration of natural vitamin E found in pasture fed beef is 2 - 4 times higher than that found in conventional beef. Vitamin E supplementation may help prevent or delay coronary heart disease, block the formation of nitrosamines, and protect against the development of cancers by enhancing immune function.

- **Higher levels of Omega-3 fatty acids**

Omega-3 fatty acids are essential fatty acids but cannot be produced by human body and they must thus be obtained from food. A proper balance of Omega-6/Omega-3 ratio helps maintain and improve health. Beef from cattle fed primarily on grass has approximately 60% more Omega-3 fatty acids than conventional beef and a more favorable Omega-6 to Omega-3 ratio.

- **Higher levels of Conjugated Linoleic Acid (CLA)**

Pasture-fed cattle produce 2 to 3 times more CLA than conventional beef. Animal tests results have suggested that numerous health benefits can be attributed to CLA, including actions to reduce carcinogenesis, atherosclerosis, onset of diabetes, and fat body mass.

* Conventional beef refers to beef produced from cattle fed in confinement on concentrate-only diets.

[5] Daley, C.A., A.Abbott, P. Doyle, G. Nader, and S. Larson. California State University, College of Agriculture, University of California Cooperative Extension Service. (2006, May). A literature review of the value-added nutrients found in grass-fed beef products.

Appendix C

Beef Consumer Survey

1 Qualifying Questions

1.1 Do you eat beef? □ Yes □ No

If Yes: would you like to participate in a 10 minute survey and a taste test for $10?

If Yes, continue; otherwise terminate.

1.2 Are you over the age of 18? □ Yes □ No

If Yes, continue; otherwise terminate.

1.3 Are you the primary person who purchases food for your household? □ Yes □ No

1.4 Are you the primary person who prepares food for your household? □ Yes □ No

Respondent must answer Yes to either 1.3 or 1.4 to continue; otherwise terminate.

2 Beef Purchasing Behavior

2.1 Does the beef you consume at home usually come from the supermarket? □ Yes □ No

If **No**, where do you get it?

□ Health/Natural Foods Store

□ Farmers Market/Local Cooperative

□ Directly from Producer

□ Internet or Direct Mail Order

2.2 How many times a week does your household typically eat beef prepared at home?

□ Less than once

□ 1 – 2 times

□ 3 or more times

2.3 How frequently do you typically purchase each of the following types of beef?

	At least once a week	2-3 times a month	About once a month	Less than once a month	Never
Ground beef	□	□	□	□	□
Steak	□	□	□	□	□
Roast	□	□	□	□	□

2.4 When you purchase beef, how many pounds of the following types of beef do you typically purchase at a time?

Ground beef: _____lbs or □ Do not purchase

Steak: _____lbs or □ Do not purchase

Roast: _____lbs or □ Do not purchase

2.5 How much does your household spend on food that will be consumed at home during a typical week or month?

$ _____ □ per week □ per month

2.6 Do you usually do your main supermarket shopping on one particular day of the week?

□ Yes □ No

If **Yes**, what day(s) of the week do you usually do your main supermarket shopping?

(Check all that apply)

□ Monday □ Tuesday □ Wednesday □ Thursday □ Friday □ Saturday □ Sunday

2.7 Do you usually go to the supermarket more often at a particular time of day?

□ Yes □ No

If **Yes**, when do you usually go to the supermarket of day?

□ Morning □ Noon □ Afternoon □ Evening

Other:_____(Please specify)

2.8 What is your experience with "natural" beef? (Natural beef is minimally processed, and it cannot contain any artificial ingredients and any preservatives. Examples: Coleman's, Laura's Lean, etc.)

□ I have never heard of it.

□ I have heard of it, but never consumed it.

□ I have consumed it, but do not regularly consume it.

□ I consume it regularly.

2.9 What is your experience with "organic" beef? (Organic beef is USDA certified and it has USDA Organic seal on labels.)

□ I have never heard of it.

□ I have heard of it, but never consumed it.

□ I have consumed it, but do not regularly consume it.

□ I consume it regularly.

2.10 What is your experience with "pasture-fed," "grass-fed" or "pasture-raised" beef?

□ I have never heard of it.

□ I have heard of it, but never consumed it.

□ I have consumed it, but do not regularly consume it.

□ I consume it regularly.

2.11 What is your expectation or impression regarding pasture-fed beef's…

impact on *human health*?	□ Negative	□ Neutral	□ Positive	□ No expectation
impact on *environment*?	□ Negative	□ Neutral	□ Positive	□ No expectation
impact on *animal welfare*?	□ Negative	□ Neutral	□ Positive	□ No expectation
taste compared to conventional beef?	□ Worse	□ Indifferent	□ Better	□ No expectation

3 Exercise and Health

3.1 How frequently do you undertake moderate or vigorous physical activities (including any activities that cause an increase in your heart or breathing rate so that you can talk but not sing, such as brisk walking, bicycling, vacuuming or other forms of exercise)?

□ Less than once a week

□ 1 – 2 times a week

□ 3 or more times a week

3.2 Have you ever been diagnosed by a medical professional with any of the following? (Check all that apply)

□ Diabetes □ Heart disease. □ High blood pressure

□ High Cholesterol □ Obesity □ None of the above

3.3 Have any of your family members been diagnosed by a medical professional with any of the following? (Check all that apply)

□ Diabetes □ Heart disease. □ High blood pressure

□ High Cholesterol □ Obesity □ None of the above

3.4 How often do you read nutrition labels when deciding to buy a food product?

□ Always □ Rarely □ Never

□ Most of the time □ Sometimes □ Don't know

3.5 How often do you read health claims on packages when deciding to buy a food product? (Such as "low fat," "low cholesterol"…)

□ Always □ Rarely □ Never

□ Most of the time □ Sometimes □ Don't know

.

3.6 Please indicate whether you agree or disagree with the following statements

(1). High levels of vitamin A in the body are toxic.

□ Agree □ Disagree □ Not sure

(2). Vitamin E can help protect against the development of cardiovascular disease and cancer.

□ Agree □ Disagree □ Not sure

(3). Omega 3 fatty acids can help reduce the risk of heart attacks.

□ Agree □ Disagree □ Not sure

(4). CLA (conjugated linoleic acid) has an anti-cancer effect.

□ Agree □ Disagree □ Not sure

3.7 Please indicate whether you agree or disagree with the following statements

(1). Beta-carotene is a safe dietary source for vitamin A.

□ Agree □ Disagree □ Not sure

(2). Nuts and green leafy vegetables are good sources of Vitamin E.

□ Agree □ Disagree □ Not sure

(3). Canola and soybean oils are good sources of Omega 3 fatty acids.

□ Agree □ Disagree □ Not sure

(4). Butterfat and meat are good food sources of CLA.

□ Agree □ Disagree □ Not sure

4 Demographic Information

4.1 What is your gender? □ Male □ Female

4.2 What year were you born? _____

4.3 Which of the following options best describes your living arrangement?

□ Live alone □ Live with spouse / partner

□ Live with unrelated people □ Live with spouse / partner and children

□ Live with extended family □ Live with children

4.4 Including yourself, how many individuals currently live in your household? _____

a) How many infants (0-2 years old) are there in your household? _____

b) How many children (3-17 years old) are there in your household? _____

c) How many adults (between the age of 18-64) are there in your household? (Including yourself) _____

d) How many seniors (over the age of 65) are there in your household? (Including yourself) _____

4.5 What is your ethnicity?

□ White □ Native Hawaiian or other Pacific Islander

□ Black or African American □ Other_____

□ Asian □ Not Sure

□ American Indian/Alaskan Native

4.6 Are you of Hispanic or Latino background?

□ Yes □ No □ Not Sure

4.7 What is the highest level of education you have completed?

□ No high school diploma or equivalent

□ High school diploma or equivalent

□ Some college/technical school

□ Associate's degree

□ Bachelor's degree

□ Graduate or professional degree

4.8 What is your current employment status?

□ Employed part time (including students who work on campus or off campus)

□ Student (full time)

□ Employed full time

□ Unemployed

□ Homemaker (unpaid)

□ Retired

□ On disability

4.9 What is your spouse's/partner's current employment status?

□ Not applicable

□ Employed part time (including students who work on campus or off campus)

□ Employed full time

□ Unemployed

□ Homemaker (unpaid)

□ Retired

□ On disability

4.10 What is your approximate annual household income before taxes?

- □ Less than $10,000
- □ $10,000 - $19,999
- □ $20,000 - $29,999
- □ $30,000 - $39,999
- □ $40,000 - $49,000
- □ $50,000 - $59,999
- □ $60,000 - $69,999
- □ $70,000 - $79,000
- □ $80,000 - $89,999
- □ $90,000 - $99,999
- □ More than $100,000

4.11 Do you or any member of your household currently participate in any of the following food assistance programs?

- □ Food Stamp Program (FSP)
- □ Women, Infants and Children Program (WIC)
- □ School Lunch program
- □ None

Appendix D

Pasture-fed Beef Evaluation

Overall, which sample of beef do you prefer?

□ Sample 1 (Pasture-fed beef) □ Sample 2 (Conventional beef) □Indifferent

If the answer is **Indifferent,** you can stop here and this completes the survey.

Supermarket price of conventional beef: _____/lb

Supermarket price of natural beef: _____/lb

Supermarket price of organic beef: _____/lb

If you preferred conventional beef, how much would the pasture-fed beef have to be **discounted** compared to the price of conventional beef for you to buy it instead of conventional beef?

$_____/lb

If you preferred pasture-fed beef, how much **more** would you be willing to pay to trade your conventional beef for an equivalent amount of pasture-fed beef?

$_____/lb

What factors influence your preference for/against the pasture-fed beef relative to the conventional beef? (Check all that apply)

□ Eye appeal

□ Flavor

□ Tenderness

□ Juiciness

□ Health benefits

□ Other (please specify): _____

Appendix E

Beef Preparation

A. Experimental Beef

Conventional beef used in the experiments was the New York strip steaks sold at the experimental supermarket stores. Pasture-fed beef used in the experiments was fresh pasture-fed New York strip steaks shipped from a beef supplier in Georgia to experimental supermarket stores the day before the experiments.

B. Visual Test

Participants were presented with conventional beef and pasture-fed beef samples cut into 1/2 pound of weight and ½ inch thick. Similar shape and size of the beef samples were carried on disposable 12 inch deli trays labeled Sample 1 or Sample 2. In every one hour, old samples were replaced by newly cut samples to ensure freshness of the beef samples.

C. Palatability Test

Raw beef samples for palatability test were cut into 1/2 inch cubes. When a participant started the written part of the survey, a sample of pasture-fed beef and a sample of conventional beef were put on a potable Hamilton Beach indoor electric grill at high temperature. Each sample was cooked for 5 minutes with each side grilled for 50 seconds. Taste samples were carried in small disposable plastic cups labeled Sample 1 and Sample 2 and served hot. Between sample 1 and sample 2 taste sessions, a small cup of distilled pure water was provided to participants for mouth raisin.

D. Auction

Conventional New York strip and pasture-fed New York strip used at auction stage were cut into ½ inch thick and1 pound of weight packs. Similar shape and fat content were ensured to avoid choice bias.

Table 1. Characteristics of Experiment Participants

		Knoxville (N =141)		Middlesboro (N=161)		Bluefield (N=124)		Overall (N=426)	
Variable	Definition	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
GENDER	Male=1, 0 otherwise	0.29	0.46	0.33	0.47	0.39	0.49	0.33	0.47
AGE	Participant's age 1 if <=24 2 if >24 and <=34 3 if >34 and <=44 4 if >44 and <=54 5 if >54 and <=64 6 if >64	4.04	1.59	3.51	1.50	4.20	1.42	3.89	1.54
HOUSEHOLDSIZE	Number of people in participant's household	2.33	1.33	2.89	1.35	2.73	1.39	2.65	1.37
ETHNICITY	White=1, Black=2, Other=3	1.12	0.42	1.04	0.22	1.05	0.28	1.07	0.32
EDU	No high school diploma or equivalent =1 High school diploma or equivalent = 2 Some college/technical school = 3 Associate's degree = 4 Bachelor's degree = 5 Graduate or professional degree = 6	4.10	1.39	2.69	1.32	3.41	1.50	3.37	1.52

		Knoxville (N =141)		Middlesboro (N=161)		Bluefield (N=124)		Overall (N=426)	
Variable	Definition	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
INCOME	Less than $10,000 = 1	5.47	3.20	3.94	2.49	5.04	2.87	4.76	2.92
	$10,000 - $19,999 = 2								
	$20,000 - $29,999 = 3								
	$30,000 - $39,999 = 4								
	$40,000 - $49,000 = 5								
	$50,000 - $59,999 = 6								
	$60,000 - $69,999 = 7								
	$70,000 - $79,000 = 8								
	$80,000 - $89,999 = 9								
	$90,000 - $99,999 = 10								
	More than $100,000 = 11								
SINGLE	Live alone =1, Otherwise = 0	0.30	0.46	0.10	0.30	0.13	0.34	0.18	0.38

Table 2. Population Socio-demographic Characteristics of the Experimental Area

Variable	Definition	Knoxville Mean(Median)	Middlesboro Mean(Median)	Bluefield Mean(Median)
GENDER	Male=1, 0 otherwise	0.49	0.46	0.46
AGE	Participant's age (year)	33.9(median)	38.6(median)	42.2(median)
HOUSHOLDSIZE	Number of people in participant's household	2.07	2.30	2.23
ETHNICITY	White=1, Other=0	0.80	0.93	0.76
EDU	No high school diploma or equivalent =1 High school diploma or equivalent = 2 Some college/technical school = 3 Associate's degree = 4 Bachelor's degree = 5 Graduate or professional degree = 6	3.12	2.21	2.88
INCOME	Dollars	34185(median)	19565(median)	27672(median)
SINGLE	Live alone=1, Otherwise = 0	0.41	0.32	0.35

Source: American Community Survey, U.S. Census Bureau. Knoxville: 2005-2007 data. Middlesboro and Bluefield: 2000 data.

Table 3. Consumer Preference for Pasture-Fed Beef / Conventional Beef

Preference		Knoxville(N=141)		Middlesboro(N=161)		Bluefield (N=124)		All Regions	
		Proportion	S.E.	Proportion	S.E.	Proportion	S.E.	Proportion	S.E.
Based on visual test	Pasture-fed beef	0.58	0.04	0.50	0.04	0.58	0.04	0.54	0.02
	Conventional beef	0.36	0.04	0.45	0.04	0.36	0.04	0.41	0.02
	Indifferent	0.06	0.02	0.05	0.02	0.06	0.02	0.05	0.01
Based on palatability test	Pasture-fed beef	0.38	0.04	0.39	0.04	0.35	0.04	0.40	0.02
	Conventional beef	0.59	0.04	0.56	0.04	0.61	0.04	0.56	0.02
	Indifferent	0.03	0.02	0.05	0.02	0.04	0.02	0.04	0.01
Over all	Pasture-fed beef	0.38	0.04	0.40	0.04	0.38	0.04	0.42	0.02
	Conventional beef	0.59	0.04	0.57	0.04	0.57	0.04	0.55	0.02
	Indifferent	0.03	0.01	0.03	0.01	0.05	0.02	0.03	0.01

Table 4. Pasture-Fed Beef Auction Bids by Location

	Knoxville (obs=54)				Middlesboro (obs=65)				Bluefield (obs=46)			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
WTP	2.07	1.84	0	10	1.71	1.62	0	6	1.66	1.45	0	6

Table 5. Pasture-Fed Beef Auction Bids by Treatment Group

	Treatment A(obs=60)				Treatment B(obs=62)				Treatment C (obs=43)			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
WTP	1.61	1.82	0	10	1.74	1.26	0	5	2.20	1.87	0	6

Table 6. Wilcoxon-Mann-Whitney Test of the Auction Bids for Pasture-Fed Beef between Locations

	Knoxville (obs=54)	Middlesboro (obs=65)	Bluefield (obs=46)
Knoxville		0.134	0.248
		0.578	0.566
		0.422	0.434
Middlesboro			0.845
			0.489
			0.511

Note: In each comparison, the first number is the probability that the mean bid of the row location equals the column location. The second number is the probability that the random draw from the row location is greater than the random draw from the column location. The third number is the probability that the random draw from the row location is less than the random draw from the column location.

Table 7. Wilcoxon-Mann-Whitney Test of the Auction Bids for Pasture-Fed Beef between Treatments

	Treatment A(obs=60)	Treatment B(obs=62)	Treatment C (obs=43)
Treatment A		0.084 0.311 0.589	0.035 0.379 0.621
Treatment B			0.572 0.468 0.532

Note: In each cell, the first number is the probability that the mean bid of the row treatment group equals the column treatment group. The second number is the probability that the random draw from the row treatment group is greater than the random draw from the column treatment group. The third number is the probability that the random draw from the row treatment group is less than the random draw from the column treatment group.

Table 8. Probit Estimates for Consumer Choice Equation

	Coefficients	Std.Err	Marginal Effect	Std.Err
Constant	-0.7417	0.2166		
Dlcolor	-0.0049	0.0784	-0.0016	0.0255
Dfcolor	-0.0208	0.0736	-0.0068	0.0239
Dtexture	0.2397***	0.0622	0.0781	0.0197
DTender	0.6419***	0.0886	0.2090	0.0272
DJuicy	0.4626***	0.0887	0.1506	0.0287
DFlaor	0.3954***	0.0846	0.1287	0.0284
d2	0.6668***	0.2542	0.2244	0.0860
d3	0.4725*	0.2666	0.1618	0.0940
Percentage of correct choice predictions	89%			

Notes: (*) denotes statistical significance at least at a=0.1. (**) denotes statistical significance at least at a=0.05. (***) denotes statistical significance at least at a=0.01.

Table 9. Variable Description

Variable	Description	Scale	Mean	S.D.	N
Dependent					
WTP	Willingness-To-Pay	>=0, continuous	0.7089	1.3607	404
Independent					
Tb	Treatment B	1=Treatment B,0 otherwise	0.3614	0.4810	404
Tc	Treatment C	1=Treatment C,0 otherwise	0.2599	0.4391	404
Freq	Beef consumption frequency per week		2.3515	0.6062	404
		1=Less than once			28
		2=1 or 2 times			206
		3=3 or more times			170
Experience	Consumption experience about PFB	1=Yes, 0 otherwise	0.5767	0.4947	404
Exph	Impression of pasture-fed beef's impact on human health	1= positive, 0 otherwise	0.4505	0.4982	404
Expe	Impression of pasture-fed beef's impact on environment	1= positive, 0 otherwise	0.4530	0.4984	404
Expa	Impression of pasture-fed beef's impact on animal welfare	1= positive, 0 otherwise	0.4604	0.4990	404
Disease	If the participant and her/his household member has ever been diagnosed with any of the five food-related diseases	1=Yes, 0 otherwise	0.8663	0.3407	404

Variable	Description	Scale	Mean	S.D.	N
Kf	Nutrient function knowledge	0-4,(low to high)	1.4827	1.1037	404
		0			86
		1			127
		2			120
		3			52
		4			19
Ks	Food source knowledge	0-4(low to high)	1.6609	1.2469	404
		0			98
		1			90
		2			88
		3			107
		4			21
Dlcolor	Difference of lean meat color evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.8540	1.3718	404
Dfcolor	Difference of fat color evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.3713	1.8307	404
Dtexture	Difference of meat texture evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	0.0693	1.8112	404
Dtender	Difference of tenderness evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.3366	2.0851	404
Djuicy	Difference of juiciness evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	0	1.6921	404
Dflavor	Difference of flavor evaluation scores: conventional beef minus	-6 to 6	-.2921	1.6904	404

Variable	Description	Scale	Mean	S.D.	N
	pasture-fed beef				
Age	Participant's age		3.9035	1.5396	404
		1 if <=24			33
		2 if >24 and <=34			53
		3 if >34 and <=44			67
		4 if >44 and <=54			93
		5 if >54 and <=64			83
		6 if >64			75
Single	Marital status	1=single, 0 otherwise	0.1733	0.3790	404
Householdsize	Household size	>=1, integers	2.6485	1.3642	404
Ethnicity	Participant's ethnicity	1=White, 0=otherwise	0.9554	0.2066	404
Edu	Education level		3.3342	1.5026	404
		1=No high school diploma or equivalent			34
		2= High school diploma or equivalent			106
		3=Some college/technical school			113
		4=Associate’s degree			37
		5=Bachelor’s degree			70
		6=Graduate or professional degree			44
Income	Household income level		4.7451	2.9151	404
		1=Less than $10,000			33
		2=$10,000 - $19,999			75
		3=$20,000 - $29,999			68
		4=$30,000 - $39,999			49
		5=$40,000 - $49,000			42
		6=$50,000 - $59,999			36
		7=$60,000 - $69,999			30

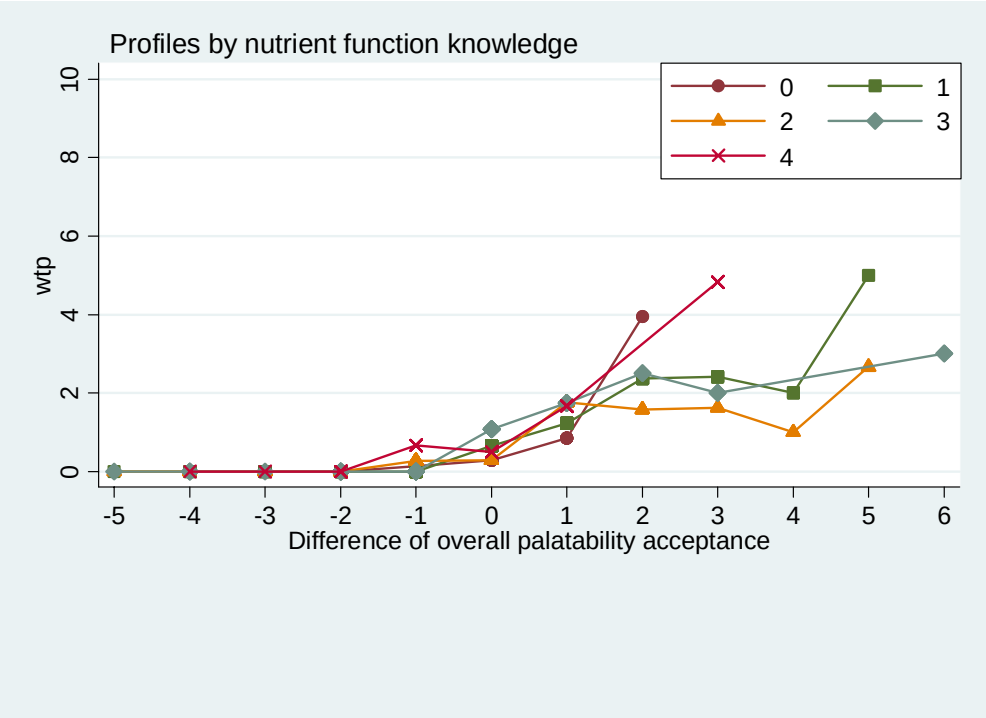
Variable	Description	Scale	Mean	S.D.	N
		8=$70,000 - $79,000			18
		9=$80,000 - $89,999			10
		10=$90,000 - $99,999			9
		11=More than $100,000			34
D2	location dummy	1= Middlesboro, 0 otherwise	0.3861	0.4875	404
D3	location dummy	1= Bluefield, 0 otherwise	0.2896	0.4541	404

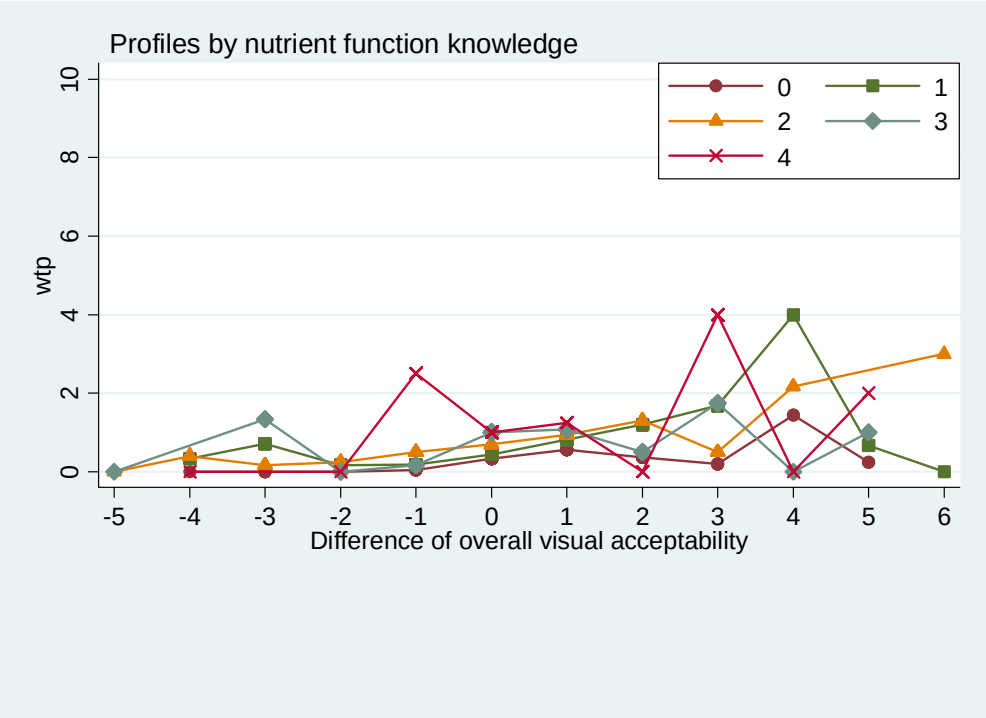
Table 10. Tobit Estimates of WTP Equation

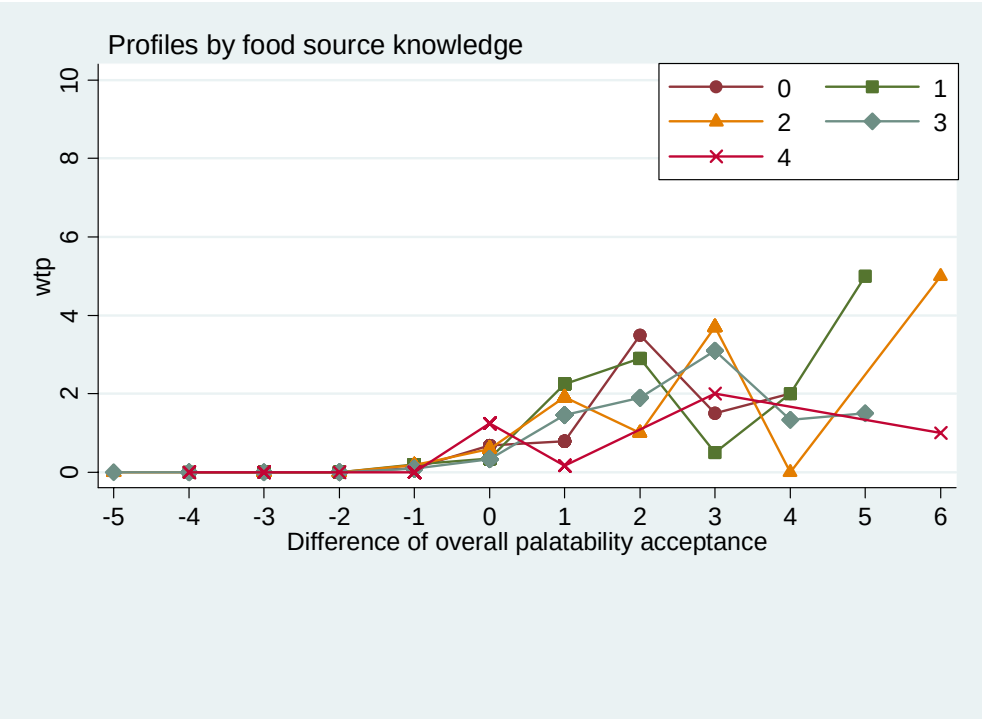
			Marginal Effect	
Variable	Coefficient	S.E.	Unconditional Expected Value	Conditional on being Uncensored
constant	-2.80	1.33		
Tb	0.43	0.37	0.14	0.12
Tc	0.26	0.40	0.08	0.07
Freq	0.44*	0.28	0.14*	0.12*
Experience	-0.13	0.32	-0.04	-0.04
Exphp	-0.26	0.48	-0.08	-0.07
Expep	0.51	0.50	0.17	0.14
Expap	0.01	0.45	0.00	0.00
Disease	0.87*	0.54	0.28*	0.24*
Kf	0.54***	0.18	0.18***	0.15***
Ks	-0.37**	0.16	-0.12**	-0.10**
Dlcolor	0.01	0.13	0.00	0.00
Dfcolor	-0.04	0.11	-0.01	-0.01
Dtexture	0.27***	0.09	0.09***	0.08***
Dtender	0.56***	0.12	0.18***	0.16***
Djuicy	0.41***	0.14	0.14***	0.11***
Dflavor	0.24*	0.13	0.08*	0.07*
Gender	-0.27	0.34	-0.09	-0.08
Age	-0.04	0.11	-0.01	-0.01
Single	-1.31**	0.54	-0.43**	-0.36**
Householdsize	-0.23*	0.14	-0.07*	-0.06*
Ethnicity	0.40	0.76	0.13	0.11
Edu	0.07	0.13	0.02	0.02
Income	-0.02	0.06	-0.01	0.00
D2	-0.10	0.44	-0.03	-0.03
D3	-0.54	0.43	-0.18	-0.15

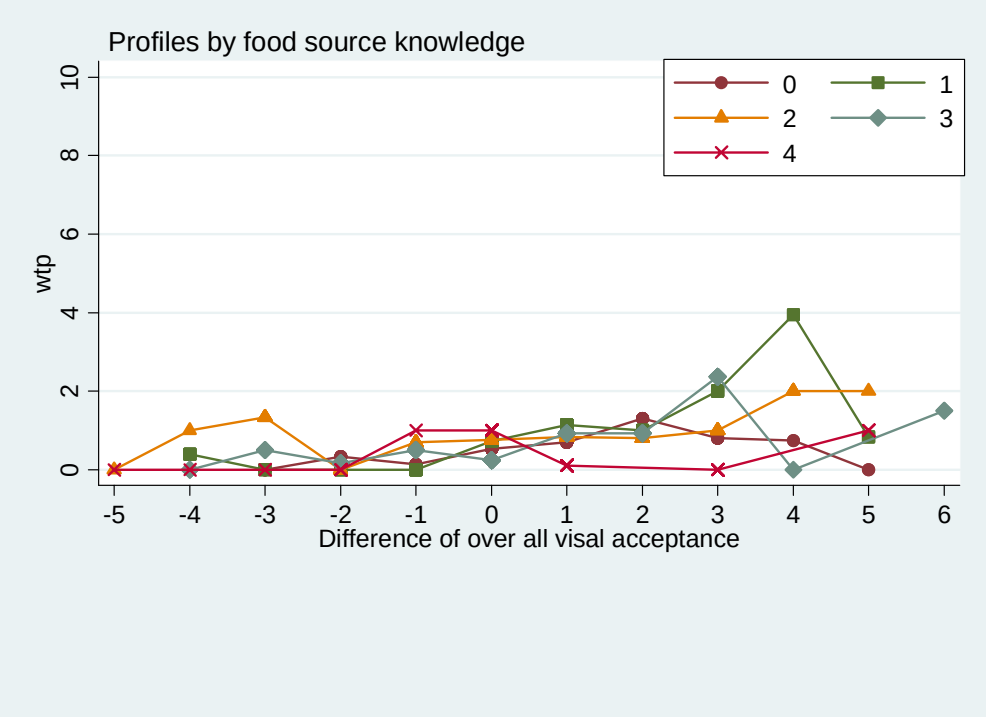
Notes: (*) denotes statistical significance at least at a=0.1. (**) denotes statistical significance at least at a=0.05. (***) denotes statistical significance at least at a=0.01.

Figure 1: Interactions between nutrition knowledge and sensory evaluation on consumers' WTP for PFB






Profiles by food source knowledge
wtp
0
2
4
6
8
10
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Difference of overall palatability acceptance
0
1
2
3


Profiles by food source knowledge
wtp
0
2
4
6
8
10
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
Difference of over all visal acceptance
0
1
2
3