

Two Essays on Beef: Restaurants' Preferences for Tennessee Certified Beef and Cattle
Producers' Preferences for Horn Fly (*Haematobia irritans* (L.)) Resistant Cattle

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ABSTRACT

Beef cattle producers are constantly faced with decisions that will affect the profitability of their operations. Marketing avenues, product differentiation, inputs, efficiency of production, and many other factors can impact profitability. This research analyzes two aspects of the beef industry: restaurant preferences for Tennessee Certified Beef (TCB) and cattle producer preferences for horn fly (*Haematobia irritans* (L.)) resistant (HFR) cattle. Two surveys were developed using the contingent valuation method to estimate willingness to pay (WTP) for TCB products and HFR bulls. Previous studies have shown consumer and producer interest for TCB; however, this study of restaurant WTP provides further information on the scope of the market. On average, restaurants are willing to pay 36% and 48% premiums above the base price of generic beef products for TCB ground beef and sirloin steak respectively. On the other hand, research has shown the horn fly is a damaging pest to the beef industry causing decreased weight gains and complications from insecticide resistance. This study of cattle producer WTP for HFR bulls found that producers are interested and willing to pay 59% and 55% premiums above the price of a non-HFR bull in Tennessee and Texas respectively. Results suggest that producers could gain from the incorporation of these two ideas through increased premiums received for TCB products and increased horn fly management efficiency through the purchase of HFR bulls.

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CHAPTER 1: INTRODUCTION

The beef industry is an important sector of United States (U.S.) agriculture. In 2015, The value of U.S. cattle and calf production was 60 billion dollars (U.S. Department of Agriculture, Economic Research Service, 2018a). The competitiveness of the beef industry, however, can cause complications for individual producers attempting to survive in a large competitive market. According to Barkley and Barkley (2016), agricultural entities are typically considered to be perfectly competitive due to the large number of sellers and homogeneity of products. Cattle are non-homogenous, unlike corn, soybeans, and other commodities, though characteristics of the cattle industry are still competitive (Barkley and Barkley, 2016). The more competitive a firm is, the less influence it has on the price of the product it sells. Since beef cattle producers cannot often influence the prices they receive, they utilize other methods of improving profitability that involve marketing and production decisions. If a producer can capitalize on the non-homogeneity of the livestock industry through product differentiation, he or she could break into a niche market where there is opportunity to acquire a premium above the price of a generic product. If not, the producers whose cattle are less differentiated from the rest of the industry can compete through improving efficiency and adopting new technology and management practices.

This research examines aspects of two beef production decisions and analyzes the possibility of introducing them to the beef industry through estimating willingness to pay (WTP). The primary stakeholders targeted for this research are Tennessee cow-calf producers; however, results from this research could be useful for other states and segments of the beef industry as well. Chapter two examines restaurant preferences for Tennessee Certified Beef (TCB). TCB products are an example of a differentiated beef product which represents a type of marketing

decision. Chapter three examines cattle producer preferences for horn fly resistant (HFR) cattle. The purchase of a HFR bull represents a production decision to increase efficiency.

To obtain information about preferences for TCB products and HFR bulls, surveys were developed using the contingent valuation method for both studies. The TCB survey was administered to independent restaurants in the state, and the horn fly survey was administered to cattle producers involved with the Tennessee Agriculture Enhancement Program (TAEP) and the Texas and Southwest Cattle Raisers Association (TSCRA). The responses were then used to calculate WTP estimates which can provide clarity for researchers and producers on the feasibility of introducing TCB products and HFR bulls. Knowing restaurant WTP for TCB allows producers to have a better idea of the size of the market and potential for increased profit margins from selling TCB. Producer WTP for HFR bulls shows the extent of producer interest in horn fly resistance as a trait that could be used to increase efficiency of production.

CHAPTER 2: RESTAURANTS' PREFERENCES FOR TENNESSEE CERTIFIED BEEF

Background and Objective

Beef cattle are the second largest commodity in Tennessee with respect to agricultural cash receipts (U.S. Department of Agriculture, Economic Research Service, 2018b). In 2012, the number of Tennessee farms with beef cattle totaled 33,556 (U.S. Department of Agriculture, National Agricultural Statistics Service, 2012a) which is roughly 50% of Tennessee farms (U.S. Department of Agriculture, National Agricultural Statistics Service, 2018). Within the beef industry, there are multiple marketing options available to cattle producers; however, in Tennessee, beef cattle farms are mostly cow-calf operations where calves are raised until they are sold as feeder cattle and sent to a feedlot in another state to be finished (Lewis et al., 2016). Tennessee cattle producers have shown interest in exploring untraditional marketing avenues that would result in cattle being finished, processed, and packaged in Tennessee and then marketed to Tennessee consumers (McLeod et al., 2018). If beef products that go through each stage of production within the state are appealing to consumers as a local food option, then producers would benefit through product differentiation.

In recent years, consumer interest in purchasing local foods has been increasing (Packaged Facts, 2018). Research has found that consumers are willing to pay premiums for local foods (Brown, 2003; Carpio and Isengildina-Massa, 2009; Gracia et al., 2012; Adalja et al., 2015; Merritt et al., 2018). For example, consumers surveyed in Missouri (C. Brown, 2003), Midwest retail stores (Darby et al., 2008), South Carolina (Carpio and Isengildina-Massa, 2009), Spain (Gracia et al., 2012), and Maryland (Adalja et al., 2015) were willing to pay a premium for locally produced foods. Dobbs et al. (2016) used a contingent valuation method in their analysis

of consumer willingness to pay (WTP) for Tennessee beef, finding that consumers would pay more for beef that carried a Tennessee label. Merritt et al. (2018) conducted an online consumer choice experiment and found that Tennessee consumers were willing to pay a premium for Tennessee Certified Beef (TCB).

While the literature for consumer preference of local foods is vast, there are other steps in the supply chain to take into consideration when examining the logistical feasibility and economic sustainability of local food markets. Research reports several barriers to marketing local foods, despite consumer willingness to pay local food premiums. For example, the success of a local food product requires reliable distribution systems, food handling and processing facilities, producer interest in providing the product, and food retailers and restaurants being willing to offer local products in their stores and on their menus (Inwood et al., 2009; C. B. Lewis and Peters, 2012; Sharma, Moon, and Strohbehn, 2014; Starr et al., 2003; McLeod et al., 2018). While consumer preferences (Merritt et al., 2018), producer interest (McLeod et al., 2018), availability of processing facilities (Hughes, 2017), and distribution systems (Menard, Jensen, and English, 2012) have been explored with respect to Tennessee beef products, there have been no previous studies regarding restaurant WTP for Tennessee beef. Furthermore, given the growth in restaurants offering farm-to-fork or farm-based menus (Menus of Change, 2017), it is of interest to marketers of local products and researchers to better understand restaurant attitudes toward purchasing and offering local beef on their menus. Therefore, the objective of this study is to examine restaurant WTP for Tennessee Certified Beef (TCB) products and to determine the factors contributing to restaurant decisions to adopt this local product. Results from this analysis provide Tennessee cattle producers and restaurant suppliers a market scope and depth profile for TCB products.

Literature Review

Factors Affecting Consumers' Preferences for Local Foods

Numerous studies have examined consumer perceptions of local foods and found many factors to influence consumers' decisions to purchase local foods (Brown, 2003; Carpio and Isengildina-Massa, 2009; Darby et al., 2008; Gracia et al., 2012; Adalja et al., 2015; Dobbs et al., 2016). Brown (2003) found quality, freshness, price, and consumer attitudes toward the environment were important factors relating to the purchase of local foods. Carpio and Isengildina-Masa (2009) found premiums for local foods were affected by age, gender, perceived quality, and a desire to support the local economy. Adalja et al. (2015) found consumers viewed local products and grass-fed products as substitutes. Dobbs et al. (2016) found consumers who value safety and natural products had a higher WTP for Tennessee ground beef.

Restaurants' Preferences for Local Foods

Restaurants are an important sector to examine because the percentage of US household expenditures on food away from home has increased since the 1960s (U.S. Department of Agriculture, Economic Research Service, 2016). From 2014 to 2016, household expenditures on food away from home were increasing at a higher rate than expenditures on food-at-home (United States Department of Labor, Bureau of Labor Statistics, 2016). In 2015, there were over 10,000 eating and drinking establishments, with projected sales in 2017 of \$12.2 billion (National Restaurant Association and Tennessee Hospitality and Tourism Association, 2018).

Despite the abundant literature on consumer preferences for local foods, only three restaurant surveys were identified in this literature review. However, no studies reviewed estimated restaurant WTP for local foods and the factors affecting restaurant preference to adopt

a specific local food product. Inwood et al. (2009) surveyed restaurants in Ohio and used a ‘diffusion of innovation’ framework to examine the characteristics of restaurants that adopted local foods. They found that chefs were important opinion leaders in restaurants’ decisions to offer local foods, and barriers for serving local foods included distribution problems and lack of convenience (Inwood et al., 2009). Starr et al. (2003) analyzed the linkages between farmers and restaurants, focusing particularly on the constraints and opportunities influencing local food markets. Supporting local businesses, minimizing environmental impact, choosing locally grown and processed products, and restaurant located in an agricultural region were drivers of restaurant purchasing patterns of local foods (Starr et al., 2003). Lastly, Sharma et al. (2014) surveyed Iowa restaurant managers to determine the factors influencing their purchase of local foods. They found that restaurants already purchasing local foods viewed product uniqueness, order processing time, and nutritional value as important factors influencing their interest in local food products. Additionally, restaurants generally perceived local foods to be of higher quality, were willing to promote local foods, and viewed local produce as clean (Sharma et al., 2014). In all of the aforementioned studies, restaurants were interviewed or surveyed about the products they were already purchasing.

Impact of State Branding Programs on WTP for Products

Producers can take an approach very similar to using the local label by participating in a state branding program. As defined by the 2008 Food, Conservation, and Energy Act, “locally or regionally produced agricultural food product means any agricultural food product that is raised, produced, and distributed in the locality or region in which the final product is marketed, so that the total distance that the product is transported is less than 400 miles from the origin of the

product; or the State in which the product is produced” (110th Congress, 2008). The term “local” can have various meanings to different consumers, producers, and retailers throughout the world; however, studies have suggested labeling a product as grown in a particular state is a substitute for the local label (Starr et al., 2003; Selfa and Qazi, 2005; Darby et al., 2008; Carpio and Isengildina-Massa, 2009). As seen with products sporting local labels, state branded products often sell for premiums. Everett et al. (2017) analyzed consumer perceptions of Tennessee produced wine and found Tennessee consumers were willing to pay a premium of \$6.27 per bottle of Tennessee wine over the price of California wine.

Consumers’ Preferences for Differentiated Beef Products

Consumers are often willing to pay more for beef products with certain attributes, such as Certified Angus Beef, natural beef, or grass-fed beef (Feldkamp, Schroeder, and Lusk, 2005; Xue et al., 2010; Zimmerman and Schroeder, 2013). Considerable increases in demand for Certified Angus Beef since the creation of the brand demonstrate the potential for success of branded beef programs (Zimmerman and Schroeder, 2013). Feldkamp, Schroeder, and Lusk (2005) examined consumer WTP for “Guaranteed Tender,” “Natural,” “USDA Choice,” and “Certified Angus Beef” steaks. Consumers’ WTP was the highest for Certified Angus Beef steaks, and the lowest for Natural steaks. Xue et al. (2010) found consumers were willing to pay \$2 per pound more for grass-fed beef as opposed to conventional beef.

Research also suggests consumers place importance on origin of their beef products. Mennecke et al. (2007) found several attributes to have an effect on consumers’ perceptions of beef products, such as animal breed, traceability, animal feed, and beef quality. Region of origin, however, was the most important beef characteristic to consumers (Mennecke et al., 2007). One

study in rural areas of Alabama found consumers held positive perceptions of local beef with respect to animal welfare, societal benefits, freshness, and many other attributes (Telligman, Worosz, and Bratcher, 2017). Ridley, Davados, and Shook (2014) estimated the elasticity of demand for local beef and found demand becomes more elastic as distance from origin increases.

Methods

Survey

A telephone survey of Tennessee restaurants was conducted to determine restaurant WTP for TCB and is included in Appendix C. The survey was reviewed and accepted by the University of Tennessee Institutional Review Board. Telephone numbers for restaurants across the state were compiled from Pick Tennessee Products (2018) and TripAdvisor (2018). Pick Tennessee Products (2018) is a state-sponsored marketing campaign that promotes agricultural products produced in Tennessee. The campaign provides an online directory of restaurants that offer Tennessee products. Restaurants were screened to verify they offered beef products by examining their websites and reviewing menu photos. Chain restaurants were not included in the contact list. Similarly, Inwood et al. (2009) and Starr et al. (2003) did not include chain restaurants in their analysis. Omitting chain restaurants, there were 798 restaurant telephone numbers compiled. A telephone survey was used to ensure the respondent was the primary food purchaser, thereby safeguarding against responses that might not be reflective of the way a restaurant would actually make local food purchases.

The Human Dimensions Research Lab at the University of Tennessee administered the telephone survey in fall 2017. In summer 2017, survey pretests were conducted at local restaurants in the Knoxville area with the restaurant's primary decision maker to determine the

length of time of completion and assess the clarity and appropriateness of questions. After revising the survey based on pretest responses, a final version of the survey was developed. Individuals at the Human Dimensions Research Lab then called each restaurant and asked to speak to the primary decision maker for beef purchases. If the primary decision maker was unavailable, a callback time was arranged with the restaurant when the primary decision maker could answer the survey. The survey began by asking the respondent if they were 18 years or older, were responsible for making the beef decisions at the restaurant, and if the restaurant currently offered or planned to offer beef products. If the respondent answered “no” to any of these questions, they were excused from the survey.

Contingent Valuation Method

The contingent valuation (CV) method was used to estimate restaurant WTP for TCB. The CV method is commonly used to determine WTP for goods and services not currently in the market. While there are multiple methods for determining WTP (e.g., experimental auctions, choice experiments), the CV approach was most conducive for this telephone survey. Dobbs et al. (2016) also used a CV method to elicit consumer WTP for a local Tennessee beef product, allowing for comparison between this study’s restaurant WTP estimates and consumer WTP for a similar product. When implementing the CV method, there are several formats that can be used, including open-ended questions, bidding games, and discrete choice experiments (Hoyos and Mariel, 2010). According to Hoyos and Mariel (2010), closed ended contingent valuation questions are considered more reliable than open-ended questions, which can potentially introduce bias. Three types of closed ended CV dichotomous choice methods are widely accepted: single bounded, double bounded, and one-and-one-half bounded (Hoyos and Mariel,

2010). For this research, the single bounded dichotomous choice CV method was applied to elicit restaurant WTP for TCB.

The survey contained a CV question corresponding with an 85% lean/15% fat ground beef product and a contingent valuation question about a sirloin steak cut. Prior to the CV questions, respondents were provided the following information: “*TCB declares that the animal was born, raised, and harvested in Tennessee and graded USDA Choice or Prime.*” Respondents were assigned one of four price levels per pound for TCB ground beef and asked if they would purchase the product at the given price level or a generic ground beef product at a base price of \$3.00 per pound¹. Respondents were also given the option to choose neither product. The assigned price levels for TCB ground beef were \$3.00, \$4.00, \$5.00, or \$6.00 per pound. Next, respondents were asked a CV question for purchasing TCB sirloin steak compared to a generic sirloin steak at a \$5.00 per pound base price. For the TCB sirloin steak, the price levels assigned were \$5.00, \$6.50, \$8.00, or \$9.50 per pound. Prices were determined based on the National Retail Report for beef (U.S. Department of Agriculture, Agricultural Marketing Service, 2017), discussion with local restaurants, and by observing beef prices on the surveyed restaurant menus.

Questions regarding restaurant demographics, restaurant manager/owner attitudes toward attributes of TCB products, and current management practices (eg. if the restaurant currently offered certain products) were also included in the survey. These questions originated from the literature review of restaurant and consumer surveys on local foods (Starr et al., 2003; Selfa and Qazi, 2005; Carpio and Isengildina-Massa, 2009; Dentoni et al., 2009; Duram and Cawley, 2012; Telligman et al., 2017).

¹ “Generic” beef is the unlabeled and unbranded option.

Econometric Model

A consumer will purchase one product over another when his or her utility for that product is greater than the utility for the other product. McFadden's (1974) random utility model is often used to model this decision, from which WTP for a good or service can be discerned.

McFadden's random utility framework is extended to the restaurant's purchasing decision, assuming that a restaurant maximizes profit rather than utility. Following the framework of the random utility model, restaurant r will choose TCB instead of a generic beef product if its expected profit from purchasing TCB, represented by $E(\Pi_{rTCB})$, is greater than its expected profit from purchasing generic beef, represented by $E(\Pi_{rG})$; i.e., $E(\Pi_{rTCB}) > E(\Pi_{rG})$.

Determining the probability (Pr) that a restaurant will choose TCB corresponds with the probability that the expected profit from serving TCB will exceed the expected profit from serving a generic beef product. Therefore,

$$\Pr[y_{rTCB} = 1] = \Pr[E(\Pi_{rTCB}) > E(\Pi_{rG})] = \Pr[\mathbf{x}'\boldsymbol{\beta} + \varepsilon > 0|\mathbf{x}] = F(\mathbf{x}'\boldsymbol{\beta}) \quad (1)$$

where $\mathbf{x}'\boldsymbol{\beta}$ are observable elements of the difference between the expected profits; ε the difference between the random elements; and F a cumulative distribution function (Greene, 2012). For this research, $\mathbf{x}$ is a vector of independent variables consisting of restaurant characteristics, TCB price, and restaurant manager attitudes towards serving local products. The latent linear model depicting this choice is

$$y_{rTCB}^* = \mathbf{x}'\boldsymbol{\beta} + \varepsilon \quad (2)$$

where

$$y_{rTCB} = \begin{cases} 1 & \text{if } y_{rTCB}^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

because only the decision to purchase TCB is observed and not the actual expected profit.

Two separate probit models were estimated using the same independent variables – one for the restaurant's decision to purchase the TCB ground beef product, and the other for the restaurant's decision to purchase the TCB sirloin steak. The dependent variable of the ground beef probit model was equal to one if a restaurant selected the TCB ground beef product and zero otherwise. The dependent variable in the steak probit model was equal to one if the restaurant selected the TCB sirloin steak and zero otherwise. Independent variables used in the models were determined using log likelihood ratio tests.

The errors of the linear model in Equation 2 are assumed to be normally distributed with an expected value of zero and a variance of one (Greene, 2012). The normal cumulative density function is the probability a restaurant purchases a TCB product demonstrated as

$$Pr[y_{rTCB} = 1] = F(\mathbf{x}'\boldsymbol{\beta}) = \int_{-\infty}^{\mathbf{x}'\boldsymbol{\beta}} \phi(z)dz = \Phi(\mathbf{x}'\boldsymbol{\beta}) \quad (4)$$

where $\phi(z)$ is the probability density function of the standard normal distribution. The log likelihood function of this model is:

$$\ln L = \sum_{r=1}^N [y_{rTCB} \ln \Phi(\mathbf{x}'_r \boldsymbol{\beta}) + (1 - y_{rTCB}) \ln \{1 - \Phi(\mathbf{x}'_r \boldsymbol{\beta})\}] \quad (5)$$

where the vector of β 's in Equation 5 are the maximum likelihood (ML) estimates (Greene, 2012). Average marginal effects for discrete and continuous variables were calculated according to Wooldridge (2002).

Willingness to Pay Calculations

Results from the probit model were used to estimate restaurant average WTP for TCB ground beef and sirloin steak with the formula:

$$\widehat{WTP}_{TCB} = -\frac{\hat{\beta}_0 + \mathbf{z}'\hat{\beta}_{-p}}{\hat{\beta}_p} \quad (6)$$

where $\hat{\beta}_0$ is the estimated intercept, $\hat{\beta}_{-p}$ is a vector of estimated parameters excluding the price coefficient, $\mathbf{z}$ is the vector of independent variables excluding price, and $\hat{\beta}_p$ is the estimated parameter for the price of TCB (Dobbs et al., 2016). WTP was determined as the average over the WTP evaluated for each participant by using the sample. WTP mean and 95% confidence intervals were also calculated using the Krinsky and Robb procedure using 5,000 replications (Krinsky and Robb, 1986).

Explanatory Variables Included in the Probit Models and Their Hypothesized Signs

Independent variables included in the models, hypothesized signs, and sample means are reported in Table 1. Consistent with demand theory, as the price of TCB (*Price*) increases, restaurants were hypothesized to be less likely to purchase TCB. Restaurants located in a city (*City*) were hypothesized to be more likely to purchase TCB products than those located in a suburb, small town, or rural area given the local foods movement has become popular in cities

(Clark, 2016). On average, 40% of the surveyed restaurants stated they were located in a city. Regional dummy variables corresponding with West, Middle, and East Tennessee were also included in the regressions to control for unobserved heterogeneity associated with these regions. It was uncertain how location across the state (*EastTN*, *WestTN*) would influence restaurant preference for TCB. Nearly 60% of the restaurants surveyed were located in East Tennessee.

As restaurants stated that profitability (*Profits*) and quality (*Quality*) had a greater influence on their decision to offer TCB, it was hypothesized they would be more likely to adopt TCB. Consumers often view local foods as having higher quality than alternative products and exhibit a premium WTP for local food products (Brown, 2003). If restaurants also hold the view that TCB is a premium local product and are highly influenced by profitability and product quality when making purchasing decisions, they might be more likely to purchase TCB. Restaurants indicating that sustainability issues (*Sustain*) more greatly factor into their purchasing decisions would be more likely to purchase TCB because consumers typically consider local products to be more sustainable than products not labeled as local (Megicks, Memery, and Angell, 2012). On average, restaurant owners and managers stated higher expected profits, better quality, and sustainability could influence their choice to offer TCB “a lot” (Table 1). Restaurants already offering local foods (*Local*) were hypothesized to be more likely to purchase TCB. Almost 40% of surveyed restaurants were already offering local products.

It was hypothesized that the longer a restaurant had been in business (*YrsBsns*), the less likely it would be to purchase TCB. This reasoning follows because older restaurants have likely used the same supplier for many years and would be less likely to change to TCB. Network associations restaurants have made with suppliers can be barriers to their adoption of local foods (Inwood et al., 2009). The average number of years restaurants had been in business was 17. It

was hypothesized that the more ground beef and sirloin steak purchases the restaurant made per week (*Purch*), the less likely they would be to choose TCB. A reliable supply of local meat can be more difficult to find if the restaurant is purchasing greater volumes of it, given the scarcity of processing facilities in the state (Hughes, 2017). Lack of processing facilities can be another barrier restaurants face when adopting local meats (Lewis and Peters, 2012). On average, restaurants purchased about 163 pounds of ground beef per week and about 148 pounds of steak per week. The higher the restaurant's seating capacity (*Seating*), the less likely the restaurant was hypothesized to be willing to purchase TCB. Smaller restaurants may find it easier to introduce TCB to their menus than larger restaurants because of the additional amount of preparation it takes to provide a product to a larger number of customers. Average seating capacity was about 150.

Sixteen percent and 20% of the restaurants in the ground beef and sirloin steak groups, respectively considered themselves to be fine dining establishments (*FineDining*). The expected signs of the coefficients for *FineDining* were positive because clients frequenting expensive restaurants typically expect premium products. Restaurants with managers who were older (*MgrAge*) were hypothesized to be less likely to offer TCB products. Older individuals are often perceived as less willing to change their habits (Weiss and Maurer, 2004). The average age of managers was 46. It was uncertain how the percentage of clientele that are adults (*Adults*) or families (*Families*) would impact restaurants' decision to offer TCB, given that no previous literature has yet examined this issue. Overall, a higher percentage of the restaurants' clientele were adults than families.

Results

Tennessee Restaurants' Preferences for TCB

The survey had an overall response rate of 19% with 152 restaurants responding to the telephone survey. After eliminating records with missing information, there were 107 records available for analysis of the ground beef model (13% of total restaurants contacted) and 90 observations available for analyses of the sirloin steak model (11% of total restaurants contacted).

Figures 1 and 2 show the percentages of restaurants indicating they would purchase TCB products at each price level as opposed to the generic beef product at a base price. As expected, for both TCB ground beef and sirloin steak, the percentage of restaurants indicating they would purchase the TCB product decreased with each increase in the price of TCB. For ground beef, almost 93% of the restaurants indicated they would purchase the TCB ground beef over the generic ground beef product when both were \$3.00 per pound. However, only 35% of restaurants chose TCB at \$4.00 per pound over the generic ground beef product at \$3.00 per pound. The purchasing pattern continued to decline to 29% when the TCB ground beef price was \$5.00 per pound and to 14% when TCB ground beef was \$6.00 per pound. Analyzing responses from the sirloin steak model, 95% of restaurants indicated they would purchase the TCB sirloin steak rather than generic sirloin steak when both products were \$5.00 per pound. When the TCB sirloin steak was \$6.50 per pound compared to generic sirloin steak at \$5.00 per pound, 54% of restaurants still chose the TCB product. Thirty-eight percent of restaurants chose TCB sirloin steak when its price was \$8.00 per pound, and 21% chose \$9.50 per pound TCB sirloin steak over generic sirloin steak at \$5 per pound.

Overall, 46% of restaurants chose TCB ground beef and 52% of restaurants chose TCB sirloin steak regardless of price point (Table 1). In comparison, Dobbs et al.'s (2016) study of

Tennessee consumers found 36% of consumers chose Tennessee ground beef and 42% chose Tennessee steak regardless of price point. Dobbs et al. (2016) price points ranged from \$3.36 to \$5.88 for ground beef compared to this study's price point range of \$3.00 to \$6.00. Dobbs et al. (2016) used steak prices ranging from a base price of \$9.25 per pound to \$16.19 per pound compared to the steak prices used in this study, which ranged from \$5 per pound to \$9.50 per pound. In addition, the survey by Dobbs et al. (2016) of consumers represented a retail situation unlike this survey of restaurants which was more similar to a wholesale situation². Overall, these results suggest that restaurants were more likely to buy TCB beef than Tennessee consumers.

Factors Affecting Restaurants' Preferences for TCB

The coefficients and marginal effects of the probit models appear in Table 2. As hypothesized, higher prices for TCB ground beef were associated with lower quantity of restaurants demanding the product. The probability of a restaurant purchasing the TCB product decreased as the unit price of TCB increased for both the ground beef and sirloin steak models. Restaurants were 23% less likely to purchase TCB ground beef and 16% less likely to purchase TCB sirloin steak, given a \$1.00 per pound increase in the price of the TCB product (Table 2).

Restaurants located in a city (*City*) had a higher probability of choosing TCB ground beef, as hypothesized. However, being located in a city was not significant in the sirloin steak model. A restaurant's likelihood of purchasing TCB ground beef increased by 20% if the restaurant was located in a city. Restaurants located in East Tennessee (*EastTn*), relative to Middle TN, were 16% more likely to choose the TCB ground beef product. Meanwhile,

² It is likely the restaurants in this study viewed the prices as a wholesale price since they would need to serve it to customers at a higher price than they paid for it to make money.

restaurants were 24% less likely to choose TCB sirloin steak if they were located in West Tennessee (*WestTn*) relative to Middle Tennessee.

Contrary to the hypothesized sign, restaurants were 9% less likely to choose TCB sirloin steak with each one-unit increase on the five-point Likert scale for the influence of profitability (*Profits*) that ranged from not at all to extremely. It is possible this result is due to certain restaurants being satisfied with the profitability of their current products or, they may view adoption of TCB products as a decision that poses some level of risk on their profitability. This variable did not have an influence on restaurants' decision to offer ground beef. Surprisingly, the influence of quality in the decision to offer TCB (*Quality*) did not have an influence on a restaurant choosing to offer TCB ground beef or sirloin steak. Restaurants were 18% more likely to choose TCB sirloin steak as their perception of the importance of sustainability (*Sustain*) increased by one unit on the Likert scale, coinciding with the hypothesized sign. The *Sustain* variable did not affect a restaurant's choice to purchase TCB ground beef. Restaurants already offering local foods (*Local*) to their customers were 24% more likely to choose TCB ground beef and 29% more likely to choose TCB sirloin steak, which is also in accordance with the hypothesis.

The number of years a restaurant had been in business (*YrsBsns*) and the amount of ground beef and sirloin steak the restaurant purchased per week (*Purch*) did not have an impact on a restaurant choosing TCB ground beef or sirloin steak. As hypothesized, a restaurant was 6% less likely to offer TCB sirloin steak as its seating capacity increased by 100 seats. Seating capacity did not impact a restaurant's decision to purchase TCB ground beef. Fine dining restaurants (*FineDine*) were 31% less likely to choose TCB sirloin steak. This result does not correspond to the hypothesis. The likelihood of a restaurant choosing TCB ground beef was

unaffected by the *FineDine* variable. The age of the manager responding to the survey did not have an impact on TCB purchases. A 10% increase in adult clientele (*Adults*) increased the probability a restaurant would choose TCB ground beef by 4%, but it did not have an impact on the restaurant's purchasing decision for sirloin steak. A 10% increase in the number of families (*Families*) represented in a restaurant's clientele decreased the probability the restaurant would choose TCB sirloin steak by 2%, but it did not impact the restaurant's choice to purchase TCB ground beef. These results suggest that restaurant personnel make beef purchasing decisions based on certain factors for ground beef that are different from factors influencing their purchase of sirloin steak.

Variance inflation factors (VIF) were calculated for both models to determine if multicollinearity was affecting estimates of the standard errors. None of the variables' coefficient standard errors had VIF scores exceeding 10. The average VIF across all standard errors of the coefficients was 1.50 for the ground beef model and 1.54 for the sirloin steak model. The VIF results suggest that multicollinearity is not inflating the standard errors of the estimates for either model. Additional collinearity tests were conducted using the StataCorp (2017) *coldiag2* command. The condition index number for the ground beef variables was 27.01 and was 27.37 for the sirloin steak model. Both indices are below 30, again supporting the VIF results (Belsley, 1991).

Willingness to Pay

The mean WTP of restaurants for TCB ground beef using the sample was \$4.09 per pound, a \$1.09 per pound (36%) premium above the base price level for generic ground beef. For TCB sirloin steak, the mean WTP of restaurants was \$7.41 per pound, a \$2.41 per pound (48%)

premium above the base price for generic sirloin steak. Using the Krinsky and Robb method WTP for TCB ground beef was \$4.10 per pound. At the 95% confidence level the lower bound for WTP was \$3.78 per pound, and the upper bound for WTP was \$4.36 per pound. For sirloin steak the WTP using Krinsky and Robb (1986) was \$7.45 per pound with a lower bound of \$7.02 per pound and an upper bound of \$7.89 per pound. The portions of WTP contributed by individual variables in the models are listed in Tables 3 and 4.

Dobbs et al. (2016) also reported higher premiums for Tennessee steak than for Tennessee ground beef with consumer WTP for Tennessee ground beef of \$5.02 per pound, a \$1.66 per pound (49%) premium above the base price. Consumer WTP for Tennessee steak was \$14.31 per pound, a \$5.06 per pound (55%) premium above the base price (Dobbs et al., 2016). The premium percentages for TCB from this study are lower than those reported by Dobbs et al. (2016). This result could reflect that restaurants purchase beef at a wholesale price, add value to the product, and then serve the beef at a higher price to customers in order to create a profit, unlike consumers who purchase beef at retail prices. The difference between the two studies could also indicate that hypothetical bias of those managing a business is lower than that of the average consumer.

Discussion

In recent years, consumer demand for local foods has increased (Brown, 2003; Carpio and Isengildina-Massa, 2009; Gracia et al., 2012; Adalja et al., 2015; Merritt et al., 2018), and there has been an increase in food away-from-home purchases (United States Department of Labor, Bureau of Labor Statistics, 2016). Thus, restaurant perceptions for local food products have become increasingly important. While research on consumer perceptions for local food is

abundant, no previous study has examined restaurant WTP for local foods and the factors influencing restaurant decisions to source local foods. This study analyzed the willingness of restaurants to purchase TCB ground beef and sirloin steak, along with the factors influencing the restaurants' decision to purchase a hypothetical TCB product.

Results indicate that restaurants were interested in purchasing TCB ground beef and sirloin steak. On average, restaurants would be willing to pay premiums for both products. Factors influencing restaurant adoption of TCB products included product price, restaurant location, the type of clientele, the restaurant's current menu items, concerns for profit and sustainability, and whether the restaurant perceived itself to be a 'fine dining' establishment. Restaurants located in a city, located in East Tennessee compared to Middle Tennessee, who were already selling local foods, and whose clientele were typically adults were more likely to adopt TCB ground beef. Restaurants already serving local foods, not self-classified as fine dining, located in Middle Tennessee compared to West Tennessee, less concerned with profitability and more concerned with sustainability were more likely to adopt TCB sirloin steak.

Restaurants were willing to pay premiums above the price of generic beef of 36% and 48% for TCB ground beef and TCB steak, respectively. This indicates that TCB suppliers would expect higher premiums from selling a TCB steak product to restaurants than from selling a TCB ground beef product to restaurants. WTP premiums for TCB from this study were lower than those of Dobbs et al. (2016), who found that consumers were willing to pay 49% and 54% premiums for Tennessee ground beef and steak, respectively. This result might be reflective of the fact that restaurants purchase beef at wholesale prices as compared to consumers who purchase beef at retail prices. Alternatively, this could indicate that the hypothetical bias of restaurants is lower than that of consumers.

Future research could further examine the difference in WTP estimates between general consumer samples and restaurant samples to determine if this difference exists between other food products and the reasons this discrepancy exists. The results of this study provide information that would be useful for producers in marketing TCB, and on a broader scale, this research serves as an example for future studies of restaurant WTP for products. This study shows restaurants are willing to pay for TCB products and determines which factors affect restaurant WTP for these products. Having knowledge of these demographic factors can be useful to producers when they determine where to sell TCB products.

CHAPTER 3: CATTLE PRODUCERS' PREFERENCES FOR HORN FLY (*HAEMATOBIA IRRITANS* (L.)) RESISTANT CATTLE

Background and Objective

The horn fly (*Haematobia irritans* (L.)) is an ectoparasite that can negatively affect animal welfare and the profitability of livestock operations. Horn flies are a recognized and chronic problem in the cattle industry due to the estimated 30 blood meals per day they take from their host (Arther, 1991). Gordon, Haufe, and Klein (1984) estimated the economic threshold of horn flies for insecticide application to be between 10 and 230 flies per animal depending on cattle price and environmental conditions. The most recent estimate of an annual loss to the industry is \$876 million a year (Kunz et al., 1991). Horn flies also contribute to health problems in cattle such as transmitting *S. aureus* (a mastitis-causing pathogen), bovine teat atresia, and hide damage (Edwards et al., 2000; Gillespie et al., 1999; Guglielmone et al., 1999). Increases in fly counts have also been associated with decreases in milk yield of cows (Mays et al., 2014) which reduces weight gain in their calves (Clutter and Nielsen, 1987).

Common practices used to treat cattle for horn flies include fly traps, manure manipulation, boluses, and topical insecticides – such as ear tags, sprays and dusts (Foil and Hogsette, 1994). Studies have shown that horn fly management practices can result in increased weight gains in cattle and positive returns to producers (DeRouen et al., 2003, 1995; Harvey and Brethour, 1979; Haufe, 1982, 1986; Kunz et al., 1984; Sanson et al., 2003). For example, up to 17% higher weight gain in cattle has been attributed to horn fly control (DeRouen et al., 1995; Haufe, 1982). However, current management practices are not without limitations. Some practices are highly labor intensive, incurring an opportunity cost of producers' time, while others are simply not efficient for the beef industry. For example, Denning, Washburn, and

Watson (2014) examined a vacuum fly trap which proved to be effective in reducing horn fly numbers on organic dairy farms; however, efficacy of the trap was affected by frequency of use, and it required electricity, making the trap less than ideal as a management practice for most beef operations.

Possibly the greatest concern in managing horn fly populations is a horn fly's ability to develop resistance to insecticides (Barros et al., 2001; Byford et al., 1999; Cilek, Steelman, and Knapp, 1991; Quisenberry et al., 1984; Sheppard, 1984; Sparks et al., 1985). Campbell et al. (2006) found that resistance in horn flies was not enough to impact the efficacy of the ear tags used in the study; nevertheless, other studies found horn flies can develop resistance to a chemical in as little as two years (Quisenberry et al., 1984; Sheppard, 1984) with complete product failure in four years (Byford et al., 1999). Cross resistance between different insecticides has also been found (Cilek et al., 1991; Sheppard, 1984).

With the threat of horn flies developing resistance to insecticides, introducing new management practices is essential to reducing the impact of the problems caused by horn flies. Selection for horn fly resistance in cattle has been proposed as a viable alternative for the purposes of allowing producers to be environmentally safe (Brown et al., 1992) as well as managing insecticide resistant horn flies (Steelman et al., 2003). No previous study has determined the level of interest producers have in horn fly resistance as a trait; therefore, the goal of this study is to determine if producers would be willing to adopt horn fly resistant (HFR) cattle into their herds. To accomplish this, a survey of Tennessee and Texas cow-calf producers was conducted to estimate their willingness to pay (WTP) for a HFR bull and to determine the factors affecting their decision to adopt a HFR bull.

Literature Review

Factors Affecting Horn Fly Resistance

Although no known studies have examined whether producers would be interested in adopting HFR cattle into their herds, studies have been conducted which show variation in fly counts between breeds (Guglielmone et al., 2000), host color (Schreiber and Campbell, 1986), frame size (Steelman et al., 1996), and hair density (Steelman et al., 1997). Other studies have phenotyped individual cattle within breeds as more susceptible to horn flies or higher carriers than others (Jensen et al., 2004; Pruett et al., 2003; Steelman et al., 1993). Cattle that consistently carry fewer flies than other cattle with the same environmental and treatment conditions are often considered to be resistant to horn flies. Horn fly resistance does not mean that the animals have no flies, but they have lower fly counts in comparison to other animals in the herd. Research has also shown that Brahman cattle carry significantly fewer horn flies than other breeds such as Angus (Steelman et al., 1994). Results of this research will provide insight into whether cattle producers are willing to adopt HFR cattle into their herds to control for the horn fly.

Economic Impact of the Horn Fly on Cattle Production

Numerous studies have shown cattle with fewer horn flies are more profitable to the farming operation due to higher weight gains (Haufe, 1982; Kunz et al., 1984; Haufe, 1986; DeRouen et al., 1995, 2003; Harvey and Brethour, 1979; Sanson et al., 2003). In a six-year study by Harvey and Brethour (1979), cattle were treated using bags filled with insecticide dust which were hung by the entrances of pastures where the cattle passed through. The study found weight gains of steers treated with dust bags to be an average of 11 pounds greater per animal than untreated steers in early grazing periods and seven pounds greater in late grazing periods; these

weight gains of treated animals corresponded to increased estimated revenue of \$11 per animal (Harvey and Brethour, 1979). Kunz and Meyerhoeffer (1984) found calves belonging to cows treated for horn flies outweighed others by an average of 16 pounds per head which corresponded to overall returns ranging from \$2.16 to \$8.38 for every \$1.00 spent on insecticides. Overall, producers' revenues increase when they have fewer horn flies on their cattle.

Methods

Survey

To determine cattle producers' preferences for a HFR bull, a survey was created using the contingent valuation (CV) method. Cattle producers participating in the Tennessee Agriculture Enhancement Program (TAEP) and the Texas and Southwestern Cattle Raisers Association (TSCRA) were emailed the online web based Qualtrics (*Qualtrics Software*, 2018) survey regarding their preference for HFR cattle³. Producers were required to be 18 years or older to complete the survey. Eleven percent of Tennessee producers (464 of 4,028) and 8% of Texas producers (317 of 3,882) contacted completed the survey. Prior to the survey being fully disseminated, the survey was pretested by cattle producers. Producers who pretested the survey did not participate in the full launch of the survey.

All producers completing the survey were given the following definition of horn fly resistance: "an animal with few to minimal horn flies present, noticeable, or feeding on the animal. It also means that other traits you select for would be unaffected by the addition of the horn fly resistance trait, so that the horn fly-resistant cattle and your current cattle are the same

³ For the remainder of this paper, TAEP respondents are referred to as Tennessee producers, and TSCRA respondents are referred to as Texas producers.

weight and have IDENTICAL muscling, gains, health and other traits.” Following this definition of horn fly resistance, Tennessee and Texas cattle producers were asked a single-bounded dichotomous choice CV question to determine their preference for HFR cattle – as was used in Chapter 2. The CV method has been used for valuation of agricultural products such as Tennessee labeled beef (Dobbs et al., 2016) and insect control (Miller and Lindsay, 1993). The specific CV question producers were asked was dependent upon which segment of the cattle industry they were primarily involved with. Approximately 75% of producers surveyed managed cow-calf operations and were therefore asked a CV question regarding their preference for a HFR bull as opposed to a bull that was not HFR. Other CV questions were asked to producers whose management practices included the use of straws of semen, the purchase of stocker steers, and the purchase of cattle for finishing to determine perceptions of horn fly resistance from producers from different segments of the industry. This study focuses only on the data collected pertaining to the cow-calf segment of the industry since not enough observations were collected to analyze the other segments of the industry resulting from the large majority of survey respondents being cow-calf producers.

Tennessee cow-calf producers were asked if they would purchase a bull at a base price of \$3,000 or a HFR bull at one of four prices: \$3,000; \$3,500; \$4,000; or \$4,500. Texas cow-calf producers were asked if they would purchase a bull at a base price of \$5,000 or a HFR bull at one of four prices: \$5,000; \$5,500; \$6,000; or \$6,500. These price points were based on the average market prices of bulls in Tennessee (University of Tennessee Bull Test, 2017) and Western states at the time of the survey (Gardiner Angus Ranch, 2017; Tri State Livestock News, 2017).

An Information Treatment was included in the survey to determine how information about the horn fly and its effects on cattle impacts producer preference for the HFR trait. Prior to the contingent valuation question, half of the producers received horn fly information (Information Treatment) and the other half did not receive this information. The Information Treatment provided was as follows:

“ABOUT HORN FLIES AND CATTLE

Horn flies are a pest of cattle that inflict painful bites to draw 20 – 30 blood meals per day and have the following effects:

- Animals’ defensive behaviors interrupt adequate rest and food consumption
- Calves protected from horn flies have weaning weights 10 – 50 pounds more than unprotected calves with 200 or more flies.
- Stockers and replacement heifers protected from horn flies have weight 16 – 18% above unprotected animals.
- Horn flies can transmit bacteria that cause mastitis.”

Econometric Model

Producers are assumed to maximize profits. Thus, a producer, i , would choose the HFR bull rather than a non-HFR bull if his or her expected profit for the HFR bull, represented by $E(\Pi_{iHFR})$, was greater than the expected profit from purchasing the typical bull $E(\Pi_{iB})$; i.e., $E(\Pi_{iHFR}) > E(\Pi_{iB})$. This is a variation of the (McFadden, 1974) random utility theory. The probability (Pr) that a producer expects profit from a HFR bull to be greater than the expected profit from the alternative bull yields the probability to choose a HFR bull. Therefore,

$$\Pr[y_{iHFR} = 1] = \Pr[E(\Pi_{iHFR}) > E(\Pi_{iB})] = \Pr[\mathbf{x}'\boldsymbol{\beta} + \varepsilon > 0|\mathbf{x}] = F(\mathbf{x}'\boldsymbol{\beta}) \quad (1)$$

where $\mathbf{x}'\boldsymbol{\beta}$ represents observable elements of the difference of the two expected profit functions, ε is the difference between the two random elements, and F is the distribution function (Greene, 2012). The latent regression model is represented by

$$y_{iHFR}^* = \mathbf{x}'\boldsymbol{\beta} + \varepsilon \quad (2)$$

where

$$y_{iHFR} = \begin{cases} 1 & \text{if } y_{iHFR}^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

because only the decision to purchase the HFR bull is observed and not the actual expected profit. Maximum likelihood was estimated using two probit models, one for Tennessee producers with Tennessee bull prices, and another for Texas producers with Texas bull prices. Log likelihood ratio tests were conducted to assist in determining appropriate variables. The function for a probit model is the standard normal cumulative distribution function (Greene, 2012):

$$\Pr[y_{iHFR} = 1] = F(\mathbf{x}'\boldsymbol{\beta}) = \int_{-\infty}^{\mathbf{x}'\boldsymbol{\beta}} \phi(z) dz = \Phi(\mathbf{x}'\boldsymbol{\beta}), \quad (4)$$

and the maximum likelihood estimation procedure is (Greene, 2012):

$$\ln L = \sum_{r=1}^N [y_{iHFR} \ln \Phi(\mathbf{x}'_r \boldsymbol{\beta}) + (1 - y_{iHFR}) \ln \{1 - \Phi(\mathbf{x}'_r \boldsymbol{\beta})\}]. \quad (5)$$

Following (Wooldridge, 2002), the associated marginal effects were also calculated.

Willingness to Pay Calculations

Results from the probit models were used to estimate producers' average WTP for a HFR bull with the formula

$$\widehat{WTP}_{iHFR} = -\frac{\hat{\beta}_0 + \mathbf{z}'\hat{\boldsymbol{\beta}}_{-p}}{\hat{\beta}_p} \quad (6)$$

where $\hat{\beta}_0$ is the estimated intercept, $\hat{\boldsymbol{\beta}}_{-p}$ is a vector of estimated parameters excluding the price coefficient, $\mathbf{z}$ is the vector of independent variables excluding price, and $\hat{\beta}_p$ is the estimated

parameter for the price of an HFR bull. Average WTP was determined by calculating the mean of the WTP of each individual producer in the sample (Dobbs et al., 2016). WTP mean and 95% confidence intervals were also calculated using the method outlined by Krinsky and Robb using 5,000 replications (1986).

Explanatory Variables Included in the Probit Models and Their Hypothesized Signs

Table 5 shows the variable means and hypothesized signs of the independent variables included in the Tennessee and Texas models. Of survey respondents, 254 answered all questions included in the Tennessee model, and 119 answered all questions included in the Texas model. In Tennessee and Texas, as the price of the HFR bull (*BullPr*) increased, this was hypothesized to decrease the probability the producer would purchase the HFR bull compared to a non-HFR bull. About 81% of Tennessee producers and 89% of Texas producers chose the HFR bull over the non-HFR bull (Table 5). A dummy variable was included to determine if the Information Treatment (*Info*) impacted producer preference for HFR bulls. About half of the producers saw the Information Treatment which was hypothesized to increase producer preference for HFR bulls.

Producers who observed higher levels of fly intensity on their cattle (*HFIntens*) were hypothesized to be more likely to choose the HFR bull. It is likely they would be interested in alternative horn fly management options if they had not previously been able to control horn flies successfully. Producers considered the level of fly intensity on their cattle a moderate to serious problem on average in both Tennessee and Texas. Producers who experienced higher levels of horn fly treatment effectiveness (*TrtEffect*) were hypothesized to be less likely to choose the

HFR bull. In Tennessee and Texas, producers perceived their treatments to be “as effective” as they were five years prior.

Producers were hypothesized to be more likely to choose the HFR bull if they had higher levels of education (*Education*). Education has been shown to increase willingness of producers to make successful changes in management practices (Kilpatrick, 2000). The average producer from both states had some level of college or technical school education. Older producers (*Age*) were hypothesized to be less likely than younger producers to choose the HFR bull because they are often considered less willing to change (Weiss and Maurer, 2004). The average age of Tennessee producers was 57 years, and the average age of Texas producers was 62 years. These sample averages are consistent with the average age of farmers in the United States (U.S.) of 58 years (U.S. Department of Agriculture - National Agricultural Statistics Service, 2012).

Producers who had higher levels of income (*Income*) were hypothesized to be more likely to purchase the HFR bull because they have a greater amount of funds available to spend on a bull. On average, Tennessee producers fell into the \$50,000 to \$99,999 range, while average Texas producers fell into the \$100,000 to \$149,999 range. Average U.S. household income for farms is \$119,880 (Schnepf, 2017). The hypothesized effects of the producers’ business structure being a sole proprietorship (*SolePr*) was unknown. Eighty-one percent of Tennessee producers and 76% of Texas producers operated under a sole proprietorship.

Producers were hypothesized to be more likely to choose the HFR bull if they expected higher increases in weight gain due to horn fly resistance (*WtChng*). This variable captured each producer’s perception of the impact horn fly resistance would have on their herd. Producers would be more willing to make changes in their operations the greater their perceived impact of this change. Tennessee producers expected a 21% increase in weights as a result of horn fly

resistance; whereas, Texas producers expected a 23% increase in weight. It is unknown if producers' current use of some form of horn fly management such as insecticide pour-ons or ear tags (*Insecticide*, *EarTag*) would have an impact on their purchase of the HFR bull. These producers already recognize horn flies as a problem; however, they could be satisfied with their current horn fly management practices. In both states 92% of producers used insecticides; 57% of Tennessee producers and 39% of Texas producers used ear tags. Producers who viewed additional labor to address horn flies as burdensome (*Labor*) were hypothesized to be more likely to choose the HFR bull. In theory, a HFR herd would result in less labor from implementing other horn fly management practices. Producers who view this labor as burdensome might be more interested in exploring other options such as breeding for horn fly resistance. On average, producers in both states "somewhat agreed" that the additional labor was burdensome.

Producers who gained information about horn flies from Extension services (*Extens*) were hypothesized to be more likely to choose the HFR bull because this type of training can have a positive impact on management decisions (Kilpatrick, 2000). Seventy-five percent of Tennessee producers and 70% of Texas producers learned information about horn flies from Extension services. Producers owning Charolais influenced cattle (*Charolais*) were hypothesized to be less likely to choose the HFR bull since European cattle breeds have been reported to have lower horn fly densities than British breeds such as Angus cattle (Steelman et al., 1991). In Tennessee, 21% of producers owned Charolais cattle while only 14% of producers in Texas owned Charolais cattle. Producers owning Angus influenced cattle (*Angus*) were hypothesized to be more likely to choose the HFR bull since they are not a breed known for resistance to horn flies. In Tennessee, 87% of producers owned Angus cattle, and 65% of producers owned Angus cattle in Texas. Producers with larger herds (*HerdSize*) were hypothesized to be more likely to

choose the HFR bull since larger farmers may have more incentive to adopt this practice. Average herd sizes were 111 in Tennessee and 202 in Texas. State averages for herd size on beef cattle farms are 47 and 74 in Tennessee and Texas respectively (U.S. Department of Agriculture, National Agricultural Statistics Service, 2012a, 2012b). Producers placing higher importance on horn fly resistance as a trait (*HFRTrait*) were hypothesized to be more likely to choose the HFR bull. In both states producers considered a horn fly resistance trait as “moderately important.” Finally, a dummy variable (*Texas*) was included in the Texas model to control for producers who were not located in Texas. Only 9% of producers in the “Texas” model were located in some other southwestern state⁴. It was unsure how this variable would impact a producer’s choice to purchase the HFR bull.

Results

Producers’ Preferences for Horn Fly Resistant Bulls

Figure 3 shows the percentages of Tennessee producers who chose the HFR bull over a \$3,000 bull that was not HFR at various price levels. The solid bars represent this percentage for producers who received the Information Treatment, and the bars with diagonal lines represent those who did not. In Tennessee, the base price of a bull that was not resistant to horn flies was \$3,000 in each scenario. When the HFR bull was \$3,000 – the same price as the non-HFR bull – 100% of producers with information chose the HFR bull. Ninety-seven percent of producers without information chose the HFR bull. When the HFR bull was \$3,500, 94% of producers with the Information Treatment and 86% without the Information Treatment chose the HFR bull. At a price of \$4,000 for the HFR bull, 64% of producers with information and 87% of producers

⁴ Ten of the 11 other southwestern state entries were located in Oklahoma, and one identified as “other.”

without information chose the HFR bull. Finally, 53% of producers with information and 64% of producers without information chose the HFR bull when it was \$4,500. Using a t-test, it was determined that the percentages of producers with and without the Information Treatment who chose the HFR bull were only significantly different at the \$4,000 price level.

In Texas, the base price for a bull that was not resistant to horn flies was \$5,000 in each scenario, as shown in Figure 4. When the HFR bull was \$5,000 – the same price as the other bull – 100% of producers, both with and without information, chose the HFR bull. At a price of \$5,500 for the HFR bull, 100% of producers with information and 92% of producers without information chose the HFR bull. Seventy-nine percent of producers with information and 90% of producers without information chose the HFR bull when the price was \$6,000. At the highest price level of \$6,500, 76% of producers with information and 83% of producers without information chose the HFR bull. The differences in percentages for producers with the Information Treatment and those without were not significantly different at any price level in the Texas model.

Factors Affecting Producers' Preferences for Horn Fly Resistant Bulls

Results of the Tennessee and Texas probit models are reported in Table 6. In Tennessee and Texas, the price of a HFR bull (*BullPr*) negatively impacted producers' choice to purchase a HFR bull, coinciding with the hypothesis. With each \$100 increase in price, Tennessee producers were 3% less likely to choose the HFR bull. With each \$100 increase in price, producers in Texas were 1% less likely to choose the HFR bull. In Tennessee, producers who received the Information Treatment (*Info*) were less likely to choose the HFR bull, which was contrary to the hypothesis. The probability a producer would choose the HFR bull was 8% lower for producers

who received the Information Treatment than for those who did not. It is possible producers without the Information Treatment overestimated the negative impacts horn flies have on their cattle. The Information Treatment was not significant in the Texas model. In Tennessee, intensity of horn flies (*HFIntens*) on the producers' cattle positively affected the likelihood that a producer would choose the HFR bull, agreeing with the hypothesis. As producers indicated that horn fly intensity was more of a problem, the probability that a producer would choose the HFR bull increased by 8%. In Texas, intensity of horn flies (*HFIntens*) on the producers' cattle negatively affected the likelihood that a producer would choose the HFR bull, contrary to the hypothesis. As producers indicated that horn fly intensity was more of a problem, the probability that a producer would choose the HFR bull decreased by 5%. Neither the effectiveness of horn fly treatment (*TrtEffect*) nor the producer's education level (*Education*) had a significant impact on producers' decision to purchase the HFR bull in either state.

Surprisingly, older producers (*Age*) in Texas were more likely to choose the HFR bull. As producers were one year older, there was a 1% increase in the probability they would choose the HFR bull. A possible explanation could be that older producers have been using horn fly insecticides long enough to see the effects of insecticide resistance and realize the need for new horn fly control practices. As hypothesized, total household income (*Income*) had a positive effect on producers' likelihood of choosing the HFR bull in Texas. With each one-unit increase on the income scale (Table 6), a producer was 3% more likely to choose the HFR bull. Also in Texas, producers operating under a sole proprietorship (*SolePr*) were less likely to choose the HFR bull than those with other business structures. Producers were 9% less likely to choose the HFR bull if they were sole proprietors. Age, income and operating under a sole proprietorship were not significant in the Tennessee model.

Producers who expected they would see greater increases in weight gain if their entire herd was resistant to horn flies (*WtChng*) were more likely to choose the HFR bull in both Tennessee and Texas. This result parallels the hypothesis. With each 1% increase in expected weight gain, producers in both states were 1% more likely to choose the HFR bull. Producers who used insecticide as their form of horn fly management (*Insecticide*) were 12% more likely to choose the HFR bull in Tennessee and 14% more likely in Texas. Producers who used ear tags to manage horn flies (*Eartag*) were 12% less likely to choose the HFR bull in Texas; however, this variable was not significant for Tennessee. The more producers in Tennessee agreed with the statement that the amount of labor required to address horn flies is burdensome (*Labor*), the less likely they were to choose the HFR bull. This interesting result could mean producers in Tennessee have a misunderstanding of how labor would be impacted through the adoption of HFR bulls. With each one-unit increase on the four-point Likert scale for *Labor* ranging from strongly disagree to strongly agree, the probability the producer would choose the HFR bull decreased by 6%. However, in Texas, producers who were in greater agreement that labor to manage horn flies was burdensome (*Labor*) were more likely to choose the HFR bull which coincides with the hypothesis. As producers agreed more that additional labor needed to address horn flies was burdensome, the likelihood of choosing the HFR bull increased by 12%.

The variables indicating producers owned Charolais influenced cattle (*Charolais*) and obtained information on horn flies from extension services (*Extens*) were not significant in either model. As hypothesized, producers in Texas with Angus cattle in their herds (*Angus*) were 10% more likely to choose the HFR bull. Texas producers with a larger herd size (*HerdSize*) were more likely to choose the HFR bull, also according to the hypothesis. As producers' herds were 100 head larger, they were 3% more likely to choose the HFR bull. Angus and herd size

variables were not significant in Tennessee. As producers considered the HFR trait (*HFRTrait*) to be more important, they were 7% and 5% more likely to choose the HFR bull in Tennessee and Texas, respectively. These findings also correspond to the hypothesized signs.

Variance inflation factors (VIFs) and condition index tests were used to determine if multicollinearity was a problem in either model. The VIFs were all less than 10, and the mean VIF was 1.11 and 1.21 for the Tennessee model and Texas model, respectively. Upon calculating the condition index using the *coldiag2* code using STATA (StataCorp, 2017), these indices were less than 34 for both models. Thus, multicollinearity was not a concern with the models.

Willingness to Pay

The WTP of each observation included in the models was calculated. From those calculations, the average WTP for producers in each state was calculated from the sample. Producers in Tennessee had an average WTP for a HFR bull of \$4,652. This is a premium of \$1,652 (59%) above the base price for a bull. In Texas, producers' average WTP for a HFR bull was \$7,949, a premium of \$2,949 (55%) above the base price of a bull.

WTP was also calculated using the Krinsky and Robb (1986) method. Tennessee producers' WTP for a HFR bull was \$4,644. At the 95% confidence level the lower bound for WTP was \$4,444, and the upper bound for WTP was \$4,962. Texas producers' WTP using this method was \$7,759 with a lower bound of \$7,028 and an upper bound of \$10,981. The portions of WTP contributed by individual variables in the models are listed in Tables 7 and 8.

Discussion

The goal of this study was to determine producer interest and WTP for horn fly resistance in their cattle. The CV method was used to question cow-calf producers, primarily from Tennessee and Texas, about whether they would purchase a horn fly resistant bull or another bull that was not horn fly resistant at varying price levels. Producers from Tennessee and Texas were surveyed because approximately 17% – using the number of beef cows that calved as a proxy for beef cattle production – of all U.S. cow-calf production resides in these states (Livestock Marketing Information Center, 2018).

Overall, 83% of producers in the two models chose the HFR bull rather than the bull that was not resistant to horn flies, 81% of producers in Tennessee, and 89% of producers in Texas. Producers in both states indicated an average WTP higher than the base price of a non-HFR bull in their state. In Tennessee producers were willing to pay a \$1,652 (59%) premium, and producers in Texas were willing to pay a \$2,949 (55%) premium for the HFR bull. These WTP estimates were found to be affected by demographic factors, management practices, and the producers' perceived impact of horn fly resistance. Tennessee producers who had observed greater horn fly intensity, expected greater increases in weight gain, used insecticides, and more greatly valued the HFR trait were more likely to indicate they would purchase the HFR bull. In Texas, producers who were older, had greater total household incomes, expected greater increases in weight gain, used insecticides, considered labor of horn fly management more burdensome, had Angus cattle, had larger herd sizes, and more greatly valued the HFR trait were more likely to choose the HFR bull.

Resulting from this study, it is now known that producers are willing to pay for HFR bulls and are interested in the horn fly resistance trait. Their WTP amounts suggest they would

be interested in adoption of the HFR trait as a new and efficiency-increasing practice in their cattle production. The knowledge of producer interest in horn fly resistance as a trait allows for the continued study and development of the trait and methods for its delivery.

CHAPTER 4: CONCLUSIONS

This research is intended to help with the advancement of new marketing and production decisions for beef cattle producers. Alternative methods of marketing and production assist producers with the difficulties they face when attempting to increase profit margins in a highly competitive market. Producing TCB as a value-added beef product and introducing a horn fly resistance trait through the purchase of HFR bulls are two emerging production techniques with potential for producers to increase profits. This research can inform decisions to further develop both practices as viable options for cattle producers.

The survey results of Tennessee restaurants provide a further understanding of the extent of the market for TCB. Most Tennessee restaurants view TCB ground beef and sirloin steak as premium products with 21% indicating they are willing to pay a premium for TCB ground beef and 31% indicating they are willing to pay a premium for TCB sirloin steak. Results can be used to develop a profile of the type of restaurant TCB should be marketed to if producers are interested in differentiating their product from other beef products.

Horn fly resistance is a concept where additional research needs to be conducted; however, for research on horn fly resistance to continue and advance, evidence was required to ensure producers were interested and willing to pay for the trait in some capacity. In Tennessee, 57% of producers indicated they were willing to pay a premium for a HFR bull over a non-HFR bull, and 64% were willing to pay a premium in Texas. This research shows cow-calf producers were not only interested in purchasing a bull with the HFR trait but their WTP values were 59% and 55% higher than the base price for a non-HFR bull in their respective state. This research is an important part of the motivation for future research on horn fly resistance in cattle.

The introduction of TCB products to the market and horn fly resistance as a genetic trait would allow producers more options to choose from when making marketing and production management decisions. Product differentiation with TCB products or increased production efficiency with HFR bulls, allows for potential increased profitability in a highly competitive industry. Results from this research are helpful for producers attempting to break into a niche market and for more conventional beef cattle producers alike.

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APPENDICES

Appendix A: Tables

Table 1. Variable Definitions, Means, and Hypothesized Results for the Ground Beef and Sirloin Steak Models

Variable	Description	Hyp. sign	Ground Beef		Sirloin Steak	
			Mean (N=107)	Std. Dev.	Mean (N=90)	Std. Dev.
Dependent Variable						
<i>TCB</i>	Restaurant’s choice between TCB and generic beef (1 if they chose TCB, 0 otherwise)		0.46	0.50	0.52	0.50
Independent Variables						
<i>Price</i>	Ground beef price levels of \$3.00, \$4.00, \$5.00, or \$6.00/lb Steak price levels of \$5.00, \$6.50, \$8.00, or \$9.50/lb	-	4.29	1.00	7.17	1.51
<i>City</i>	1 if the restaurant is located in a city, 0 if the restaurant was located in a suburb, small town, or rural area	+	0.39	0.49	0.40	0.49
<i>EastTn</i>	1 if the restaurant is located in East Tennessee, 0 if located in West Tennessee or Middle Tennessee	?	0.59	0.49	0.57	0.50
<i>WestTn</i>	1 if the restaurant is located in West Tennessee, 0 if located in East Tennessee or Middle Tennessee	?	0.18	0.38	0.22	0.42
<i>Profits</i>	Influence of profitability on choice to offer TCB ^a	+	4.17	1.19	4.18	1.24
<i>Quality</i>	Influence of quality on choice to offer TCB ^a	+	4.45	1.06	4.50	1.01
<i>Sustain</i>	Influence of sustainability on choice to offer TCB ^a	+	4.12	1.19	4.27	1.11
<i>Local</i>	1 if the restaurant currently has products labeled as local on their menu, 0 otherwise	+	0.38	0.49	0.36	0.48
<i>YrsBsns</i>	Number of years the restaurant has been in business	-	16.53	18.55	16.56	18.97
<i>Purch</i>	Pounds of ground beef/steak purchased per week	-	162.59	190.74	148.48	276.78
<i>Seating</i>	Seating capacity of the restaurant	-	144.22	102.80	154.73	109.11
<i>FineDining</i>	1 if the restaurant is classified as fine dining, 0 otherwise	+	0.16	0.37	0.20	0.40
<i>MgrAge</i>	Age of manager/owner	-	46.04	12.44	45.98	12.03
<i>Adults</i>	Percentage of clientele that are adults	?	59.57	23.62	57.56	23.88
<i>Families</i>	Percentage of clientele that are families	?	47.79	24.63	47.60	24.94

Notes: a 1=Not at All, 2=Influence Slightly, 3=Influence Moderately, 4=Influence A Lot and 5=Influence Extremely

Table 2. Probit Model Results and Marginal Effects for the Ground Beef and Sirloin Steak Models

	Ground Beef		Sirloin Steak	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect
<i>Price</i>	-1.05*** (0.19)	-0.23*** (0.02)	-0.86*** (0.16)	-0.16*** (0.02)
<i>City</i>	0.95* (0.40)	0.20** (0.07)	0.28 (0.35)	0.05 (0.06)
<i>EastTn</i>	0.76* (0.39)	0.16* (0.08)	-0.37 (0.43)	-0.07 (0.08)
<i>WestTn</i>	-0.10 (0.50)	-0.02 (0.11)	-1.32* (0.53)	-0.24* (0.10)
<i>Profits</i>	0.11 (0.16)	0.02 (0.03)	-0.51** (0.20)	-0.09* (0.04)
<i>Quality</i>	0.31 (0.27)	0.07 (0.06)	0.05 (0.24)	0.01 (0.04)
<i>Sustain</i>	0.31 (0.22)	0.07 (0.05)	0.99*** (0.24)	0.18*** (0.04)
<i>Local</i>	1.13** (0.36)	0.24** (0.07)	1.57** (0.51)	0.29** (0.08)
<i>YrsBsns</i>	-0.00 (0.01)	-0.00 (0.00)	-0.02 (0.01)	-0.00 (0.00)
<i>Purch</i>	-0.00 (0.00)	-0.00 (0.00)	-0.0005 (0.0007)	-0.00 (0.00)
<i>Seating</i>	-0.00 (0.00)	-0.00 (0.00)	-0.003* (0.002)	-0.0006* (0.0003)
<i>FineDining</i>	-0.60 (0.53)	-0.13 (0.11)	-1.67** (0.59)	-0.31** (0.10)
<i>MgrAge</i>	0.01 (0.01)	0.00 (0.00)	0.0003 (0.01)	0.00 (0.00)
<i>Adults</i>	0.02** (0.01)	0.004** (0.00)	0.01 (0.01)	0.00 (0.00)
<i>Families</i>	-0.00 (0.01)	-0.00 (0.00)	-0.01 (0.01)	-0.002* (0.001)
Constant	-1.41 (1.49)		5.19** (2.00)	
Observations	107		90	
Pseudo R ²	0.442		0.518	
Wald χ^2 (15)	54.20***		56.72***	

Notes: Standard errors in parentheses

* $p < 0.1$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Variables' Effects on Restaurants' WTP for TCB Ground Beef

Variable	\$/lb.	Lower Bound	Upper Bound
<i>City</i>	0.90	0.16	1.63
<i>EastTn</i>	0.72	-0.03	1.63
<i>WestTn</i>	-0.10	-1.05	0.75
<i>Profits</i>	0.10	-0.18	0.48
<i>Quality</i>	0.30	-0.19	0.86
<i>Sustain</i>	0.29	-0.14	0.76
<i>Local</i>	1.07	0.40	1.99
<i>YrsBsns</i>	0.00	-0.02	0.01
<i>Purch</i>	0.00	0.00	0.00
<i>Seating</i>	0.00	0.00	0.00
<i>FineDining</i>	-0.57	-1.58	0.47
<i>MgrAge</i>	0.01	-0.01	0.04
<i>Adults</i>	0.02	0.01	0.04
<i>Families</i>	0.00	-0.01	0.01

Note: The lower and upper bounds represent a 95% confidence interval

Table 4. Variables' Effects on Restaurants' WTP for TCB Sirloin Steak

Variable	\$/lb.	Lower Bound	Upper Bound
<i>City</i>	0.32	-0.53	1.16
<i>EastTn</i>	-0.43	-1.38	0.64
<i>WestTn</i>	-1.53	-2.81	-0.49
<i>Profits</i>	-0.59	-1.16	-0.12
<i>Quality</i>	0.06	-0.50	0.64
<i>Sustain</i>	1.15	0.61	2.04
<i>Local</i>	1.82	0.86	2.87
<i>YrsBsns</i>	-0.02	-0.05	0.01
<i>Purch</i>	0.00	0.00	0.00
<i>Seating</i>	0.00	-0.01	0.00
<i>FineDining</i>	-1.94	-3.35	-0.68
<i>MgrAge</i>	0.00	-0.03	0.03
<i>Adults</i>	0.01	-0.01	0.03
<i>Families</i>	-0.02	-0.03	0.00

Note: The lower and upper bounds represent a 95% confidence interval

Table 5. Variable Definitions, Means, and Hypothesized Results for the Tennessee and Texas Models

Variable	Description	Hyp. sign	Tennessee		Texas	
			Mean (N=254)	Std. Dev.	Mean (N=119)	Std. Dev.
Dependent Variable						
HFR	Producer's choice to between the HFR bull and non-HFR bull (1 if they chose the HFR bull, 0 otherwise)		0.81	0.40	0.89	0.31
Independent Variables						
BullPr	Different price levels for HFR bull: \$3,000, \$3,500, \$4,000, or \$4,500 for Tennessee; \$5,000, \$5,500, \$6,000, and \$6,500 for Texas	-	3767.72	558.07	5789.92	580.38
Info	1 if Information Treatment was seen, 0 otherwise	+	0.47	0.50	0.55	0.50
HFIntens	Level of intensity of fly problem on back and withers ^a	+	3.20	0.81	3.68	0.75
TrtEffect	Level of effectiveness of horn fly insecticides today compared to five years ago ^b	-	4.09	1.61	4.20	1.61
Education	Highest level of the producer's education ^c	+	3.38	0.78	3.61	0.63
Age	Age of the producer	-	57.32	11.79	62.31	11.00
Income	Level of total household income ^d	+	4.81	1.45	5.87	1.74
SolePr	1 if business structure is sole proprietorship, 0 otherwise	?	0.81	0.40	0.76	0.43
WtChng	Estimated percentage change in weight gain given the producer's entire herd were resistant to horn flies	+	21.26	12.90	23.13	13.96
Insecticide	1 if the producer applies insecticides (ex. pour-on) to animals, 0 otherwise	?	0.92	0.28	0.92	0.27
EarTag	1 if the producer uses ear tags, 0 otherwise	?	0.57	0.50	0.39	0.49
Labor	Level of agreement with the statement that additional labor needed to address horn flies is burdensome ^e	+	3.22	0.82	3.26	0.74
Extens	1 if the producer gained information about horn flies from extension services, 0 otherwise	+	0.75	0.44	0.70	0.46
Charolais	1 if the producer has Charolais cattle, 0 otherwise	-	0.21	0.41	0.14	0.35
Angus	1 if the producer has Angus cattle, 0 otherwise	+	0.87	0.33	0.65	0.48
HerdSize	Number of animals in the herd (bulls, cows, and calves)	+	110.99	118.89	202.34	307.22
HFRTrait	Importance of the horn fly resistance trait ^f	+	3.06	0.63	3.24	0.65
Texas	1 if the producer was in Texas, 0 otherwise	?			0.91	0.29

Notes: ^a1=No problem, 2=Minor problem, 3=Moderate problem, 4=Serious problem, 5=Very intense problem; ^b1=Much less, 2=Somewhat less, 3=Slightly less, 4=As effective, 5= Slightly more, 6=Somewhat more, 7=Much more; ^c1=Less than high school, 2=High school graduate, 3=Some college or technical school/associate's degree, 4=College degree or higher; ^d1=Less than \$10,000; 2=\$10,000-\$29,999; 3=\$30,000-\$49,999; 4=\$50,000-\$99,999; 5=\$100,000-\$149,999; 6=\$150,000-\$199,999; 7=\$200,000-\$249,999; 8=\$250,000-\$499,999; 9=\$500,000 or greater; ^e1=Strongly disagree, 2=Somewhat disagree, 3=Somewhat agree, 4=Strongly agree; ^f1=Not important, 2=Slightly important, 3=Moderately important, 4=Very important

Table 6. Probit Model Results and Marginal Effects for the Tennessee and Texas Models

Variable	Tennessee		Texas	
	Coef.	Marginal Effects	Coef.	Marginal Effects
<i>BullPr</i>	-0.002*** (0.0002)	-0.0003*** (0.00004)	-0.002** (0.0006)	-0.0001** (0.00004)
<i>Info</i>	-0.46* (0.22)	-0.08* (0.04)	0.21 (0.43)	0.02 (0.04)
<i>HFIntens</i>	0.44** (0.14)	0.08** (0.03)	-0.58* (0.27)	-0.05* (0.02)
<i>TrtEffect</i>	-0.06 (0.07)	-0.01 (0.01)	0.02 (0.13)	0.002 (0.01)
<i>Education</i>	0.01 (0.15)	0.001 (0.03)	-0.47 (0.53)	-0.04 (0.04)
<i>Age</i>	-0.01 (0.01)	-0.002 (0.002)	0.11*** (0.03)	0.01*** (0.002)
<i>Income</i>	0.10 (0.08)	0.02 (0.01)	0.31* (0.14)	0.03* (0.01)
<i>SolePr</i>	-0.09 (0.27)	-0.02 (0.05)	-1.09* (0.63)	-0.09* (0.05)
<i>WtChng</i>	0.04** (0.01)	0.01** (0.002)	0.08** (0.03)	0.01*** (0.002)
<i>Insecticide</i>	0.67* (0.34)	0.12* (0.06)	1.68* (0.81)	0.14* (0.07)
<i>Eartag</i>	0.23 (0.23)	0.04 (0.04)	-1.37** (0.53)	-0.12* (0.05)
<i>Labor</i>	-0.33* (0.14)	-0.06* (0.02)	1.41*** (0.38)	0.12*** (0.03)
<i>Extens</i>	0.34 (0.24)	0.06 (0.04)	0.55 (0.53)	0.05 (0.04)
<i>Charolais</i>	-0.41 (0.26)	-0.07 (0.05)	0.07 (0.62)	0.01 (0.05)
<i>Angus</i>	0.13 (0.33)	0.02 (0.06)	1.14* (0.55)	0.10* (0.04)
<i>HerdSize</i>	0.001 (0.001)	0.0002 (0.0002)	0.004* (0.002)	0.0003* (0.0001)
<i>HFRTrait</i>	0.38* (0.20)	0.07* (0.03)	0.64* (0.33)	0.05* (0.03)
<i>Texas</i>			-0.19 (0.71)	-0.02 (0.06)
Constant	4.27** (1.34)		-2.36 (3.99)	
Observations	254		119	
Pseudo R^2	0.337		0.553	
Wald χ^2	61.05***		39.76***	

Notes: Standard errors in parentheses

* $p < 0.1$, ** $p < 0.01$, *** $p < 0.001$

Table 7. Variables' Effects on Tennessee Producers' WTP for a HFR Bull

Variable	\$/Bull	Lower Bound	Upper Bound
<i>Info</i>	-305.90	-590.54	-21.25
<i>HFIntens</i>	289.64	94.45	484.83
<i>TrtEffect</i>	-39.77	-128.28	48.73
<i>Education</i>	3.65	-184.25	191.56
<i>Age</i>	-7.04	-19.62	5.55
<i>Income</i>	66.53	-41.71	174.77
<i>SolePr</i>	-61.95	-420.02	296.12
<i>WtChng</i>	23.27	7.55	38.99
<i>Insecticide</i>	440.37	-21.84	902.58
<i>Eartag</i>	152.41	-138.00	442.83
<i>Labor</i>	-217.68	-414.16	-21.21
<i>Extens</i>	225.49	-95.08	546.06
<i>Charolais</i>	-269.06	-600.95	62.83
<i>Angus</i>	83.65	-341.25	508.56
<i>HerdSize</i>	0.83	-0.88	2.53
<i>HFRTrait</i>	251.54	-0.62	503.70

Note: The lower and upper bounds represent a 95% confidence interval

Table 8. Variables' Effects on Texas Producers' WTP for a HFR Bull

Variable	\$/Bull	Lower Bound	Upper Bound
<i>Info</i>	130.22	-409.26	669.69
<i>HFIntens</i>	-353.17	-740.28	33.95
<i>TrtEffect</i>	11.82	-144.50	168.14
<i>Education</i>	-285.87	-958.84	387.11
<i>Age</i>	65.67	16.29	115.06
<i>Income</i>	192.03	13.40	370.67
<i>SolePr</i>	-668.14	-1591.01	254.73
<i>WtChng</i>	48.82	17.06	80.58
<i>Insecticide</i>	1030.03	-266.45	2326.51
<i>Eartag</i>	-839.30	-1691.47	12.87
<i>Labor</i>	862.19	235.65	1488.74
<i>Extens</i>	337.49	-222.85	897.83
<i>Charolais</i>	43.65	-708.45	795.75
<i>Angus</i>	696.53	51.16	1341.89
<i>HerdSize</i>	2.41	-0.53	5.35
<i>HFRTrait</i>	388.85	-102.20	879.90
<i>Texas</i>	-117.36	-967.14	732.41

Note: The lower and upper bounds represent a 95% confidence interval

Appendix B: Figures

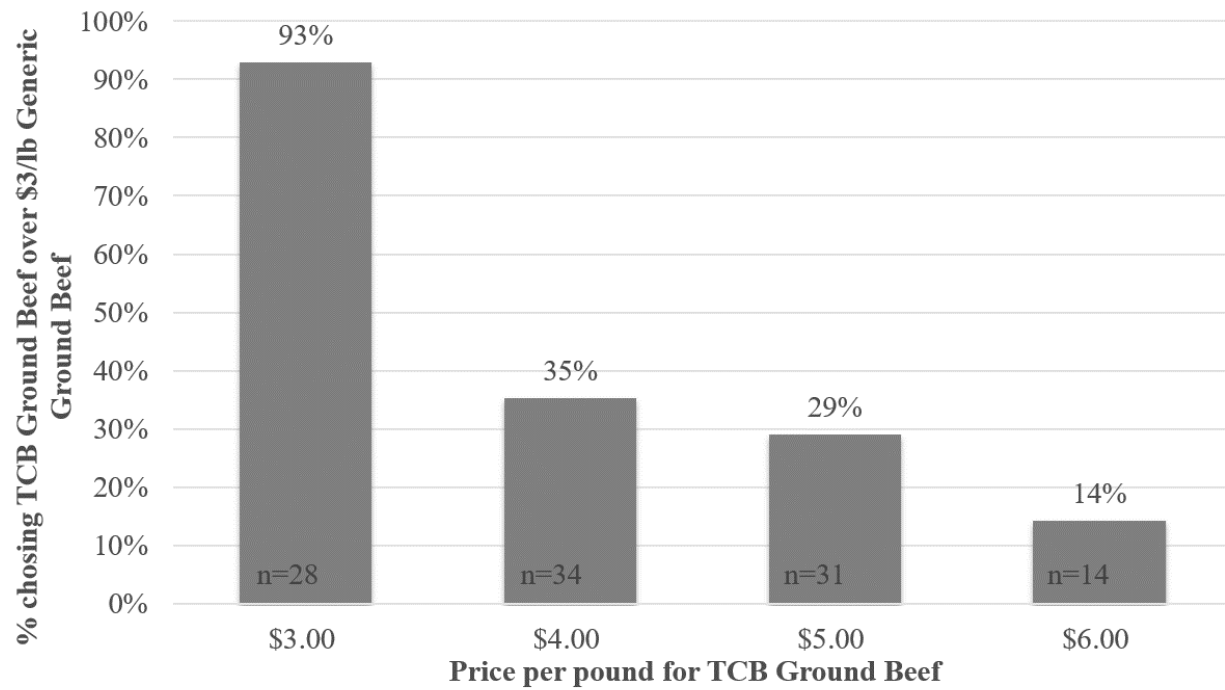


Figure 1. Percentage of Restaurants Choosing TCB Ground Beef over \$3/lb Generic Beef

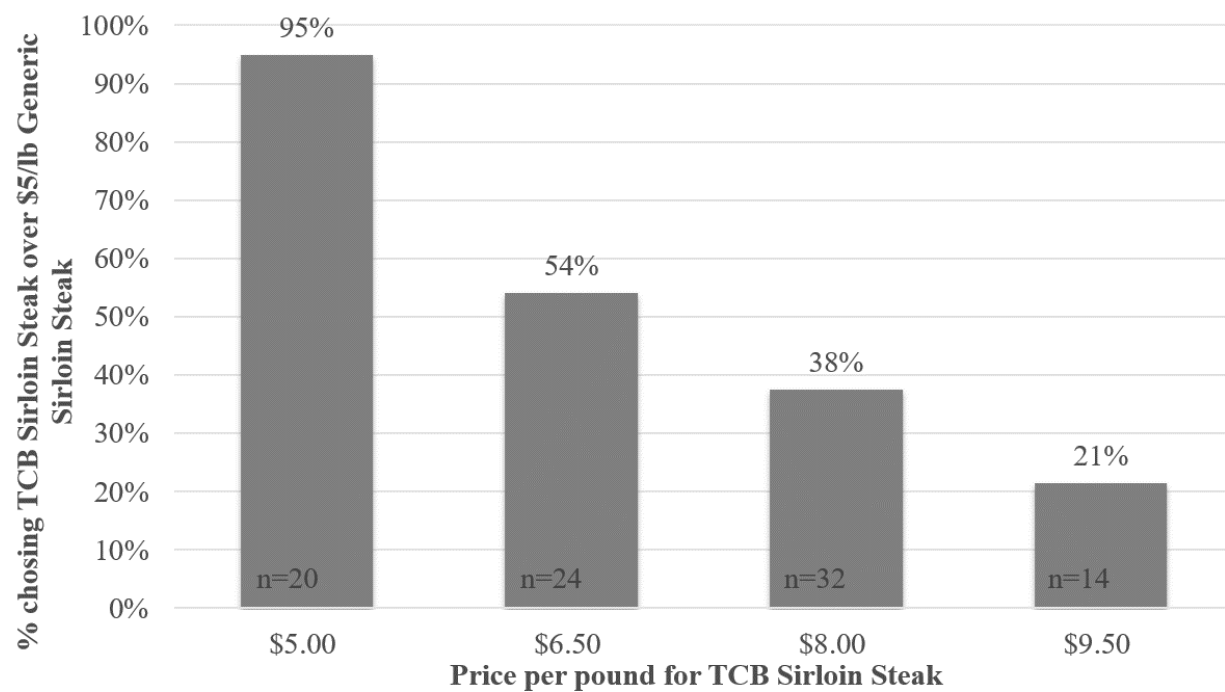


Figure 2. Percentage of Restaurants Choosing TCB Sirloin Steak over \$5/lb Generic Beef

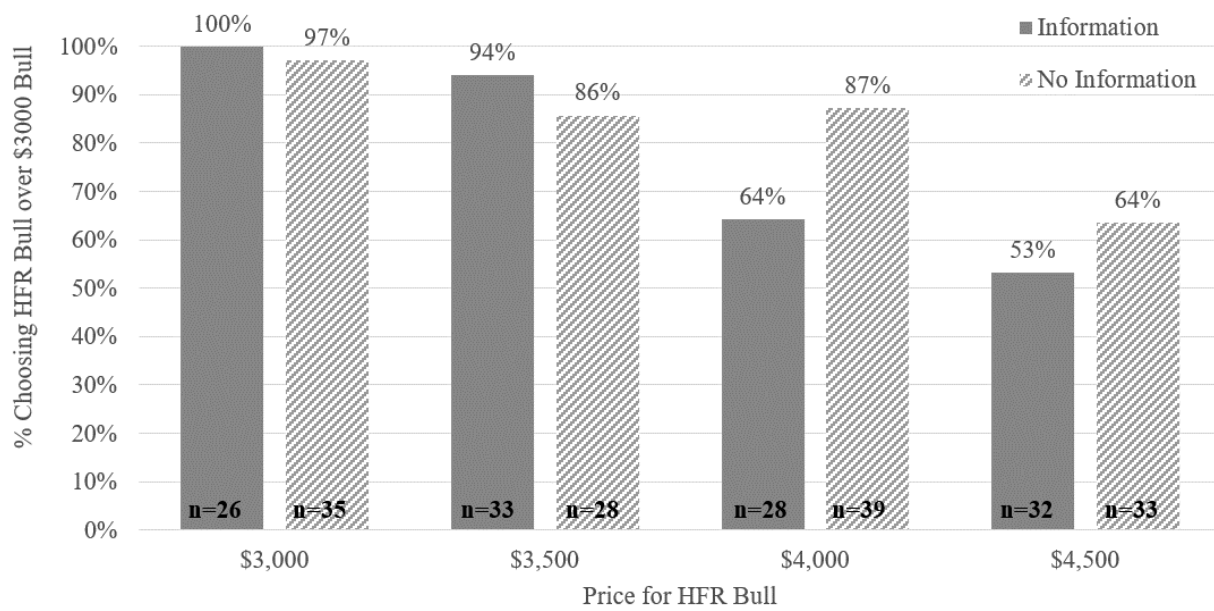


Figure 3. Percentage of Tennessee Producers Choosing a HFR Bull over a \$3,000 Bull

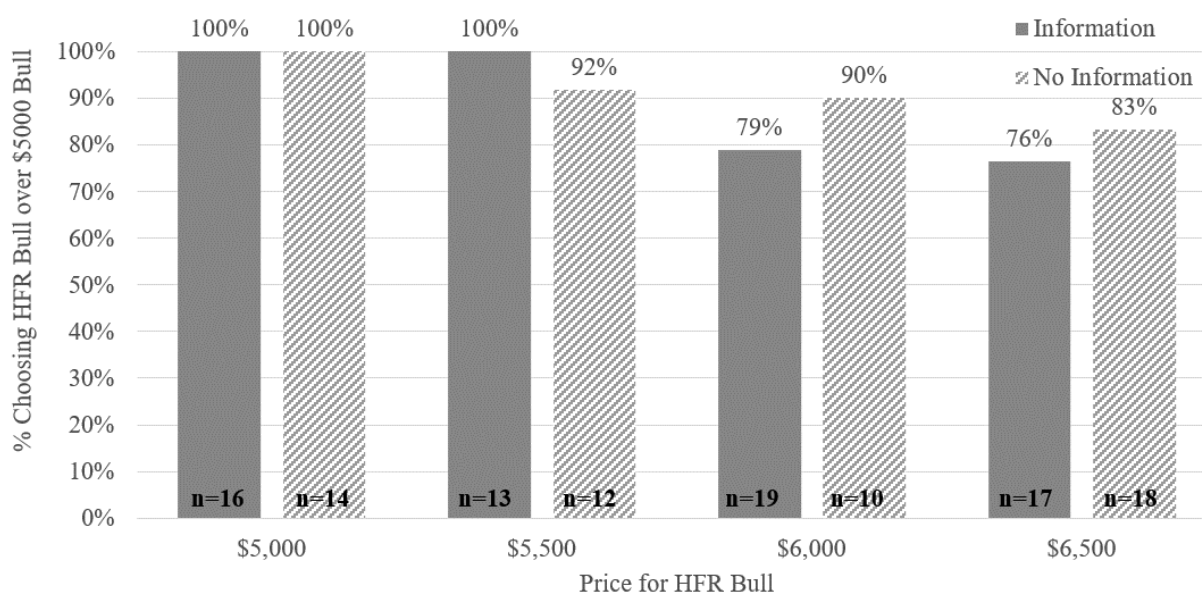


Figure 4. Percentage of Texas Producers Choosing a HFR Bull over a \$5,000 Bull

Appendix C: Surveys

Tennessee Restaurant Survey

Screenener

Hi, I'm ____ from the University of Tennessee Institute of Agriculture. I'd like to speak to the manager who makes decisions about purchasing to ask some questions about Tennessee beef.

If correct person not available:

Who would that person be? _____

What time is _____ likely to be in?

Days of week: _____

Times of day: _____

Correct person

Hi, I'm ____ from the University of Tennessee Institute of Agriculture. I'm a student research assistant working on a study about the marketability of TCB in Tennessee restaurants. I'd like to ask you a few questions about your restaurant's beef purchases and your opinions about Tennessee beef. We'll use the information you provide to better assess the markets for Tennessee-produced beef. Would that be okay? The questions will take about 12 minutes.

If you answer these questions you will be voluntarily participating in a research project. Any information you provide will not be associated with your name or your restaurant's name. We'll release information only as summaries. There's no known risk to you for participating in this research, nor are there direct benefits. You can skip any question you don't want to answer and withdraw from the study anytime without penalty, in which case the data you provide will be destroyed. You may contact the UT Compliance Officer at 865-974-7465 for additional information about your rights as a research participant.

Retailer Survey for Tennessee Certified Beef

General Questions

1. Are you 18 years of age or older?

- a. Yes
- b. No

[If no, please have someone over the age of 18 complete this survey.]

2. Does your restaurant currently offer beef products to your customers?

- a. Yes
- b. No
 - i. If 'No', would you be interested in offering beef products to your customers in the future?
 - 1. Yes
 - 2. No

[If still no, do not continue the survey.]

3. Do you currently make the purchase decisions regarding beef (or food products) at your restaurant?

- a. Yes
- b. No

[If no, please have someone who makes purchasing decisions for the restaurant complete this survey.]

4. How would you classify your restaurant? Please select all that apply.

- a. Fast Food
- b. Bar and Grill
- c. Family Restaurant
- d. Fine Dining
- e. Other _____

“Tennessee Certified Beef” declares that “the animal was born, raised, and harvested in Tennessee and graded USDA Choice or Prime.” Please keep this definition in mind when answering the following questions.

[note to administrator of survey: if they ask if this is a current program, reply the following:

“This product could become available in the future, but might not be currently available.”]

5. Assuming Tennessee Certified Beef is profitable, would you consider offering Tennessee Certified Beef products to customers?

- a. Yes
- b. No
 - i. Why not? _____

Contingent Valuation Questions (note: There are 4 different versions of this question)

For the next questions, assume all beef options are the same weight and have IDENTICAL freshness, color, texture, fat, tenderness, juiciness, and flavor.

XXX= different price levels \$3.00, \$4.00, \$5.00, or \$6.00/lb

6. Assume you are purchasing 85% lean/15% fat ground beef for your restaurant.

Which ground beef would you choose?

- a. Ground Beef at \$3 per pound
- b. Tennessee Certified Ground Beef at XXX per pound
- c. Neither
 - a. Is there a reason you chose neither? _____

6a. If respondent answered 'b' for previous question, ask:

What percentage of your ground beef would you prefer to be Tennessee Certified Beef at this price level? _____%

XXX= different price levels \$5.00, \$6.50, \$8.00, or \$9.50/lb

7. Assume you are purchasing Sirloin Steak for your restaurant. Which Sirloin Steak would you choose?

- a. Sirloin Steak at \$5.00 per pound
- b. Tennessee Certified Sirloin Steak at XXX per pound
- c. Neither
 - a. Is there a reason you chose neither? _____

7a. If respondent answered 'b' for previous question, ask:

What percentage of your Sirloin Steak would you prefer to be Tennessee Certified Sirloin Steak at this price level? _____%

- 8. How much do you agree that the following factors would influence your choice to offer Tennessee Certified Beef to your customers? Please tell me whether each factor I name would explain your choice 1, Not at All; 2= Influence Slightly, 3= Influence Moderately, 4=Influence A Lot or 5=Influence Extremely.**

	Not At All Influence Extremely				
	1	2	3	4	5
It will increase profits					
It has better quality					
It is more sustainable					

- 9. Do you currently have products labeled as local on your menu?**
- a. Yes
 - b. No

The next questions are about your restaurant.

- 10. Where in Tennessee are you located?**
- a. East Tennessee
 - b. Middle Tennessee
 - c. West Tennessee

11. Where are you located?

- a. City
- b. Suburb
- c. Small Town
- d. Rural Area

12. How many years has your restaurant been in business?

13. We are interested in the demographics of your customers. What percentage of your clientele comes to your restaurant as:

- a. Families _____%
- b. Young Adults _____%
- c. Adults _____%
- d. Senior Citizens _____%

14. What is the seating capacity of your restaurant?

15. On average, how many pounds of the following beef products do you currently purchase at your restaurant per week?

Ground beef _____

Steak _____

Do not know _____

The next question is about yourself and is optional.

16. What is your age?

_____years

Thank you very much for participating in this survey!

Do you have any feedback, questions or comments?_____

Cattle Producer Survey

Thank you for participating in this survey about flies and cattle production.

The survey is conducted by University of Tennessee Institute of Agriculture researchers and will take about 15 minutes to complete. Your participation is voluntary, and information you share will be confidential.

If you have questions about your rights as a survey participant, contact the UT Institutional Review Board Staff at utkirb@utk.edu or (865) 974-7697. If you have any other questions about the survey, please contact me directly at schexnayder@utk.edu or (865) 974-5495..

Thank you sharing information about your operation and horn flies!

ENTER ID number _____

BACKGROUND

1. Are you 18 years or older?

☐ Yes

☐ No (*if selected participants are exited from the survey and thanked*)

2. In which segment of the beef cattle industry are you primarily involved?

☐ Purebred Breeder

☐ Commercial Producer of feeder calves and yearlings – by natural service

☐ Commercial Producer of feeder calves and yearlings – by artificial insemination

☐ Stocker or Backgrounding Operations

☐ Cattle Feeder

3. In what state is your cattle operation located?

☐ Tennessee

☐ Texas

☐ Other _____

(if selected a) or b) or c) (breeder; commercial producer) at Q1)

4. At the end of July 2017, how many bulls, cows, calves were in your herd? (If you manage herds separately on different pastures, please aggregate all herds here.)

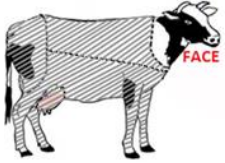
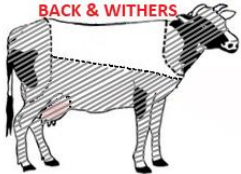
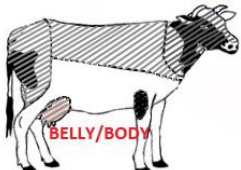
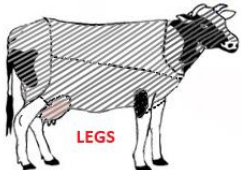
☐ Bulls

☐ Cows

☐ Calves

PRESENCE/AWARENESS OF FLIES

5. Please evaluate the intensity of the fly problems at peak fly season on each of these areas on your cattle? (*check all that apply, assume the pictures represent a steer or cow, depending on your operation type*)

Fly location areas	No problem	Minor problem	Moderate problem	Serious problem	Very intense problem
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
					

VALUE OF HORN FLY RESISTANCE IN THE CATTLE HERD

(randomly assign 50% of each producer type at Q1 to the “with information” and “without” information” cohort; all respondents get “horn fly resistance definition”)

ABOUT HORN FLIES AND CATTLE

Horn flies are a pest of cattle that inflict painful bites to draw 20 – 30 blood meals per day and have the following effects:

- Animals’ defensive behaviors interrupt adequate rest and food consumption
- Calves protected from horn flies have weaning weights 10 – 50 pounds more than unprotected calves with 200 or more flies.
- Stockers and replacement heifers protected from horn flies have weight 16 – 18% above unprotected animals.
- Horn flies can transmit bacteria that cause mastitis.

Throughout this survey, we define a “horn fly resistant animal” as an animal with few to minimal horn flies present, noticeable, or feeding on the animal. It also means that other traits you select for would be unaffected by the addition of the horn fly resistance trait, so that the horn fly-resistant cattle and your current cattle are the same weight and have IDENTICAL muscling, gains, health and other traits.

6. Assuming all other factors in your operation remained the same, but your **entire herd was resistant to horn flies**, how do you think your cattle operation would be affected? Select the % improvement you expect for the potential effect. 0% indicates no change.

(For online survey, these selections are made with slider bars.)

	Anticipated Improvement (%)										
	0%	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
Average weight gain	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(for producer by bull)

7. Assume you are purchasing a bull for breeding. Which bull would you purchase?.
- A bull for \$2,500
 - A bull that is resistant to horn flies for [\$2,500; 3,000; 3,500; \$4,000]
 - Neither
 - Is there a reason you chose neither? _____

VALUE OF HORN FLY RESISTANCE RELATIVE TO OTHER DESIRED TRAITS

8. Assuming horn fly resistance was a possible trait, how would you evaluate it?

	Not important	Slightly important	Moderately important	Very important	More Important than all other traits
Horn fly resistance	☐	☐	☐	☐	☐

CURRENT MANAGEMENT & TREATMENT FOR HORN FLY

9. What methods do you use currently to manage horn fly populations and predation on your cattle herds? For each method listed, please note whether you have NEVER used it; used it but DISCONTINUED it; USE IT as a preventative; or USE IT when fly numbers reach a particular threshold.

Control method	Use			
	Never used this method	Used it, but discontinued it	Use it to prevent flies from developing or selecting my animals	Use it to control when fly numbers reach a particular threshold
Applying ear tags to animal	☐	☐	☐	☐
Applying synthetic insecticides (spray, pour-on, dust bag, wipe-ons, etc.) to animal	☐	☐	☐	☐

(Answer this only if you currently use insecticides)

10. How would you assess the effectiveness of horn fly insecticides today compared to five years ago?

___ much more effective than 5 years prior

___ somewhat more effective

___ slightly more effective

___ as effective as 5 years prior

___ slightly less effective than 5 years prior

___ somewhat less effective

___ much less effective

PERCEPTIONS OF EFFECTS OF PESTS ON CATTLE PRODUCTION

11. Please assess the impact that horn flies have on you and your herd, by indicating the degree to which you agree with the statement.

Statement:	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Don't know
Additional labor needed to address horn flies is burdensome.	☐	☐	☐	☐	☐

INFORMATION SOURCES

12. How have you learned about flies and management options? (Check all that apply)
- ___ Extension services (ex: meetings, trainings, contact with agent, and publications)
- ___ Extension service internet sites
- ___ Producer groups (ex: Tennessee Cattlemen's Association, National Cattlemen's Association, R-CALF)
- ___ Popular press articles (ex: Drovers, Beef Magazine, Cattle Today, etc.)
- ___ United States Department of Agriculture (NASS, AMS, NRCS, FSA, etc.)
- ___ Internet sites (other than those of organizations listed above)
- ___ Industry representative (salesperson)
- ___ Other farmers
- ___ Other, please describe _____

FARM AND FARMER DEMOGRAPHICS

13. A. What breeds are used in your herd? _____
- ___ Angus
- ___ Hereford
- ___ Simmental
- ___ Charolais
- ___ Holstein
- ___ Crossbred; please describe breeds _____
- ___ Other, please describe breeds _____
14. In what year were you born? _____
15. Which of the following best describes your farming business?
- ___ Sole Proprietorship
- ___ Partnership
- ___ Corporation
- ___ Other, please describe: _____
16. What is your highest level of education?
- ___ Less than High School
- ___ High School Graduate
- ___ Some College or Technical School/Associate's Degree
- ___ College Degree or Higher

17. Which category best reflects your total taxable household income (from both farm and non-farm sources) for 2016? Remember, all information is held strictly confidential.

☐ Less than \$10,000

☐ \$10,000 to \$29,999

☐ \$30,000-\$49,999

☐ \$50,000-\$99,999

☐ \$100,000-\$149,999

☐ \$150,000-\$199,999

☐ \$200,000-\$249,999

☐ \$250,000-\$499,999

☐ \$500,000 or greater

VITA

Lettie Collett McKay was born March 22, 1995 in Decatur, Alabama. After graduating from Ardmore High School in 2013, she began studying at Martin Methodist College in Pulaski, Tennessee in the fall. In the spring of 2015, she transferred to the University of Tennessee, Knoxville where she received her Bachelor of Science degree in Agricultural and Resource Economics, majoring in Food and Agricultural Business. In the spring of 2017 she began her work as a graduate research assistant in the department of Agricultural and Resource Economics at the University of Tennessee, Knoxville. She is expected to graduate with a Master of Science degree in Agricultural and Resource Economics in December 2018.