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Food Safety Risk Perception and Consumer Choice of Specialty Meats

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ABSTRACT

Consumer perception issues and recent microbial outbreaks in the livestock industry continue to stifle demand for specialty meats in the United States. This study was designed to explore impacts of risk perception issues on consumer choice of bison meat. A stated preference discrete choice random utility model, a joint risk perception/product choice model, and a probability of frequency method to aggregating risk scenarios, were used for a range of food safety/certification regimes. Perceived risk reduces bison consumption, but its effect declines with shifts to more regulatory control inherent in the different certification regimes.

Key Words: food safety, bison, specialty meat, nested logit model, risk perception, product choice, discrete choice experiment, probability of frequency method

Food Safety Risk Perception and Consumer Choice of Specialty Meats

William Nganje and Simeon Kaitibie[1]

INTRODUCTION

Specialty meat production in the United States has been on the increase in recent years. However, demand appears to be stifled by consumer perceptions and marketing is generally limited to niche markets. Producers and sellers of specialty meats like buffalo, venison, ostrich, and elk will have to overcome risk perception issues to move their products beyond niche markets (Schupp, Gillespie, and Reed).

In the past, a major food safety challenge was preventing contamination of food with sewage, animal manure, and spoilage. Now the challenge is to prevent contamination of food by known and unknown pathogens. Each year known pathogens cause 13.8 million illnesses, 60,854 hospitalizations, and 1,809 deaths, while unknown foodborne pathogens cause 62 million illnesses, 263,000 hospitalizations, and 2,400 deaths (Mead et al.). The implications of foodborne pathogen outbreaks on consumers' risk perception and product choice are yet to be investigated especially in the case of specialty meats, where unknown pathogens may pose even greater risk.[2]

The term "specialty meats" is used to describe meats from exotic animals. For instance, the North American bison, whose United States population the National Bison Association estimates at 350,000 head, is considered by many as a specialty meat. The Food Safety and Inspection Service of the USDA estimates that each month Americans consume approximately one million pounds of bison meat. Although bison production is relatively new to North Dakota's agricultural sector, Sell, Bangsund and Leistritz suggest that the North Dakota bison industry is now a commercially viable agricultural industry. The same observation applies to other bison producing states in the United States and the Prairie Provinces of Canada. Schupp, Gillespie, and Reed note that individuals differ widely in their familiarity with animals and their use for food, such that a given animal product could be classified as exotic or specialty meat by some individuals and traditional by others. This difference in familiarity leads to a wide variety of factors that affect perception (Adu-Nyako and Thompson; Wessells, Kline, and Anderson; Schupp, Gillespie, and Reed). Although several factors are used in this study, the focus is on how microbial food safety risk perception affects consumers' bison meat consumption decision.[3]

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[2] Examples of microbial food safety risks associated with specialty meats are Chronic Wasting Disease (CWD) with emu and elk, Diseased Yellowstone Bison, and other pathogens known to cause sickness and death in humans. In a recent study of a HACCP inspected facility (Li et al., 2002a), Salmonella and other pathogens were detected at 5 critical points all along processing, slaughter to packaging.

[3] Issues with bison meat related to price, taste, and fat content have received considerable attention through federal and industry research grants. Federal research and working capital grants indirectly serve as excise subsidy to reduce prices in the long-run. However, food safety perception issues are beginning to gain considerable grounds, especially with the advent of Bovine Spongiform Encephalopathy or Mad Cow Disease, in beef, in Europe and Japan. Bison meat may gain considerable market shares in these markets if food safety risk perception issues are well understood.

Despite USDA and European Union approved certification to ensure that specialty meats like bison meat can be produced under stringent quality standards to meet food safety requirements, some studies show that consumers continue to resist consuming these meats and perceive them as somewhat unsafe (Li et al., 2002a; Schupp, Gillespie, and Reed; Gillespie, Schupp, and Taylor). In the case of bison, processing in some major facilities occurs under an approved Hazard Analysis Critical Control Points (HACCP) program. However, a significant proportion of bison meat is custom processed and game meat, requiring no HACCP system. A HACCP system provides consumers with assurances of bison meat safety, but USDA HACCP/Pathogen Reduction (HACCP/PR) Act exists in the context of known pathogens and prevailing meat safety perceptions. As a result, it is uncertain if (1) the current HACCP/PR system significantly reduces food safety risk perception associated with specialty meats consumption, and (2) consumers' specialty meat consumption behaviors are positively affected by food safety certification regimes. Devising effective marketing policies and strategies to move bison meat beyond niche markets will depend on understanding how food safety risks and other factors influence consumers' risk perception, and how risk perception in turn influences consumption decisions.

Two major challenges confronted in modeling the impact of consumers' risk perception on consumer choices are sequential estimation biases with a two-stage model and estimating risk perception with a single risk distribution. The purpose of this study is to identify factors that affect consumers' food safety risk perception of specialty meats and to use a stated preference discrete choice random utility model to examine how these factors affect consumer choice of bison meat when provided with additional information on prices and safety.

A two-level nested logit model is specified to jointly model perceived risk and product choice. This model eliminates sequential estimation biases associated with a two-stage model. To overcome the uncertainty surrounding a single risk perception distribution, a range of risk perception functions is estimated by modeling different certification regimes: custom processing, state inspection, and federal/international certification (see Figure 1). The literature (e.g., Kaplan and Garrick) suggests that risk perception, a measure of hazard and outrage, is effectively measured by a range of distributions.

REVIEW OF RELEVANT LITERATURE AND CONCEPTUAL FRAMEWORK

Risk as perceived by the public, can be broken down into two components, hazard and outrage (Sandman). This makes it easier to differentiate between actual risk and perceived risk, which Sandman contends are generally uncorrelated. The distinction between hazard and outrage (the unknown) is made in this study. Several studies have approximated food safety risk as a function of hazard, while not explicitly specifying the outrage component (Adu-Nyako and Thompson; Wessells, Kline, and Anderson; Schupp, Gillespie, and Reed; Hearne and Volcan; Huang, Haab, and Whitehead). In the case of bison meat, where specific microbial species that affect these animals are still being investigated (Li et al., 2002a; and Li et al., 2002b), the outrage component, after assuring the public the product is safe under current certification standards, may significantly contribute to risk.

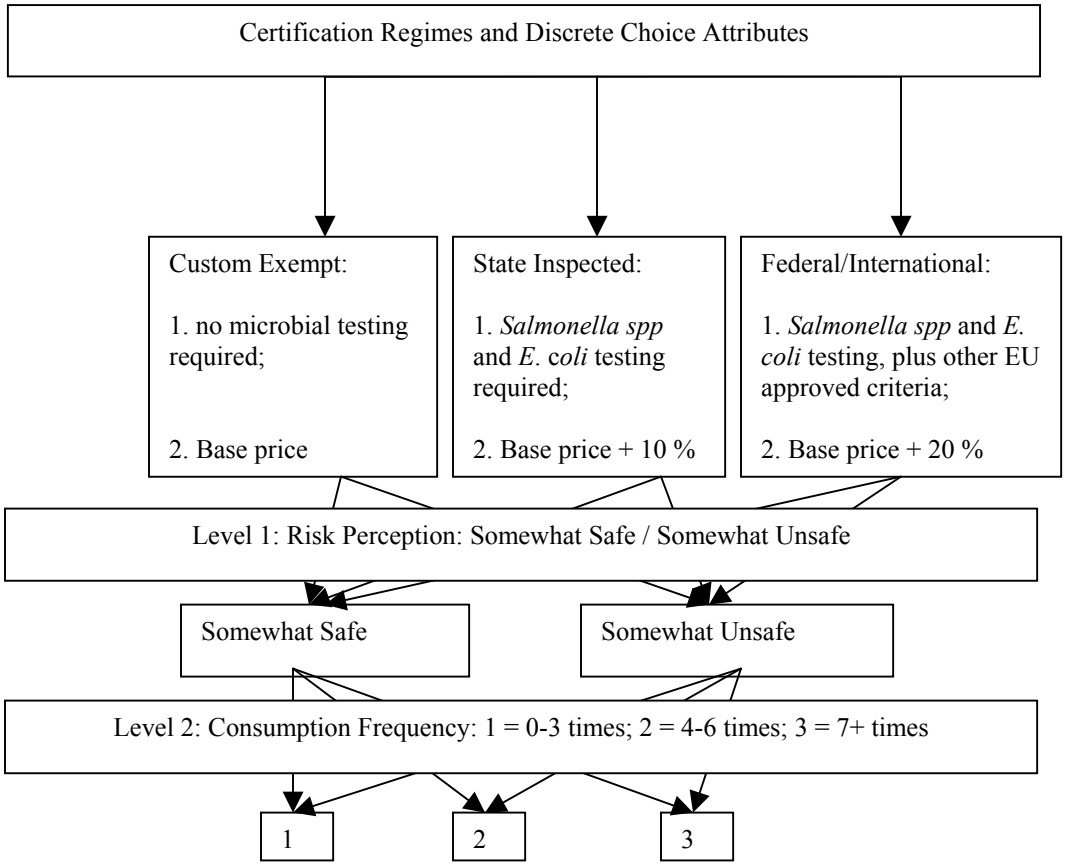

Figure 1. Two-Level Nested Logit Model of Risk Perception and Product Choice for Three Certification Regimes

There have been several refinements on theories aimed at explaining risk perception, beginning with the expected utility model by von Neuman and Morgenstern, which serves as a foundation for most health belief theories. Because of the lack of testable behavioral hypothesis with expected utility models, Weinstein's stages theory was developed to explain the process of risk perception formulation. Also, prospective reference theory (Viscusi) was developed to explain how decisions are made on the basis of perceived risk. Thus Grobe, Douthitt, and Zepeda summarized a host of factors which affect consumers' risk perception into three major categories: personal health influences; socio-cultural, demographic, and economic influences; and perceived locus of control.

Studies have found that factors under these three main categories affect consumers' food safety risk perception. For example, socio-cultural and demographic factors such as age, gender, education, place of residence, and income (Basiotis and Guthrie; Misra, Fletcher, and Huang; Schutz, Bruhn, and Diaz-Knauf; Adu-Nyako and Thompson), and prior illness experience and knowledge of a family member or friend's illness (Weinstein; Adu-Nyako and Thompson; Lin, Milon, and Babb; Wessells, Kline, and Anderson) affect food safety risk perceptions. Also, Celsi, Rose, and Leigh suggested that consumers' confidence in their ability to select a safe product affects their risk perception. A limitation of the above theories is the assumption that consumers' perception of risk is high when perceived hazards are high. Although this may be

true, the contrary may not be, especially when consumers believe another party is responsible for food safety risk. For example, studies by Williamson, Gravini, and Lawless found that about one-third of consumers believe that food safety risk problems most likely occur at food manufacturing facilities. Fein, Jordan-Lin, and Levy also found that over 65 percent of consumers attributed food safety risk problems to food prepared at restaurants. The outrage component of risk as reported by Sandman has not been explicitly modeled in risk perception studies, even though consumers' risk perception may increase if consumers attribute risk to other sources. In this study, risk perception is modeled to incorporate hazard and outrage. Hazard is measured with the three categories of factors presented above, and outrage is captured by modeling a range of distributions representing alternative certification regimes and the intrinsic value of a nested logit model.

Several studies have found that consumers make choices based on their perceived risk. For example, Wessells, Kline, and Anderson used a recursive system of equations to show a positive relationship between consumers' seafood safety perception and anticipated consumption. Adu-Nyako and Thompson also found an association between food safety risk perception and the decision of whether or not to consume food away from home. However, these studies have used either a multinomial logit model or a two-stage sequential econometric model, with obvious estimation biases.

For example, the sequential or two-stage model described by Wessells, Kline, and Anderson, based on a similar model by Kinnucan, Nelson, and Hiariey is,

(1) $R = f[\mathbf{E}, \mathbf{Z_1}]$, and

(2) $CC_i = g_i[R, \mathbf{Z_2}]$,

where R is consumers' safety ratings of the product, **E** is a vector of variables representing consumers' experience, CC_i is consumers' anticipated consumption change due to a given hypothetical event *i*, and $\mathbf{Z_1}$ and $\mathbf{Z_2}$ are vectors of social/cultural, demographic, and economic influences, and the perceived locus of control. In stage one, risk perception is modeled as a function of experience, with other socioeconomic characteristics. Stage two is used to model how risk perception in turn influences consumer choices. There are two major limitations to this procedure. First, empirical studies using this method have estimated both equations separately, making it difficult to connect both models. Second, R may not be transferred directly from equation 1 to 2 because of sequential econometric errors. The model developed and used in this study overcomes the issue of sequential econometric errors.

This study also differs from prior studies in this area by its use of a stated preference discrete choice random utility model, which is based on Lancasterian consumer theory[4], as well as the random utility theory, to elicit product choice information. The impact of other factors, like price, on the choice decision can be separated from the impact of perceived risk when these factors are held constant.

[4] Lancasterian consumer theory suggests that consumers make choices not on simple marginal rates of substitution between goods, but based on preferences (for example, risk preferences and prices).

METHODS

A stated preference discrete choice random utility model is employed in this study to elicit consumers' choice and frequency of consumption of bison meat. To maintain the focus on the objective of this study, only two attributes are used: (1) price - choice of bison meat in each choice set (see Figure 1) when prices are assumed to be equal; and (2) food safety risks, microbial hazard for each regime, represented by the degree of microbial testing between certification regimes.

A two-level nested model is used to model the impact of food safety risk perception and the choice/frequency of bison meat consumption. The model is based on the works of Morey, and Morey and Waldman, and has been applied to recreational angling by Jakus and Shaw, with the exception that the outrage component of risk is modeled. Morey expounds on the universal applicability of the nested logit model to problems involving simultaneous decisions of participation and choice. A joint estimation with a two-level nested logit model, can avoid estimation biases with a generated regressor associated with two-stage models, and provide a clear connection between perceived hazard and consumer choice.

The first level models consumers' perceived risks, while the second level models consumption frequency. The nesting structure is presented in Figure 1. It is common, but unnecessary to assume, that the nested logit models require a sequential decision process (Morey). This model is jointly estimated with the product choice model which allows the consumer to choose bison meat consumption levels. An extension to this method allows for a more generalized definition of perceived risk to enable the outrage component of risk to be modeled. The nesting structure and the outrage component of risk were tested using a Wald test of the inclusive value parameter.

Using a nested logit model and assuming an extreme value distribution, the conditional probability of the *i*th consumption frequency is given by

$$\text{(3)} \qquad \Pr ob(CF_i \mid R) = \frac{e^{\mathbf{X}_i'\boldsymbol{\beta}}}{\sum_{j=1}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}},$$

where J is the number of consumption frequencies for $j = 1,...,3$, $\mathbf{X}$ is a vector of variables such as experience with hazard (knowledge of friend or anybody being ill), price, familiarity, and demographic factors that influence the frequency of consumption of bison meat, and $\boldsymbol{\beta}$ is a vector of parameters to be estimated.

The first level decision requires consumers to decide whether or not bison meat is safe, thus influencing the measure of perceived risk. There are two approaches used to assist consumers in making this decision; first, consumers rank relative risk based on their prior experience, and second, (expert assessed) risk probabilities are communicated and consumer response is observed. Studies on perceived risk have used either of these approaches, based on available data. In this study, consumers were asked directly if they or any family member or friend has been ill as a result of consuming bison meat. Then they were asked to rate the safety of bison meat as a discrete variable, with 1 = "somewhat safe," and 2 = "somewhat unsafe." The choice of "somewhat safe" and "somewhat unsafe" prevents perfect multicolinearity, and is in

accordance with Kaplan and Garrick.

The probabilities associated with "somewhat safe" and "somewhat unsafe" can be specified using the following equations:

$$\text{(4)} \qquad \Pr ob(R = \text{somewhat safe}) = \frac{e^{\left[\phi \ln\left(\sum_{j=1}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}\right)\right]}}{e^{\left[\phi \ln\left(\sum_{j}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}\right)\right]} + e^{\mathbf{u}'\boldsymbol{\delta}}},$$

$$\text{(5)} \qquad \Pr ob(R = \text{somewhat unsafe}) = \frac{e^{\mathbf{u}'\mathbf{d}}}{e^{\left[\phi \ln\left(\sum_{j}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}\right)\right]} + e^{\mathbf{u}'\boldsymbol{\delta}}},$$

where **u** represents a vector of variables believed to influence consumers' perception of bison meat being somewhat safe or unsafe. The parameter ϕ in the numerator in equations 4 and 5 is the inclusive value parameter, which may be used to test for the nesting structure. The value 1-ϕ is a measure of correlation in the unobserved variables. The nesting structure breaks down to a multinomial logit if there is no correlation. Intuitively, ϕ should have a positive value, indicating that the utility of consumption increases as consumers perceive bison meat to be somewhat safe. The unconditional probability of the *i*th consumption frequency is given by the product of equations 3 and 4,

$$\text{(6)} \qquad \Pr ob(CF_i) = \frac{e^{\mathbf{X}_i'\boldsymbol{\beta}}}{\sum_{j=1}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}} \frac{e^{\left[\phi \ln\left(\sum_{j=1}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}\right)\right]}}{e^{\left[\phi \ln\left(\sum_{j}^{J} e^{\mathbf{X}_j'\boldsymbol{\beta}}\right)\right]} + e^{\mathbf{u}'\boldsymbol{\delta}}},$$

where the explanatory variables **X** and **U** are sets of risk perception variables, and **β**, **δ,** and ϕ are sets of coefficients to be estimated.

The connection between perceived risk and the decision to consume bison meat is presented in the product choice model below. Assuming an extreme value distribution, the probability of consuming bison meat is given by

$$\text{(7)} \qquad \Pr ob(CB_b) = \frac{e^{\mathbf{A}_b'\boldsymbol{\lambda}}}{\sum_{m=1}^{M} e^{\mathbf{A}_m'\boldsymbol{\lambda}}},$$

where **A** represents a vector of variables that may influence the choice of bison meat. The probability of consuming bison meat is assumed to be a function of availability, habit, or familiarity with bison meat, and the consumers' perceived risk measure, *PR*. The measure of perceived risk associated with product *m* (where *m* = 1 for bison and 0 otherwise) is given by PR_m = 1 - Prob(somewhat safe). Increasing values of PR_m indicate greater perceived risk, and

vice versa. Thus, the expected sign of this variable in the product choice model (equation 7) is negative.

If we define a vector comprising of perceived hazard PR_i and product choice CB_i, and assuming that the associated error terms are independent, then we can define a density function for the vector as a product of the density functions of the components. The log-likelihood for the density function of the vector is simply the sum of the logs of the component density functions. Therefore, the product choice model and perceived risk model are jointly estimated by full information maximum likelihood procedure

$$\log L = \sum_{k=1}^{N} \left[\sum_{m=1}^{M} C_{km} \log P_m^{CB} + \sum_{j=1}^{J} C_{kj}^{i} \log P_j^{i} + C_k^{Ni} \log P^{Ni} \right]. \tag{8}$$

The product choice model is represented by the first term in the bracket, whereas the second and third terms represent the risk perception models. The C_{km} represents bison consumption frequencies and P_m^{CB} is the probability of consuming bison meat; C_{kj}^{i} is the consumption frequency by consumer k of product j when they perceive bison meat to be somewhat safe, and P_j^{i} is the probability of somewhat safe; C_k^{Ni} is consumption frequency when bison meat is viewed by consumers as somewhat unsafe, and P^{Ni} is the probability when bison meat is perceived to be somewhat unsafe. The act of changing safety ratings or changing the frequency of consumption is generally highly correlated with consumers' perceived risk (perceived hazard and outrage). However, the outrage component has seldom been included in empirical studies of risk perception.

A critique of the Morey and Waldman model, by Train, McFadden, and Johnson, is that the parameters are biased and inconsistent because the random utility model does not capture all site attributes. This problem is overcome by modeling a range of risk certification regimes which is assumed to cover the reasonable spectrum of risk associated with specialty meat certification.

Probability of Frequency Approach to Measuring Perceived Hazard and Outrage

A major problem pointed out by Kaplan and Garrick is the uncertainty surrounding a single risk perception curve, because it takes an entire group of curves to fully communicate the idea of risk. This study uses the probability of frequency approach to estimate a range of risk perception functions for the three certification regimes. A risk perception curve is determined for each of the certification regimes using the same explanatory variables. The challenge becomes how to aggregate these functions in a manner that is consistent with the properties of the underlying distributions. Kaplan and Garrick argue that the question of completeness of risk analysis can be rationally handled by introducing a category of other scenarios and assessing the frequency of occurrence of this category using existing evidence and Bayesian approximation. In Bayesian analyses, prior probabilities are subjective and their inclusion is generally frowned upon unless they are deemed to play rather insignificant roles in the result. Additional evidence is necessary when the result is considered overly dependent on the prior probability. This study uses a moment generating function for the extreme value distribution.

In the case of the nested logit model, the underlying distributions are extreme value distributions, such that a random variable, R, is distributed as an extreme value, with mean θ and variance η, and the pdf is given by

$$(9) \qquad f_R(R) = \frac{1}{\theta} e^{\left[\frac{R-\eta}{\theta} - e^{\frac{R-\eta}{\theta}}\right]}, \ \forall \ \theta > 0.$$

The three scenarios covered in this study have extreme value distributions, covering the "lower" and "upper" bound of risk perception, from hazard to hazard plus outrage. We borrow the assumption of non-satiation in preference theory, that more control is preferred to less. Within the range of certification regimes, the level of regulatory control increases from custom processing, through state inspection, to federal/international certification. Bain and Engelhardt present different approaches to aggregate these distributions. The moment generating procedure is an effective method to simplify the estimation of properties (mean, variance, skewness, etc.) of the aggregate distribution. If $R_1 \sim EV(\theta_1, \eta_1)$; $R_2 \sim EV(\theta_2, \eta_2)$; and $R_3 \sim EV(\theta_3, \eta_3)$; and R_1, R_2, and R_3 are independent variables representing each of three certification regimes, and the aggregate $Y = R_1 + R_2 + R_3$, then the aggregate distribution is given by

$$(10) \qquad M_Y(t) = \left[e^{t\sum_{i=1}^{3}\eta_i} \right] . \left[\prod_{t=1}^{3} \Gamma(1+\theta_i t) \right],$$

where the $\text{mean} = \eta - \gamma\theta$, $\gamma = 0.5772$ (Euler's constant), the variance $= \frac{\pi^2\theta^2}{6}$, and the moment generating function $M_R(t) = e^{\eta t}\Gamma(1+\theta t)$. The perceived risk and product choice models are jointly estimated for each certification regime and for the aggregate model. The appropriateness and efficiency in estimation of perceived risk with an aggregate model is discussed in Appendix 1.

SURVEY DESIGN AND DATA

Data were collected for a baseline study to measure food safety risk perception gaps between consumers and processors from 404 consumers, and 24 processors and packers in 2002. Survey data from consumers were collected through direct interview at grocery store locations in the Red River Valley area of Minnesota and North Dakota. This is an area with major bison production and processing facilities, for all certification regimes. The survey was refined using two consumer and industry focus groups. A set of beginning questions was asked to determine respondents' understanding of the alternative certification regimes and microbial testing associated with each regime. For those who were not familiar with these regimes, the differences in terms of microbial testing requirements were explained to them. In general, consumers understood the difference between game and custom processing and USDA certified products sold in major grocery outlets. A phone survey was used to elicit responses from processors who were fewer and more disperse. All responses from the processor survey were used in a baseline study to determine food safety perception gaps between consumers and processors and was not part of this study.

Approximately 74.3 percent of the respondents are from North Dakota, and the rest are

from the states of South Dakota, Montana, and Minnesota. Descriptive statistics for selected variables from the survey are presented in Table 1. Income was handled as a discrete variable, and it showed the highest variability of all socioeconomic variables; whereas consumption frequency, also discrete, showed the lowest variability. A major finding of the baseline study was that perception gaps exist between consumers and processors, with 94.6 % of producers but only 55 % of consumers perceiving bison meat products as somewhat safe.[5]

The responses included demographic, socioeconomic, and cultural characteristics, and perceived locus of control. General food safety concerns were put into perspective by first asking consumers whether anyone, friend or person they knew, had fallen ill as a result of consuming bison, whether respondents dined out or prepared meals at home, and whether respondents were aware of safe food handling practices. In addition, information on safety ratings, price, consumption frequencies, and preference were elicited for alternative certification regimes using discrete choice experiments. These latter attributes (safety/certification, price, and preference) were grouped into three choice sets, the certification regimes.

For each choice set, consumers were asked how frequently they consume bison products. Three of the 404 respondents did not provide complete data and were dropped from the analysis. Direct interview surveys are expensive, but often yield good response rate and data. The decision to model the three scenarios, derives from the need to have more than one risk perception curve, because of the uncertainty associated with a single risk perception curve. The aggregate scenario followed the probability of frequency approach suggested by Kaplan and Garrick.

RESULTS

Maximum likelihood estimates for the parameters of the joint perceived risk product choice model are presented in Table 2. The results of the random utility model show that at the probability level of 0.10 the inclusive value parameter was significant for the aggregate model, but not for the three individual models derived from the different certification regimes.

When the inclusive value parameter ϕ is significantly different from zero, intuition suggests a breakdown in the nesting structure because of the apparent absence of perfect correlation (as measured by $1-\phi$) between unobserved factors. However, the high value of the inclusive value parameter (1.846) implies a high negative correlation between unobserved factors; hence, the nesting structure cannot necessarily be rejected in favor of a multinomial logit specification when the correct risk perception curve is that which is estimated by the aggregate function.

The significant dummy variables for certification regimes suggest that no single risk perception curve is adequate to draw inferences about consumer risk perception impacts (see Appendix 1). The aggregate model is, therefore, appropriate for a better estimation of hazard and outrage.

[5] One bison processor reported they have had a food recall due to microbial outbreak with their product.

Table 1. Descriptive Variables used in the Model

Variable name	Description	Mean	Standard deviation
Anybody ill in the family	1 = if someone in the family had foodborne illness 2 = no	1.613	0.221
Eat away from home	1 = 0-3 times per month 2 = 4-6 times per month 3 = 7+ times per month	1.311	0.670
Home preparation	1 = 0-3 times per month 2 = 4-6 times per month 3 = 7+ times per month	1.087	0.237
Any friend ill	1 = if a friend or anyone they know had foodborne illness 2 = no	1.233	0.334
Awareness of safe handling practices	1 = very aware 2 = somewhat aware 3 = not aware	1.769	0.712
Income	1 = less than $20,000 2 = $21,000-$40,000 3 = $40,000+	1.630	0.765
Price	Price of bison burger	$1.44	0.577
Safety rating	1 = somewhat safe 2 = somewhat unsafe	1.461	0.211
Consumption frequency	1 = 0-3 times per month 2 = 4-6 times per month 3 = 7+ times per month	1.094	0.002
Familiarity (preference for bison over other meats)	1 = bison 2 = other meats	1.301	0.112

Source: Aggregated survey data

Table 2. Model Parameter Estimates for Joint Perceived Risk/Product Choice Model for Three Certification Regimes and the Aggregate Function

Variables	Certification regime coefficients and p-values							
	Federal / International processing (n = 401)	Standard Error	State inspected processing (n = 401)	Standard Error	Custom exempt processing (n = 401)	Standard Error	Probability of frequency approach	Standard Error
Somewhat safe / somewhat unsafe								
Anybody in the family ill	0.184*	0.016	0.788*	0.091	1.104*	0.455	1.618*	0.656
Eat away from home	-1.194	1.728	-0.868	0.896	-0.995	1.205	-0.967	1.184
Any friend ill	0.977*	0.081	1.899	1.211	0.663*	0.300	0.832**	0.149
Awareness of safe handling	-1.294	1.199	-0.988	1.513	-1.978	1.327	-0.845*	0.275
Home preparation	0.122	1.076	1.3614	1.222	1.105	0.993	0.157	1.015
Inclusive value	1.758	1.438	1.234	0.945	1.970	1.282	1.846*	0.794
Consumption frequency								
Income	3.254	2.618	1.733	1.161	3.181	2.215	1.276*	0.551
Age	2.114	1.925	1.991	1.139	1.234	1.141	1.223	1.212
D1 (Custom Exempt)					1.612*	0.801	1.343**	0.104
D2 (State Certification)			3.092	2.988			0.968*	0.408
Price	-2.145**	0.867	-1.889*	0.875	-0.992*	0.410	-1.268**	0.112
Consumption of bison								
Familiarity	0.981	1.101	0.929	1.203	1.114	1.214	0.883*	0.308
Perceived risk measure	-1.595	1.140	-0.996*	0.374	-1.546**	0.402	-1.381***	0.011
Ln L at convergence	478.079		446.566		374.736		401.639	
McFadden's LRI	0.689		0.522		0.770		0.637	

*, **, and *** denote coefficients that are statistically significantly different from zero at the 10%, 5%, and 1% level.

Bison Meat Safety Perception

Awareness or concerns about food safety problems can be determined by asking questions about illness among family and friends, as well as consumer decisions to eat away from home or prepare meals at home. If consumers are familiar with safe food handling practices, it is assumed that perceived food safety concerns that arise from illness may be handled by preparing food at home and eating less outside the home. Both illness in the family and illness of a friend showed significant effects on consumer perception of the safety of bison meat under federal/international certification and custom exempt processing. Under state inspected processing, only family illness was significant. However, the aggregate function showed that both are important determinants of bison meat safety perception by consumers. Therefore, based on the aggregate function, as consumers report illness in the family or among friends, the propensity to classify bison meat as somewhat unsafe increases. This supports the framework by Ralston et al. that reconciled the Health Belief Model by interpreting the utility function as a description of the consumer's desire for better health. On the other hand, eating away from home or home food preparation were not important determinants of bison meat safety perception by consumers. Since earlier studies suggest that a significant proportion of consumers consider food contamination or safety risks are more likely to occur at manufacturing facilities or restaurants, home food preparation or the decision to eat away from home would have opposing but significant effects on food safety risk perception (see Williamson, Gravani, and Lawless; Fein, Jordan-Lin, and Levy).

The results also show that awareness of safe food handling procedures has a significant negative impact on bison meat safety perception. The implication is that, as consumers become more aware of safe handling procedures, the likelihood of perceiving bison meat as somewhat unsafe decreases. This is consistent with findings by Adu-Nyako and Thompson that being a food preparer and having a higher level of awareness of food pathogens lessened the likelihood of misperceiving the source of food risk. The benefits of consumer education on safe food handling practices are evident in this finding if bison meat marketing is to move beyond niche markets. But as Ralston et al. pointed out, targeting and designing messages for food safety education requires information about which groups have low knowledge levels or attitudes which conflict with food safety messages.

Consumption Frequency

In the aggregate model, bison meat consumption frequency is significantly influenced by product price. As expected, product price has a negative coefficient, suggesting a normal good for which consumption goes up when price goes down. Parameter estimates for product price were significant for models from all certification regimes, as well as for the aggregate model. Neither age of respondent nor income level is an important determinant of consumption frequency under the individual certification regimes. However, income but not age, was a significant (at the 10 % level) determinant of consumption frequency for the aggregate model. Relative to the product price, the threshold income level would have been exceeded among consumers in the sample, so that the effect of income becomes less important. Also descriptive statistics suggest an average consumption frequency probably too low to effect any major change in disposable income spending patterns.

Parameter estimates of the impact of certification regime for custom exempt processing and the aggregate model were significant, indicating the need to use more than one perceived

risk distribution.

Bison Consumption

The decision to consume bison meat is not affected by familiarity (as defined in Table 1) for the individual certification regimes, but it was significant for the aggregate model. Although it had no significant effect on bison consumption for federal/international certification, the perceived risk measure negatively affected consumption for the other certification regimes and for the aggregate model. In the aggregate model, the expected negative sign on the perceived risk measure which is jointly estimated with the product choice model suggests that, as perceived risk increases, consumers would be less inclined to consume bison meat. Risk perception anxiety appears to decrease across the range of certification regimes from custom processing to the more stringent federal certification.

SUMMARY AND CONCLUSIONS

Despite USDA and European Union approved certification to ensure specialty meat production under stringent quality standards to meet food safety requirements, consumers continue to resist these meats and perceive them as somewhat unsafe. This problem is exacerbated by recent microbial outbreaks, so that consumers must now make decisions in the presence of risk and uncertainty. Although bison processing in major facilities occurs under an approved Hazard Analysis Critical Control Points (HACCP) program to ensure a safe product, moving specialty meat production and marketing operations beyond niche markets can only be realized if perception issues that appear to affect demand are understood and resolved.

This study was designed to identify factors that affect consumers' food safety risk perception of specialty meats using a joint perceived risk/product choice model. In addition, it uses a stated preference discrete choice random utility model and a distribution of frequency method to examine how these factors affect consumer choice of bison meat when consumers are provided with additional information on prices and safety.

The model builds upon a joint perceived risk/product choice model that models consumer risk perception as a function of hazard and outrage, using a probability of frequency approach. The first level of the two-level nested logit model, models the safety perception decision, while the second level models the frequency of consumption decision. A product choice model is further specified to determine the impact of perceived risk on the decision to consume bison meat. The distribution of frequency method used to estimate an aggregate function was rationalized by increasing concerns over the use of single risk perception curves to characterize consumer risk. Therefore, three separate certification regimes (custom processing, state inspected processing, and federal/international certification processing) were modeled and then aggregated using the moment generating function for an extreme value distribution.

Model statistics suggest that the nesting structure is appropriate, and that the probability of frequency method gives a more efficient estimation method for risk (hazard and outrage) than modeling either of the individual certification regimes. The random utility model showed that illness in the family or among friends implied a significant increase in the propensity to classify bison products as somewhat unsafe. On the other hand, awareness of safe food handling practices resulted in a significant decline in the likelihood to perceive bison meat as somewhat unsafe. This presents an opportunity for effective communication of safe handling practices to consumers. Consumer dining habits, as suggested by the choice of preparing food at home or

dining out, were not reflected in their risk perception attitudes.

Income had a significant effect on consumption frequency, but only at the higher level of significance. This is not unexpected, given the low average level of consumption. Regulations designed to improve product safety could increase consumption frequency if they do not eventually translate into high costs to producers and consumers because, as the study shows, consumption frequency decreases as the product price increases. This presents an opportunity for consumer and producer education on the need for certain state, federal, or local regulations in the bison industry.

The product choice model presented consumers the opportunity to make consumption frequency choices for bison meat. Familiarity with the product had a significant effect on that decision. However, as consumers perceive bison products as being unsafe, they would likely reduce bison consumption level. The effect of perceived risk on bison consumption declines with shifts to more regulatory control as suggested by the certification regimes, such that for federal/international processing where tests for *Salmonella spp* and *E. coli* are mandated, in addition to approved European Union safety intervention strategies, perceived risk had no significant effect on bison consumption. The finding of a significant perceived risk measure also suggests that the model was appropriately applied to the data.

As other studies have shown, different population subgroups have different perspectives on food safety risks (see Lin; Preston and McGuirk). This implies a need for different marketing and other intervention strategies for each group. Opportunities for extending this study by classifying respondent reaction by different socio-economic and demographic sub-groups also exist. Other perception issues such as taste and fat content provide important avenues for perception research, but this study emphasized food safety risk perception alone.

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Appendix 1. Determining the Appropriateness of an Aggregate Model

How can we tell whether a single perceived risk function is adequate to draw inferences about consumers' risk perception impacts and when choice experiment and aggregation of estimated risk perception functions are needed? Prior studies on risk have shown that perceptions will change as consumer awareness or knowledge of the unknown (outrage) changes. However, risk perception studies do not evaluate the degree to which such changes are relevant. One approach is to incorporate a covariate for alternative certification regimes. Certification regimes are used to provide a finite set of alternatives representing an exhaustive set of perceived outrage and hazard. Where r in this case is the number of certification regimes, the basic allocation pattern is obtained by writing an (r-1) x (r-1) **I** matrix and adding a row of (r-1) zeros (Draper and Smith). For example, a suitable covariate in this study is presented below:

Table 1A. Covariate of Alternative Certification Regimes

Certification Regime/Dummies	D1	D2
Custom Exempt	0	1
State Inspected	1	0
Federal/EU Certification	0	0

The aggregate model in this study, therefore, includes two dummy variables for three certification regimes. The decision to incorporate either or all certification regimes in a risk perception study is determined by a Wald test of the dummy variables. General inference can be drawn using data sets for either certification regimes, if and only if, both dummy variables are not significant. However, if either dummy variable is significant, an aggregate model should be used in risk perception analysis. In this study, both dummy variables were significant, implying that results from a single perceived risk distribution may lead to faulty inferences, due to the limitations of not effectively modeling hazard and outrage joint

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