Multinomial Logit Models Comparing Consumers' and Producers' Risk Perception of Specialty Meat

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ABSTRACT

There is a dichotomy of risk perception between consumers and processors of specialty meats. Studies show that consumers continue to resist these meats and perceive them as somewhat unsafe while processors perceive them to be safe. This study uses survey data from 401 consumers and 22 bison processors to evaluate the determinants of food safety risk perception gaps. Results indicate that significant food safety risk perception gaps exist between consumers and producers of bison meat. Outrage, among other factors, accounts for consumer risk perception while the number of years in business is a major determinant of producer risk perception. Consumers' food safety risk perception affects the frequency of consumption of bison meat. This creates difficulties in formulating marketing strategies and policy initiatives aimed at moving specialty meats beyond niche markets. [EconLit citations: Q180, D190, C140.]

1. INTRODUCTION

Problems with recent microbial outbreaks underscore that consumption decisions are made in the presence of risk and uncertainty. If a food safety related panic creates an interim or long term upheaval in purchasing patterns for a certain food, it could result in a shift in market demand for the food (Jin, Sun, & Koo, 2003). Using data from the Food Marketing Trends Survey, the Economic Research Service (ERS) of the United States Department of Agriculture (USDA) concluded that when consumers perceive a food as unsafe, demand for the food can drop dramatically. Among the examples cited are: a 30% drop in apple sales in the New York City–Newark (NJ) market in 1984–1989 following revelations that Alar, a growth regulator in apples, is carcinogenic; a 40% drop in domestic sales and consumption of beef products in 1996 as a result of Bovine Spongiform Encephalopathy (BSE) in cattle in Britain and its link to a new variant of Creutzfeldt Jakob Disease (vCJD) in humans.

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Sandman (2000) posits that perceived risk is equal to actual hazard plus outrage (the unknown), so that levels of perceived risk and levels of actual risks are often uncorrelated as a result of outrage. Outrage has been used to refer to the presence of qualitative variables (such as familiarity, knowledge of controllability and handling practices, effects of risks on children, etc.) affecting risk perception. In food safety, risk communication is an important and dynamic process because risks that are hazardous and those that are merely outrageous are completely different. Risk as perceived by the public is often more a function of outrage than actual hazard. The outrage component of risk may lead to risk perception gaps between processors and consumers if factors affecting outrage are not well understood and communicated to both groups. The difference in processors' and consumers' risk perception plays an important role in food related illnesses and death, expenditure to mitigate food safety risks, and demand trends (Adu-Nyako & Thompson, 1999; Nelson, 1970).

There is a dichotomy of risk perception between consumers and processors of specialty meats. Specialty meat is a term used to describe exotic meats such as bison. Studies show that consumers continue to resist these meats and perceive them as somewhat unsafe while processors perceive them to be safe (Lin, Milon, & Babb, 1991). Risk perception gaps may indicate the presence of qualitative factors of outrage that affect risk perception, leading to incomplete information about the actual hazard, and subsequently affecting demand for the product.

Bison production in the United States is now described as commercially viable, although niche market sales are still predominant. Sometimes bison meat is custom processed, but it is also processed at major facilities under approved Hazard Analysis and Critical Control Point (HACCP) programs. The problem with moving specialty meat production and marketing operations beyond niche markets is evident in the unresolved issue of risk perception which appears to affect demand (Adu-Nyako & Thompson, 1999; Schupp, Gillespie, & Reed, 1998; Wessells, Kline, & Anderson, 1996).

This study uses discrete choice experiments to elicit consumer and processor food safety risk perceptions of bison meat, and develops multinomial logit models to evaluate the marginal impacts of factors affecting risk perception gap and their effects on consumption away from the home and at home. This study extends the current literature on risk perception determinants by incorporating risk communication variables affecting outrage and awareness of food safety risks. The hypotheses in this study are (1) that significant risk perception gaps exist between consumers and processors of bison meat, and (2) that food safety risk perception significantly affects the frequency of bison meat consumption.

2. BACKGROUND AND REVIEW OF RISK PERCEPTION LITERATURE

Perceptions about the source and causes of food safety hazards differ significantly between processors and consumers (Fein, Jordan-Lin, & Levy, 1995; Williamson, Gravini, & Lawless, 1992). In addition, contributions to risk perception literature by Frewer (2003) and Sandman (2000) make distinctions between real risks and perceived risk. The major food safety challenges in the past focused on preventing contamination of food with sewage and animal manure, and due to spoilage. In more recent times, the challenge is to prevent food contamination by both known and unknown pathogens. Hundreds of foodborne pathogens continue to pose risks to consumers. It is estimated that each year known pathogens cause 13.8 million illnesses, 60,854 hospitalizations, and 1,809 deaths; and unknown

foodborne pathogens cause 62 million illnesses, 263,000 hospitalizations, and 2,400 deaths (Mead, et al., 1999).

There have been several studies on the risk effects of known pathogens on meat, pork, and chicken products, but the effects of unknown pathogens, especially on specialty meats, remain a major food safety challenge. Significant sources of foodborne outbreaks are caused by unknown pathogens. Government spending to assess and mitigate food safety risk from known and unknown pathogens has been on the rise. In the United States alone, the cost to mitigate food safety risks is in the billion dollar range (Buzby & Roberts, 1996). For instance, ERS figures show that the cost of lost productivity due to seven specific pathogens, range between $6 billion and $9 billion.

Although sales and consumption of specialty meats have shown some increasing trends, some specialty meat industries are facing difficult financial times and stagnation in sales. Approximately 1 million pounds of bison meat is consumed each month by Americans and about 20,000 bison are slaughtered each year (USDA, 2000). Lamb, goat, and ostrich industries are experiencing similar growth trends.

The Centers for Disease Control (CDC) estimated that in 1997, about 70% of all foodborne illness outbreaks occured in food service operations, compared to 20% in homes, 3% during food processing, and 7% from unknown causes. Food handling was identified as the major cause of outbreaks in food service and at home, and restaurants accounted for about 25% of food service outbreaks. Careful handling and sanitation practices can control the factors that can lead to foodborne illnesses.

Foodborne illness outbreaks have led to increased food recalls and regulations on food labels (Hutt & Burling, 2003). Food labels are excellent sources of information about food guides to reduce food safety risk. The FDA regulates labeling to help consumers know what is in the foods they buy. According to the FDA, consumers look for the following information on food labels: exactly what is in the food package, the nutrition content of the food, how the food should be stored, and the name and address of the manufacturer. Food labels alone may not prevent foodborne disease outbreaks because of known and unknown pathogens with credence attributes (food safety attributes which cannot be inferred before or after purchase of food item) (Caswell & Mojduszka, 1996).

Contracting a foodborne illness is one of the risks that consumers face every day. Although the U.S. food supply is known as one of the safest in the world, Skees and Buzby (1994) noted that it is common to hear concerns about food contamination by microbes, chemical residue, and other health related hazards. A Food Marketing Institute survey on potential concerns related to food safety showed that consumers' top three concerns were high-saturated fats and cholesterol (39%), food poisoning such as *E. coli*, *Salmonella*, and *Botulism* (30.4%), and pesticide residues on food (13.6%) (Buzby & Ready, 1996). Although fats and cholesterol are the number one concern for all meats, this may not be the case with specialty meats. Specialty meats have the competitive advantage of being lean. Therefore bacteria and poisoning concerns, if reduced or better understood may lead to increased specialty meat consumption frequency and sales. Addressing consumer food safety concerns requires an understanding of food safety risk perception, especially with credence attributes.

The economic literature groups factors influencing consumers' risk perception into three categories: social and cultural characteristics, personal health influence, and perceived locus of control (Adu-Nyako & Thompson, 1999; Grobe, Douthill, & Zepeda, 1997). Personal health influence represents factors that characterize foodborne related illness or death; an example is the risk of becoming ill from consuming bison meat products (Cleary,

1987; Weinstein, 1988). Social and cultural factors include age, gender, and place of residence, as well as economic factors such as income level (Adu-Nyako & Thompson, 1999). Finally, perceived locus of control represents factors characterizing consumers' perception of how food safety risks are managed. The above characterization of risk is limited by the fact that risk is viewed basically as hazard, rather than hazard plus outrage.

However, Sandman (2000) pointed out that risk can only be effectively measured when categories of variables are identified to measure hazard and outrage. For example, irradiation has been shown to be very effective in eliminating microbial risks, yet some consumer surveys show that consumers perceive irradiated products as somewhat unsafe because of unknown risks associated with irradiation and cancer. There are voids in the economic literature on the impact of risk communication variables on consumption decisions.

3. METHODOLOGY AND DATA

Consumers usually make consumption decisions to maximize their utility by minimizing costs, or by selecting consumption bundles that meet their utility maximization goals at lower prices. Consumers will consume more of a particular bundle of a good if they perceive their utility must be at least as high as those of their initial consumption bundle. In the present context, the goal is to assess whether or not reducing food safety risk perception will consequently help in increasing the consumption frequency of bison meat at home and away from the home.

To accomplish this goal, determinants of outrage and other food safety risk perception variables must increase the difference in expected utility for goods with lower perceived food safety risks. Essentially information from TV and other sources, and consumers' knowledge about safe handling practices must either make consumers aware of the actual hazards associated with consuming specialty meats and/or increase utility from consuming higher bundles. However, since consumers respond to TV information and other information on food safety risks differently, there is no a priori theoretical indication of direct effects from outrage and other independent variables. Consequently, this issue must be addressed through the development of an empirical model. It is not necessary to estimate each consumer's utility function. The probability of choosing a particular consumption bundle for home consumption or for away from home consumption, as a function of risk perception attributes can be instead estimated using a discrete choice model.

3.1 Methodology

Translating the difference in expected utility into a workable limited discrete choice model requires assuming a distribution for the difference between the error term coefficients. Assuming the error terms are random independent variables following a Weibull distribution, the distribution of the difference between the errors is logistic (Domenich & McFadden, 1975). Since consumers are assumed to choose between three alternative risk levels (safe, somewhat safe, and somewhat unsafe) and three consumption levels (at home, away from home, and do not consume any bison), the model reduces to a multinomial logit model, where the probability of choosing alternative safety or consumption levels are a function of all three categories of risk perception variables and outrage proxies.

A multinomial logit model was used to evaluate the marginal impacts of risk perception attributes and their effects on consumption of bison at home and away from home.

The model is also used to evaluate the effect of risk perception attributes on consumer perception of the safety of bison meat for human consumption. A similar model was used by Schupp, Gillespie, and Reed (1998) and Moutou and Brester (1998). The relevant factors used in this model (see Table 1) derive from the discussion in part 2 of this paper, as well as the works of Ajzen (1991), and Fishbein and Ajzen (1975). It is hypothesized that factors that facilitate increase consumption frequency of bison will be used to move these products beyond niche markets. The probability of the ith risk perception category or individual's choice of jth food safety risk or where meat is consumed follows a logistic distribution:

$$P_{ij} = \frac{e^{X_i' \beta_j}}{1 + \sum_{k=1}^{m-1} e^{X_i' \beta_k}}, \quad j = 1,2,\ldots,m-1. \tag{1}$$

X is a vector of perceived risk characteristics (specified in Table 1), β is the set of estimated parameters, and m is the number of choices. The marginal effects, which are partial derivatives of probabilities with respect to the set of characteristics, were calculated from multinomial logit results following the equation below:

$$\frac{\partial P_j}{\partial X_i} = P_j\left(\beta_j - \sum_{i=1}^{m} P_i \beta_i\right), \quad j = 1,2,\ldots,m \tag{2}$$

The multinomial logit model was run using Nlogit Limdep software package.

3.2 Survey Design and Data

A survey was designed to collect primary data on food safety risk perception categories and consumption away from home and at home during 2002. Two focus group interviews and three testing of the survey instruments were performed prior to administering the survey, to refine the questions for clarity and content. Following Adu-Nyako and Thompson (1999), risk perception data on three risk perception categories (social and cultural characteristics, personal health influence, and perceived locus of control) were collected, together with data on outrage and awareness of microbial hazards and safe handling practices.

Household consumer data were collected from 404 respondents from the Northern Plains States (North Dakota, South Dakota, Montana, and Minnesota), a major bison producing area in the United States. Of the 404 respondents, three did not provide complete data and only 363 consume bison products. Of the 363 respondents, 74.3% of the respondents were from North Dakota and 22.8% were from other states (South Dakota, Montana, and Minnesota). Data were also collected from 24 processors and packers, of which 22 respondents (approximately 84.6% of processors and packers in the Upper Midwest) provided complete information that was used to identify voids in food safety risk perception between processors and consumers. On food safety risk perception, consumers were asked to rate their perception of the safety of bison meat: the mutually exclusive groups are "safe," "somewhat safe," and "somewhat unsafe." For the consumption of bison products, consumers were asked to choose whether they consume bison products more at home, or

TABLE 1. Variables Used in the Multinomial Logit Models

Variables	Description
Consumers' Responses (n = 401)	
Social and Cultural Characteristics	
US State	ND = 1; SD = 2; MT = 3; MN = 4
Gender	Male = 1; Female = 2
Age	18–25 = 1; 26–40 = 2; 41+ = 3
Income	Less than $20,000 = 1; $20,001-$40,000 = 2; $40,000+ = 3
Personal Health Influence	
Anybody ill from food related illness	Yes = 1; No = 2
Anybody ill from specialty meat	Yes = 1; No = 2
Safety of bison meat	Safe = 1; Somewhat safe = 2; Somewhat unsafe = 3
Perceived Locus of Control	
Ease of falling ill from consuming bison meat prepared at home	Very common = 1; Somewhat common = 2; Not very common = 3
Ease of falling ill from consuming bison burgers prepared away from home	Very common = 1; Somewhat common = 2; Not very common = 3
Outrage/Awareness	
Awareness of food safety risk	Very aware = 1; Somewhat aware = 2; Not aware = 3
Awareness of safe handling	Very aware = 1; Somewhat aware = 2; Not aware = 3
TV as a source of information	Yes = 1; Otherwise = 2
Magazines	Yes = 1; Otherwise = 2
Food labels	Yes = 1; Otherwise = 2
Consumption Levels	
Consumption of bison	Yes = 1; No = 2
Eat Bison	Away from home = 1; At home = 2; None
Producers' Responses (n = 22)	
Years in business	Less than 4 = 1; 5–9 =2; 10–20 =3; 20+ = 4
Number of employees	1–2 = 1; 3–10 = 2; 11+ = 3
US State	ND = 1; SD = 2; MT = 3; MN = 4
Sales volume	Less than $500,000 = 1; $500,000-$2.5 M = 2; $2.5 M-$10 M = 3; $10 M + = 4
Weighted price per pound of burger	Continuous variable (Mean = $1.43)
USDA Inspected/Microbial testing	Yes = 1; No = 2
Use food labels	Yes = 1; No = 2
Had recall	Yes = 1; No = 2
Safety of bison meat	Safe = 1; Somewhat safe = 2; Somewhat unsafe = 3
Awareness of microbial hazards	Yes = 1; No = 2

more away from the home, or did not consume bison products (none). Table 1 summarizes the relevant factors used in this study.

4. RESULTS

The research was conducted under the assumption that consumers and producers had different, probably diametrically opposed, food safety risk perceptions. Questions asked

in the survey instrument relating to the safety of bison meat products were the same for both producers and consumers. While the responses from producers and consumers show a large gap in food safety risk perception, additional tests to support the use of separate models for producers and consumers were necessary. These tests are also used to determine whether the difference in risk perception between consumers and producers is significant. Traditional tests for the equality of multinomial logit models (e.g., Hearne & Salinas, 2002; Swait & Louviere, 1993) were not applicable because of major differences between the survey instruments.

However, on the question of food safety risk perception relative to bison meat products, a comparison could be made, and a non-parametric Mann-Whitney test (also known as Mann Whitney U test when U is calculated) was used. This test is used instead of the parametric t test because of deviations from normality and differences in the sample sizes. To carry out the test measures from the two samples, producers and consumers are assembled into a single set of size $N = n_a + n_b$. The N-size measures are then ranked in ascending order, and the rankings returned to the original samples in place of the raw measures, so that n_a is the number of ranks in group A (the consumers), and n_b is the number of ranks in group B (the producers). In addition, we define T_{A} as the sum of n_a ranks in group A, T_{B} as the sum of n_b ranks in group B, and T_{AB} as the sum of N ranks in groups A and B. The Mann Whitney test used here is based on the z test which is defined as

$$z = \frac{(T_{obs} - \mu_T) \pm 0.5}{\sigma_T}, \tag{3}$$

where T_{obs} is the observed value for either T_{A} or T_B, μ_T is the mean of the corresponding sampling distribution of T, σ_T is the standard deviation of that sampling distribution, and 0.5 is used as a correction for continuity (with -0.5 used when $T_{\mathrm{obs}} > \mu_T$ and $+0.5$ used when $T_{\mathrm{obs}} < \mu_T$). With a calculated symmetric z value of 4.33 and a p value of 0.0001, we conclude that consumers' food safety risk perception is significantly different from producers' food safety risk perception. This also implies that separate multinomial logit models can be used to model consumers response and producers response.

4.1 Survey and Multinomial logit Results

Results of the multinomial regression models for consumer risk perception are presented in Table 2. Only those relationships that are significant at the 10 percent level are discussed here. In general, income, location, and source of information affect consumers' risk perception. Consumers' perception of ease of illness when bison is prepared at home and away from home, age of respondents, awareness of food safety risks associated with bison meat, gender, and consumers' belief about food safety trends (where the measure is whether the consumer believes outbreaks and recalls will decrease in the future) affects risk perception at the 5% level of significance. In addition, consumers' knowledge of microbial risks from TV and level of education affect risk perception at the 1 percent level of significance. The estimated risk perception model had a very good fit with a Nagelkerke R^2 of 0.71, a Cox and Snell R^2 of 0.63, and a model significance of 0.000. The marginal effects of the variables are also included in Table 2. It should be noted that variables that affect consumers' perception of somewhat safe and somewhat unsafe are different.

TABLE 2. Estimated Coefficients and Marginal Effects of Factors Affecting Consumers' Risk Perception

Group	Variables	Coefficient	Standard Error	Probability	Marginal Effect
Somewhat unsafe					
Social and cultural characteristics	Income	1.822	1.057	0.060	0.06996*
	Age	0.114	0.055	0.031	0.00011
	Education	2.177	1.711		0.00002
	City/location	0.628	0.331	0.055	0.00188**
	Gender	0.827	1.159		0.00003
Personal health influence	Anybody ill	8.828	1.442	0.095	0.75899*
	Family member ill	0.855	0.05	0.065	0.00425
Perceived locus of control	Ease illness homeprep	−1.581	0.667	0.018	−0.02795**
	Ease illness awayprep	−0.417	0.726		−0.00028
Outrage/awareness	Info TV	−18.094	2.271	0.000	0.00000
	Info magazines	−2.58	1.843		0.00000
	Radio	2.076	4.283		0.00044
	Food labels	−4.21	3.075		−0.00223
	Trend in safety bison meat	−0.852	0.691		0.00000
	Awareness of handling	−1.957	0.87	0.042	−0.00391*
Somewhat safe					
Social and cultural characteristics	Income	−0.131	0.158		−0.00003**
	Age	1.616	0.016		0.00011
	Education	2.175	0.429	0.001	0.00217
	City/location	−0.228	0.159		−0.00007
	Gender	−0.508	0.248	0.024	−0.00202**
Personal health influence	Anybody ill	0.119	0.305		0.00015*
	Family member ill	0.513	0.349	0.076	0.00306**
Perceived locus of control	Ease illness homeprep	−0.136	0.236		0.00000
	Ease illness awayprep	−0.609	0.288	0.084	−0.02000
Outrage/awareness	TV	−0.948	0.557	0.009	−0.00846*
	Magazines	0.496	0.452		0.00000
	Radio	0.129	0.903		0.00002
	Food labels	0.903	0.681		0.00000
	Trend in safety bison meat	−0.37	0.177	0.037	−0.01318
	Awareness of handling	5.924	0.163	0.097	0.51889*
	Ln L at convergence		473.508		
	Cox and Snell R^2		0.635		
	Nagelkerke R^2		0.714		
	Model significance		0.000		

Note. * and ** represent significance at the 1% and 5% level, respectively.

4.1.1 Personal Health Influence Characteristics and Perceived Risk About 55% of the consumers perceive bison meat as safe and somewhat safe, compared to 95.5% of the packers and processors. Only 4.5% of packers and processors who also had prior recall problems perceive bison meat to be somewhat unsafe. Although the majority of consumers did not report knowing a friend or family who had been sick as a result of consuming bison meat, this was a concern for some respondents. The degree to which this

concern affects the consumption frequency of bison is discussed with the multinomial logit results. Compared with CDC statistics that one out of every four consumers experience food related illness or death annually, it can be inferred that the actual hazard associated with bison meat consumption is relatively low.

The more respondents know of a family member or a friend who had suffered a foodborne related illness or death, the more likely they will perceive bison meat to be unsafe. This result was expected, especially with frequent food recalls and outbreaks, even though firms may operate under stringent food safety systems like Pathogen Reduction/Hazard Analysis Critical Control Points (PR/HACCP). It underscores the importance of understanding outrage and consumers' awareness of risk and designing effective risk communication strategies to educate consumers about food safety risks.

4.1.2 Perceived Locus of Control and Perceived Risk Approximately 33% of respondents indicated that it was not very common to become sick from consuming bison meat at home or from a restaurant. Contrary to traditional beliefs that outbreaks generally occur away from home, the overwhelming response from this survey indicates that this is not the case with bison. This may be true because bison consumption is largely channeled through niche markets and much care is used to prepare specialty meats. The multinomial logit analysis provides more information on how consumers perceive risks that affect bison meat consumption.

The more consumers believe it is easier to fall sick as a result of consuming specialty meats prepared at home or away from home, the more they perceive these meats as unsafe. One indicator that helps guide consumer perceived locus of control is the strength of regulatory programs. The ease of falling sick as a result of bison consumption in this study is affected by the level of regulation and the fact that game processing and custom exempt processing are a regular occurrence with specialty meats.

4.1.3 Sociocultural/Economic Characteristics and Perceived Risk More lower income individuals perceive bison meat to be somewhat unsafe (may encounter microbial issues). Also, older people view bison meat as somewhat unsafe. This is not unusual, as microbial issues relating to food affect mostly the older, the immune-deficient, and the children. It was also interesting to find that people further away from major processing areas perceive bison to be unsafe. This may be due to lack of familiarity with specialty meats.

Consumers with higher levels of education perceive bison meat to be safer (somewhat safe). It was also revealed that more men perceived bison to be safe. This is not unexpected since men comprise the majority of hunters and are therefore likely to be more familiar with specialty meats. However, it poses a major challenge to bison processors to motivate females who, in most part, prepare the food at home.

4.1.4 Outrage and Perceived Risk The literature suggests that factors that increase consumers' awareness about hazard tend to reduce outrage. A number of these factors identified from prior studies on outrage by Sandman are: sources of information to educate consumers about risk, use of food labels to increase awareness of safe handling information and food safety information, and the presence of a USDA certification seal.

About 49% of the respondents indicated that they receive food safety information from TV, while 24% indicated that they receive some of the information from magazines. Consumers indicated that food labels were their second most important source of food safety information (26%), followed by magazines. Although about 44.8% of consumers are aware

of handling and precautionary practices concerning bison products, more than 21.8% indicated they did not know how to handle bison products to prevent food safety problems.

Sandman (2000) noted that as outrage increases, perceived risk will increase. On the other hand, as consumers become aware of the risk involved, perceived risk decreases. It is assumed that variables that will increase awareness about risk will decrease outrage and decrease perceived risk. Information sources (TV, magazines, food labels, etc.) about food safety risk, consumers' knowledge, and awareness of microbial risk were all used as proxies for outrage (Sandman, 2000). Information from TV is a significant source of food safety risk perception for bison. However, this coefficient was negative for consumers' perception of somewhat safe, indicating that consumers probably receive more negative information about food safety on TV than positive information.

The results indicate that the more information they get from the TV, the more they perceive bison meat to be unsafe; the marginal effect of TV is negative. Processors and packers should seek to use food labels and other information sources to promote food safety knowledge of bison. Consumers who believe they are aware of safe handling practices about bison safety had lower risk perception of bison meat safety. Evaluating the effectiveness of an education campaign on safe handling practices and the impact of such a campaign on risk perception will likely be revealing. In fact, Figure 1 indicates that as outrage decreases, consumers' perception of whether bison meat is somewhat safe increases, while consumers' perception of bison meat being somewhat unsafe decreases. This also suggests that the impact of outrage, a component of risk that is distinct from hazard, is real. Hence, there is need for an effective educational campaign to reduce risk to hazard alone.

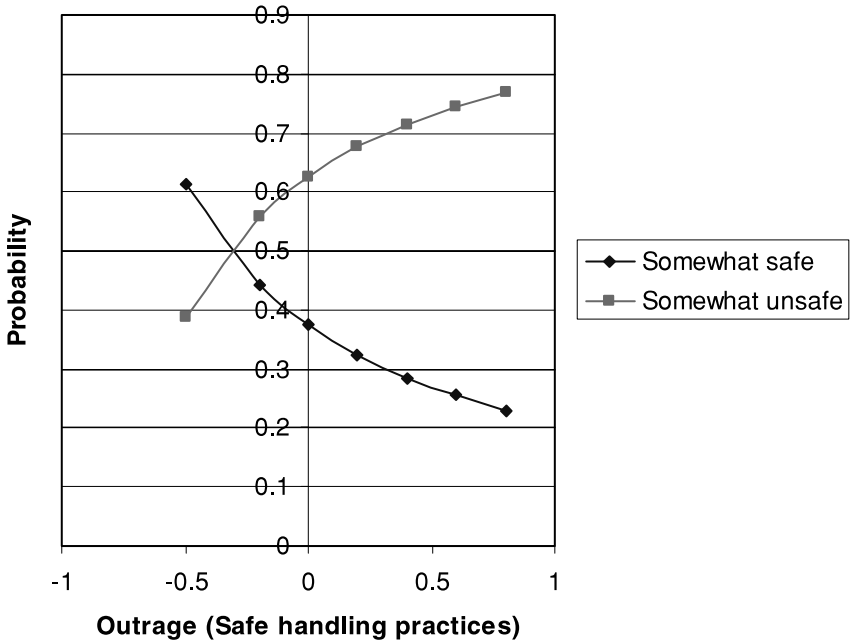

Figure 1 Marginal Impacts of Outrage on Risk Perception.

4.2 Marginal Effects and Impacts on Consumption Frequencies

Table 3 presents coefficients and estimated marginal effects of food safety risk perception determinants on consumption of bison at home and away from home. All significant variables from Table 2, in addition to weighted average price and perceived risk, were used to evaluate the impact of risk perception determinants on consumption at home and away from home. Overall, gender and knowledge of a family member or a friend being ill from food safety hazard were significant at the 10% level. Income, consumers' perception of the ease

TABLE 3. Estimated Coefficients and Marginal Effects of Factors Affecting Consumption Away From Home and at Home

Group	Variables	Coefficient	Standard Error	Probability	Marginal Effect
Bison consumption at home					
Social and cultural characteristics	Income	0.593	0.195	0.022	0.00118*
	Age	0.027	0.018		0.00000
	Education	0.038	0.195		0.00001
	City/location	−0.109	0.169		0.00000
	Gender	0.979	0.303	0.093	0.00293
	Price	−0.244	0.118	0.001	−0.00024*
Personal health influence	Anybody ill	−0.163	0.037	0.015	−0.00241*
	Family member ill	−0.223	0.424		−0.00002
Perceived locus of control	Ease illness homeprep	−0.459	0.297		−0.00005
	Ease illness awayprep	−0.327	0.352		−0.00017
Outrage/awareness	Info TV	−0.089	0.011	0.033	0.00000
	Awareness of handling	4.112	1.023	0.027	0.10803*
Food safety risk perception	Trend in food safety risk	−0.241	0.244		0.00000
	Bison meat safety	−1.640	0.478	0.012	−0.09538**
Bison consumption away from home					
Social and cultural characteristics	Income	1.165	0.431	0.041	0.00116**
	Age	0.051	0.076		0.00000
	Education	0.375	0.429		0.00008
	City/location	−0.302	0.184		−0.00017
	Gender	0.102	0.310		0.00000
	Price	−0.189	0.012	0.012	−0.00224**
Personal health influence	Anybody ill	−0.236	0.038	0.051	−0.00024**
	Family member ill	−0.426	0.044	0.074	−0.00588
Perceived locus of control	Ease illness homeprep	−0.191	0.308		−0.00004
	Ease illness awayprep	−0.029	0.004	0.042	−0.00006
Outrage/awareness	TV	−0.329	0.007	0.028	−0.00261**
	Awareness of handling	2.998	0.336	0.071	0.19775*
Food safety risk perception	Trend in safety bison meat	−0.100	0.249		0.00000
	Bison meat safety	−1.282	0.486	0.011	−0.11743*
	Ln L at convergence		477.74		
	Cox and Snell R^2		0.795		
	Nagelkerke R^2		0.848		
	Model significance		0.000		

Note. * and ** represent significance at the 1% and 5% level, respectively.

of becoming ill by eating away from home, and TV were significant at the 5% level. Price and food safety risk perception affect consumption at the 1% level. The estimated model had very good fit with a Nagelkerke R^2 of 0.84, and a model significance of 0.000. The marginal effects of the variables and their significance are also included in Table 3.

Prices were assigned to consumers based on the weighted price at their respective locations. The results indicate that higher prices will decrease bison consumption away from home and at home. This result is as expected, given that the prices of specialty meat products are higher than conventional beef, pork, or poultry. The impact of gender on consumption of bison at home is interesting, as the results indicate that women prefer to consume bison at home versus consuming bison away from home.

Food safety risk perception determinants and whether or not consumers perceive bison to be safe, somewhat safe, or somewhat unsafe significantly reduces consumption frequency at home and away from home. Awareness of safe handling practices significantly influences consumption frequency at home and away from home. As awareness increases, outrage decreases and consumers consume bison more frequently. Incorporating food safety microbial attributes on food labels and through other information media may facilitate and educate consumers about safe handling practices (washing, cooking, and refrigerating conditions), which may subsequently minimize microbial hazard.

Interpreting results of the multinomial logit models based on the coefficients alone must be approached with caution because the coefficients do not give a true measure of the change in the dependent variable with respect to a unit change in the independent variable. The marginal effects give the effect of a unit change in the dependent variable on the change in probability of a certain risk perception category.

For instance in Table 2, the zero values of the marginal effects suggest that the true effect (unitary change) of the outrage variables (TV, magazines, trends in bison meat safety) is negligible on the probability of consumers' choice of "somewhat unsafe." Similarly, that magazines and food labels have negligible effects as outrage variables on the probability of characterizing bison meat as 'somewhat safe' is illustrated. However, TV has a relatively high negative and significant marginal effect on the probability of consumers' perception of bison meat as somewhat safe.

The variables with the greatest marginal effects are "anybody ill" on "somewhat unsafe" (0.759) and "awareness of handling" on "somewhat safe" (0.519). This means that a unitary change in the dependent variable (anybody ill) will significantly increase the probability of perceiving bison meat as somewhat unsafe by 0.759, while a unitary increase in "awareness of handling" will significantly increase the probability of perceiving bison meat as somewhat safe by 0.519. Hence, personal health influence plays a major role in the probability of characterizing bison meat as somewhat unsafe while awareness of handling is a major determinant in the probability of characterizing bison meat as somewhat safe.

In Table 3, TV as an outrage variable had zero marginal effect on the probability of deciding to consume bison meat at home. Based on their marginal effects, unitary changes in the dependent variables 'awareness of handling' and 'bison meat safety' would respectively result in the highest significant increase and decrease in the probability of deciding to consume bison meat at home. Similarly "awareness of handling" and "bison meat safety" were the most significant determinants of the probability of deciding to consume bison meat away from home. The marginal effect of price was relatively small, in Table 3. Americans in general spend a significantly lower percentage of their income on food, compared to other countries. This may tend to reduce the marginal effects of price, especially

for staples like meat and poultry products. This illustrates the importance of incorporating other factors, like food safety, in demand estimation analysis.

4.3 Producer Risk Perception

Table 4 shows estimates of coefficients and marginal effects of factors affecting processors' risk perception. This model was estimated because producers and consumers exhibited statistically significant differences in risk perception. The results suggest that among social and cultural characteristics, years in business plays a significant role in food safety risk perception; the effect on perception of somewhat safe is positive while the effect on somewhat unsafe is negative. The longer (shorter) the processor stays in business, the more (less) likely they are to perceive bison meat as safe (unsafe). On the other hand, sales volume and location (city/state) had no significant effect on producer risk perception of bison meat.

Among factors that constitute perceived locus of control, meat recalls have a significant effect on food safety risk perception. Not surprisingly, increase in the number of

TABLE 4. Estimated Coefficients and Marginal Effects of Factors Affecting Processors' Risk Perception

Group	Variables	Coefficient	Standard Error	Probability	Marginal Effect
Somewhat safe					
Social and cultural characteristics	Years in business	3.112	1.001	0.060	0.17552**
	Sales volume	8.121	6.225		0.00179
	City/location	0.988	0.751		0.00090
Perceived locus of control	Recall	−4.128	1.042	0.091	−0.34146*
	USDA inspected/ microbial testing	3.252	0.785	0.020	0.06374**
	Awareness of microbial hazards	3.551	1.677	0.011	0.03863*
	Food labels	−0.457	0.526		−0.00005
Somewhat unsafe					
Social and cultural characteristics	Years in business	−2.031	0.188	0.019	−0.03786**
	Sales volume	1.066	2.011		0.00001
	City/location	−3.218	2.959		−0.00109
Perceived locus of control	Recall	1.177	0.505	0.001	0.00118*
	USDA inspected/ microbial testing	−1.511	0.441	0.016	−0.02379**
	Awareness of microbial hazards	−0.336	0.255		−0.00040
	Food labels	−0.619	0.438		−0.00032
	Ln L at convergence		414.001		
	Cox and Snell R^2		0.432		
	Nagelkerke R^2		0.522		
	Model significance		0.001		

Note. * and ** represent significance at the 1% and 5% level, respectively.

recalls would create the perception that bison meat was somewhat unsafe. USDA inspection or microbial testing and awareness of microbial hazards have positive effects on processor perception of a somewhat safe meat product. Therefore as USDA inspection and microbial testing increase, risk perception of bison meat as somewhat safe (unsafe) increases (decreases). The producers would undoubtedly be aware of the benefits of HACCP. An increase in the awareness of microbial hazards increased the perception of somewhat safe and decreased the perception of somewhat unsafe. Food labels had negative non-significant effects on producer risk perception of the safety of bison meat.

In Table 4, unitary changes in "effect of a recall" resulted in a significant decrease in probability of producers perceiving bison meat as somewhat safe by 0.34. To a lesser extent, the number of years in business played a major role in producers' perception of bison meat as somewhat safe. With respect to the probability of perceiving bison meat as somewhat unsafe, unitary increases in years in business as well as USDA inspected/microbial testing resulted in decreased perception probabilities.

5. CONCLUSIONS

Differences exist in processors' and consumers' risk perception of bison meat, and these differences play an important role in understanding food related illnesses and death, expenditure to mitigate food safety risks, and moving specialty meats like bison beyond niche markets. Consumer risk perception may suppress demand for bison meat, therefore, this study is also important for risk communication purposes, in an industry that generates an estimated $70 million in annual economic activity in North Dakota alone (Sell, Bangsund, & Leistritz, 2000). FSIS estimates that approximately 1 million pounds of bison is consumed each month by Americans. Although this is a relatively small amount compared to beef, Raabe (2004) reports that the trendy bison meat has recovered from a four-year market swoon and is now charging ahead with rising prices and strong market demand. The recent BSE cases in cattle have played a major role.

The study is limited by the scope and inclusiveness of non-specialty meat consumers even though some respondents reported they do not consume bison meat. The results suggest that producers and processors of specialty meats like bison must overcome risk perception issues if they must move their products beyond niche markets. While outrage and personal health influence affect consumer risk perception, the absence/reduced number of recalls, and to a lesser extent, the number of years in business appear to have greater influence on positive producer risk perception. Outrage and food safety risk perceptions also exert a major influence on the decision to consume bison meat at home or away from home.

The results in this study extend the literature on determinants of food safety risk perception by incorporating outrage and awareness as risk communication variables. The effect of outrage/awareness on the probability of consumers' specifying bison meat as somewhat unsafe is minimal; whereas, awareness is the major factor in classifying bison meat as somewhat safe. This implies a role for food safety experts to communicate actual risk in order to reduce outrage and increase consumption frequency of bison meat at home and away from home. The results also reveal that a combination of strategies on pricing and risk perception are required to increase the demand of specialty meat products beyond niche markets. This study illustrate that food safety risk perception issues should not be overlooked to focus mainly on pricing strategies, especially with emerging food safety perception concerns.

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