Unwillingness to Consume Irradiated Beef and Unwillingness to Pay for Beef Irradiation

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The benefits of food irradiation, such as effectively killing harmful microorganisms, prolonging shelf life of food, and reducing spoilage, have long been recognized by food-safety authorities. Application of food irradiation has been promoted at an international level by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) of the United Nations. In the United States, however, efforts to promote food irradiation have not accomplished much due to consumer resistance to this food-processing technology.

Consumer resistance to food irradiation in spite of scientific evidence of and professional attestation to its benefits and safety was largely unexpected, and efforts have been made to determine the driving force behind it. Previous studies have suggested various explanations for consumer resistance such as misunderstanding of and a distorted image toward radiation (Furuta et al. 2000) and negative perceptions of food irradiation aroused by food-safety advocacy groups (Hayes, Fox, and Shogren 2002). While such explanations may provide some useful information for food-policy makers, they tend to be very general. Furthermore, explanations for consumer resistance suggested in previous studies were mostly based on assessment of consumer acceptance of food irradiation, but not directly on assessment of resistance. Now, since it is commonly agreed that there is a substantial proportion of the population resistant to food irradiation, a sensible and more direct way to address the issue is to investigate why these consumers are unwilling to accept food irradiation. This study addresses two issues related to beef irradiation: why some consumers are unwilling to consume irradiated beef, and why some consumers are willing to consume irradiated beef but are unwilling to pay a higher price for it.

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Food Safety and Beef Irradiation in the United States

In the United States, consumers have come to expect their food to be both nutritious and safe. They have many reasons to do so. With an advanced food production and processing technology, extensive temperature-controlled distribution networks, an efficient transportation infrastructure, and a rather comprehensive set of food regulations formulated and enforced by government agencies, the United States is better equipped than most of the countries in the world to supply safe foods. Some nutritionists and food scientists have claimed that the United States has the safest food supply in the world (Foster 1982). But this does not mean food in the United States is absolutely safe. As a matter of fact, food contamination by harmful microorganisms poses a serious problem. According to the U.S. Public Health Service, about 6.5 to 8.1 million cases of diarrhea diseases occur in the United States each year due to food contamination by pathogenic bacteria. Even more bothersome is the fact that each year there are about 9000 deaths as a result of diarrhea diseases related to pathogenic bacteria (Farkas 1998). In addition to the threat to public health, food contamination causes tremendous economic loss due to medical costs and loss of productivity (Todd 1989; Buzby et al. 1996).

Of all kinds of food, food of animal origin is most likely to get contaminated by microorganisms. The impact of contamination of meat food by microorganisms can hardly be exaggerated. In past decades, several severe outbreaks of *E. coli* illnesses, principally resulting from consuming hamburger meat, caused many deaths and permanent injuries; they caused enormous economic loss, destroyed product brand names, and caused the closure of involved companies (Adams 2000). These outbreaks may have shaken the American public's confidence in the safety of their food supply and damaged public trust in food-safety authorities and the food industry.

In the United States, beef and beef products are

more likely to get contaminated than are other kinds of meat. The number of outbreaks, incidents, and recalls of beef is much higher than that of other kinds of meat. In 1998, out of a total of 44 recalls of meat products, at least 25 were related to beef, while only 8 were related chicken. To enhance the safety level of beef and beef products in response to multiple outbreaks of *E. coli* illnesses, the Food and Drug Administration (FDA) of the United States approved in December 1997 the use of irradiation to kill harmful bacteria in beef (Adams 2000). About fifteen months later, in February 1999, the Department of Agriculture of the United States (USDA) published its proposed rule on beef irradiation (Adams 2000). The approval is the results of combined efforts. The National Food Processors Association (NFPA) and the American Meat Institute (AMI), for instance, have been instrumental in the advancement of the approval of beef irradiation (Adams 2000).

Both food suppliers and consumers may benefit from food irradiation. Consumers may benefit from safer food, lower food prices and increased in-home storage time; manufacturers may benefit from lower processing, storage, and transportation costs and less wastage; while retailers may benefit from increased shelf lives and improvements in the cost and efficiency of merchandising food products (Henson 1995). But producer and consumer responses to the approval are in sharp contrast. The American meat industry showed a keen interest in learning about the irradiation technology after the approval. Most major beef suppliers conducted trial applications of the technology to their ground beef products to gain an understanding of the effects of the process (Adams 2000). The American consumers, on the other hand, displayed a strong resistance to the adoption of the technology. Because of this consumer resistance, promotion of beef irradiation has not made much progress.

Consumer Resistance and Unwillingness to Pay

Consumer resistance to food irradiation is very strong in the United States. Some aggressive opponents even threatened food processors with public denouncements, protests, and business disruption if they were to adopt food irradiation (Adams 2000). The resistance is not only very strong, but also difficult to dissuade by authoritative institutions. This is evidenced by consumer reactions to the FDA approval of food irradiation in the United States, when some consumers indicated that the approval would result in increased concerns over food irradiation (Schutz, Bruhn, and Diaz-Knauf 1989). Such a strong and stubborn resistance effectively constrained the promotion of food irradiation (Henson 1995).

Consumer resistance may be related to misunderstanding of and a distorted image toward irradiation (Furuta et al. 2000) and lack of knowledge about food irradiation (Farkas 1998; Bruhn 1995; Resurreccion et al. 1995). For a lay public without any knowledge about food irradiation, the word irradiation may bring to his mind the concept of harmful radioactivity. As (Hunter 2000) stated, "If you give someone irradiated food for the first time they will likely hesitate before they eat it because their mind will conjure up images of invisible things in the food that are going to do something to them." This kind of subconscious fear is likely to cause consumer resistance to food irradiation and must be overcome in order to gain consumer acceptance for food irradiation.

Another major factor influencing consumer resistance is the efforts made by food-safety advocacy groups against this food processing technology. A typical response from food-safety advocates was that no one knows what effect food irradiation will have on our health. Assertions made by food-safety advocacy groups about the effects of food irradiation are generally not based on scientific evidence. But consumers tend to trust message from their advocates more than information from other sources. Consumers typically attend to and accept negative information over positive information (Henson 1995). Some researchers (Hayes, Fox, and Shogren 2002) found that even though consumers are given scientific evidence favorable for food irradiation, claims by opponents, even if they are inaccurate and only suggest potential risks, may reduce their desire for its adoption.

Consumer resistance is believed to have something to do with consumer perception about governmental food-safety regulatory institutions' intention and ability to ensure the safety of their food supply (Henson 1995). In the United States, application for food irradiation has to be approved by governmental food-safety authorities. If consumers believe governmental authorities have a good intention and a firm commitment to promote their

benefits, then they may consider the approval as an insurance of safety and even of benefits of food irradiation. However, consumers in the United States do not wholeheartedly trust the government and its administrative agencies regarding food safety, and they are generally suspicious of the food-safety regulatory process itself (Henson 1995). Many consumers can recount examples of perceived "cover-ups" (Henson 1995) and government and corporate conspiracies are a widespread concept in the United States (Hunter 2000). Such perceived cover-ups and conspiracies tend to heighten consumer suspicions over the intent and motives of food regulators, and the impact is generally difficult to dissuade. If consumers do not trust government and its administrative agencies, then they may view approval of food irradiation with doubt about its benefits and will tend to be resistant to it.

Regarding consumer unwillingness-to-pay for food irradiation, no great efforts were made in previous studies to determine the driving force behind it. As a matter of fact, no previous study has ever assessed unwillingness-to-pay for food irradiation of those who would consume irradiated food. According to the survey from which the data used in this study were collected, however, there did exist such a group of consumers who would accept irradiated food at the current market price for non-irradiated food, but were unwilling to pay a higher price for it. No information is available in the literature as to whether there is a common set of factors influencing both consumer resistance and unwillingness-to-pay. A possible factor affecting unwillingness-to-pay is perceived benefit distribution, with consumers' perception being that there is minimal personal benefit from food irradiation but significant potential for increased profits for the food industry (Adams 2000; Macfarlane 2002). If consumers believe they do not benefit much from consumption of irradiated food, they are unwilling to bear the costs of irradiation.

The explanations suggested above for consumer resistance and unwillingness-to-pay are very general. The impacts of such factors are likely to transform into some specific perceptions or opinions more closely and directly related to consumer resistance and unwillingness-to-pay. For example, a distorted image toward radiation may result in fear of health risks from consuming irradiated food, while perceived failure of governmental administrative agencies to ensure food safety may transform into a desire for government to pay the costs of food irradiation. It is such perceptions and opinions that we are to investigate in this study.

Econometric Model

Different individuals may have different reasons for their resistance to food irradiation. Each reason may be associated with or affected by a set of factors, such as demographic characteristics. Taking this into consideration, a multiple-choice question was specially designed in the survey to obtain information on the various reasons why consumers were resistant to beef irradiation. Those who would not buy irradiated beef at the current market price for non-irradiated beef were asked to indicate, from a list of four given alternatives, the most important reason why they did not want to consume the product. Assuming that the probability that an individual selects a specific alternative as the most important reason is affected by a set of demographic factors, a multinomial logit model is appropriate for the analysis of consumer resistance.

Regarding consumer resistance to irradiated beef, it is possible that there are many reasons why an individual is unwilling to buy irradiated beef. It is unlikely that all the reasons have the same impact on his decision not to consume the product. Generally, there is one reason that affects his decision more than other reasons. Denoting the J+1 unordered reasons considered in the study by 0, 1, 2, ...J, then, the probability that an individual would select the j^{th} reason as his most important reason for not consuming the product can be expressed as

$$1) \quad \text{prob}(Y_i = j) = \frac{e^{\beta_j x_i}}{\sum_{k=0}^{J} e^{\beta_j x_i}}$$

where Y_i denotes the j^{th} individual's choice from the given alternative reasons; j = 0, 1,...J and k = 0,1,...J indicate possible reasons considered in the study; X_i is a vector of explanatory variables; and $_i$ and $_j$ are vectors of parameters to be estimated. The solutions to the set of equations provide a set of probabilities for the J + 1 choices for an individual with characteristics of X_i. The method of normalization is usually used to remove an indeterminacy in the model. The normalization is commonly carried out by assuming that $_0 = 0$ (Greene 1997). With the indeterminancy having been removed, the probabilities that an individual would select a

specific alternative as his most important reason can be expressed as

$$2)\quad \text{prob}(Y_i = 0) = \frac{1}{1 + \sum_{k=0}^{J} e^{\beta_j x_i}}$$

and

$$\text{prob}(Y_i = j) = \frac{e^{\beta_j x_i}}{1 + \sum_{k=0}^{J} e^{\beta_j x_i}} \qquad \textit{for } j = 1,2,...J.$$

Multinomial logit models are usually estimated using the maximum-likelihood method. The multinomial logit model is actually a generalization of the binomial logit model, hence, its log-likelihood function can be specified as a generalization of that for the binomial logit model (Greene 1997):

$$3)\quad \ln L = \sum_{i=1}^{N} \sum_{j=0}^{J} d_{ij} \ln \text{prob}(Y_i = j),$$

where N is the total observations in the sample, and $d_{ij} = 1$ if the i^{th} individual selects the j^{th} alternative reason as the most important reason for his unwillingness to consume irradiated beef at the current market price for non-irradiated beef and 0 otherwise.

Information on consumer unwillingness to pay a higher price for irradiated beef was also obtained using a multiple-choice question. Those who would consume irradiated beef at the current market price but would not pay a higher price were asked to select from a set of given alternatives one choice as the most important reason why they would not pay a higher price for the product. Given the unordered multiple-choice nature of the dependant variable, a multinomial logit model is also appropriate for the analysis of consumer unwillingness to pay a higher price.

It is noteworthy that not the whole sample of respondents was asked the resistance or unwillingness-to-pay question, so the subsamples used for the analyses of resistance and unwillingness-to-pay are not random samples from the population. At first glance it seems to be a typical truncated sample, like the well-known analysis of the earnings equation estimated from the data for the negative-income-tax experiment by Hausman and Wise (1976, 1977). But a closer scrutiny reveals the difference. In their study, the sample was truncated according to household income, with high-income households being excluded from the survey, so the included households and the excluded households differed quantitatively according to the truncation criterion of income. In another words, all households have some income, but the researchers arbitrarily divided them into two groups, where one group of household incomes is less than or equal to a certain amount and the other group of household incomes is greater than that amount. In our study, taking resistance for example, there are naturally two groups of respondents, one group resistant to food irradiation, and one group not.

In food-consumption studies, researchers sometimes take into consideration both consumption participation and consumption behavior such as consumption frequency. Double-hurdle count-data models are usually used in such studies. While there seems to exist a kind of similarity between those studies and this study, because consumer resistance is actually non-participation in consumption, there is a basic difference between them. In those studies, two aspects of consumption were investigated, zero consumption and positive consumption. There may be a meaningful economic relationship between these two aspects and a major goal of analyzing such models is to investigate whether consumption participation and consumption behavior are determined by the same set of factors. In this study, we explore the various reasons consumers do not participate in consumption, rather than positive consumption.

Regarding the sampling issue in this study, one can think there are two sub-populations, one resistant to food irradiation and one not. We are interested in some issue unique to one of the sub-populations. Based on this concept, we did not incorporate truncated distribution in the specification of the likelihood function or include a binomial analysis of non-participation in the model.

Survey and Data

Ten months after the USDA published its proposed rule, a telephone survey was conducted to obtain information on consumer perception of and attitudes toward beef irradiation, especially on consumer acceptance of irradiated beef and willingness to pay for beef irradiation. The survey was conducted by the University of Georgia Survey Research Center in December 1997 and January 1998. A sample of 740 households was randomly selected nationwide. To improve the reliability of the survey, primary grocery shoppers of the households were requested to complete the survey. Vegetarians were excluded from the survey. About 93% of the respondents

used to buy beef at a grocery store at least once in a month.

Information on consumer acceptance of beef irradiation was obtained using a dichotomous-choice question. Respondents were asked whether they would buy irradiated beef at the current market price for non-irradiated beef. About 51% of the sample responded positively while more than 31% said "no"; the rest were unsure whether they would buy it or not. Information on various reasons for consumer resistance to beef irradiation was then elicited using a multiple-choice question. Those who would not buy irradiated beef were asked to select an item from a set of alternatives as the most important reason for their unwillingness to consume irradiated beef at the current market price. The result indicates that safety concern is the biggest barrier to consumer acceptance of beef irradiation. Of the those who would not buy irradiated beef at the current market price, about 66% indicated the most important reason for their resistance to the product was that they were not sure whether the process of beef irradiation is safe. More than 23% were unwilling to consume the product because they considered irradiation harmful and believed that consumption of irradiated beef may lead to health complications. Around 4% indicated that their resistance to irradiated beef was mostly due to their perception that food irradiation poses occupational hazards, and 3% resisted the product because of their concerns about environmental pollution by food irradiation. The rest (roughly 13%) did not accept the product because of other reasons not listed in the survey.

Those who would buy irradiated beef were then asked whether they were willing to pay a higher price for it. About 60% of them indicated that they were willing, 32% were unwilling, and about 8% were not sure about their attitude. For those who were willing to consume irradiated beef but were unwilling to pay a higher price for it, information on various reasons for unwillingness-to-pay was then obtained using a multiple-choice question, asking those respondents to select one choice from a set of given alternatives as the most important reason why they would not pay a higher price. For 40% of these respondents, the most important reason for their unwillingness-to-pay is that the current price is all that they were willing to pay. About 10% of them were unwilling to pay a higher price because they thought irradiation would not actually make the beef safer than it already is. Roughly 19% indicated that the most important reason for their unwillingness-to-pay was that they believed the government should pay for the costs of irradiation. Around 15% were unwilling to pay a higher price because of other reasons not listed in the survey, and 17% were not quite sure about what was the most important reason for their unwillingness-to-pay.

Estimation Results

Table 1 presents the description and mean values of the explanatory variables. Notice that the means values of the consumption model are different from those of the payment model because the data sets are from different sub-samples of the survey. Also notice that the variables "sufficient" is not included in the payment model because, conceptually, we do not see any convincing relationship between this factors and consumer unwillingness to pay a higher price for irradiated beef.

Table 2 presents the estimation results from a multinomial logit analysis of the most important reasons for consumer resistance to irradiated beef. The dependent variable reflects various reasons why consumers do not want to consume the product, including "irradiation is harmful and consumption of irradiated beef may lead to health complications" (Reason 1), "irradiation poses occupational hazards for those involved" (Reason 2), "irradiation poses serious environmental hazards" (Reason 3), and "not sure whether the process is safe," which is used to normalize the set of equations.

The results show that, compared with middle-aged respondents (between 40 and 60), young and senior respondents are more likely to resist irradiated beef because of the perceptions that irradiation is harmful and consumption of irradiated beef may lead to health complications and that irradiation poses serious environmental hazards. Females tend to resist irradiated beef because they think irradiation is harmful and consuming irradiated beef may lead to health complications. Those who consider the food-safety regulations either inadequate or not effectively enforced are more likely to select the alternatives "irradiation is harmful and consumption of irradiated beef may lead to health complications" and "irradiation poses serious environmental hazards" as the most important reasons for their resistance to the product. As for those who think they have sufficient knowledge about food irradiation, their resistance to irradiated beef is more likely due

Table 1. Description and Mean Values of the Variables.

Variable	Description	Mean (Consumption model)	Mean (Payment model)
Young	1 = less than 40 years old, 0 otherwise.	0.336	0.418
Senior	1 = more than 60 years old, 0 otherwise.	0.274	0.224
Female	1 = female, 0 = male.	0.733	0.627
College	1 = have college education, 0 other wise.	0.301	0.336
Income	1 = less than $25,000; 2 = between $25,000 and $35,000; 3 = between $35,000 and $45,000; 4 = between $45,000 and $55,000; 5 = between $55,000 and $65,000; 6 = between $65,000 and $75,000; 7 = more than $75,000.	4.281	3.658
White	1 = white people, 0 otherwise.	0.774	0.821
Unsafe	1 = considering the food safety regulations are either inadequate or ineffectively enforced, 0 otherwise.	0.712	0.716
Sufficient	1 = the respondent has sufficient knowledge about food irradiation, 0 otherwise.	0.038	N/A

to their concern that irradiation poses occupational hazards for those involved and irradiation poses serious environmental hazards.

Table 3 presents the estimation results from a multinomial logit analysis of the most important reasons why consumers are unwilling to pay a higher price for irradiated beef. The reasons considered are "the current price is all I am willing to pay" (Reason 1), "irradiation will not actually make the beef safer than it already is" (Reason 2), "the government should pay for the cost of irradiation" (Reason 3), and "other reasons given by the respondents," which is used to normalized the set of equations. Gender is the only variable found to have a significant impact in the model, with females being more likely to think the government should pay for the cost of beef irradiation.

Conclusion

Consumers in the United States are resistant to food irradiation in spite of scientific evidence of and professional attestation to its benefits and safety. Due to strong consumer resistance, promotion of food irradiation has not accomplished much. This study investigated various reasons why some consumers do not want to consume irradiated beef while some other consumers would consume irradiated beef but would not pay for the cost of irradiation. This study has gained some useful insights, especially the message that information dissemination may be a key to the promotion of food irradiation. We found that the majority of the respondents resisted irradiated beef just because of safety concerns, which are unfounded according to scientific evidence and

Table 2. Multinomial Logit Regression Results for Reasons of Non-Participation in the Consumption of Irradiated Beef.

Variable	Reason 1	Reason 2	Reason 3
Constant	-3.817***	-3.018*	-7.381***
	(0.819)	(1.637)	(2.439)
Young	0.712**	0.199	1.966*
	(0.354)	(0.683)	(1.175)
Senior	0.684*	-0.735	2.705*
	(0.427)	(0.927)	(1.451)
Female	1.102***	-0.242	-0.591
	(0.378)	(0.668)	(0.771)
College	0.081	-0.115	0.337
	(0.114)	(0.272)	(0.275)
Income	-0.008	-0.064	-0.059
	(0.048)	(0.114)	(0.143)
White	-0.194	1.095	-0.776
	(0.339)	(1.076)	(0.831)
Unsafe	0.708**	0.109	2.085*
	(0.339)	(0.651)	(1.183)
Sufficient	1.177	2.395**	2.622**
	(0.864)	(1.005)	(1.230)

t-values are in parentheses.
* denotes significant at the 0.1 level, ** denotes significant at the 0.05 level, *** denotes significant at the 0.01 level.

Table 3. Multinomial Logit Regression Results for Reasons of Not Paying a Higher Price for Irradiated Beef.

Variable	Reason 1	Reason 2	Reason 3
Constant	0.656	0.304	0.293
	(1.066)	(1.331)	(1.205)
Young	0.199	-0.215	0.662
	(0.598)	(0.756)	(0.677)
Senior	-0.373	-1.392	-0.839
	(0.616)	(0.952)	(0.806)
Female	0.451	0.2398	1.061*
	(0.512)	(0.690)	(0.623)
College	0.501	-0.624	-0.045
	(0.531)	(0.801)	(0.635)
Income	0.093	0.049	0.004
	(0.099)	(0.129)	(0.116)
White	-0.144	-0.421	-1.212
	(0.757)	(0.941)	(0.795)
Unsafe	-0.405	0.109	0.158
	(0.559)	(0.651)	(0.696)

t-values are in parentheses.
* denotes significant at the 0.1 level, ** denotes significant at the 0.05 level, *** denotes significant at the 0.01 level.

professional attestation. This implies that dispelling the unfounded concerns through effective information dissemination to consumers may effectively enhance acceptance of irradiated beef.

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