Impact of Socioeconomic Characteristics on Attitudes Toward Food Irradiation

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Irradiation of food products is one of several techniques that reduce the risk of food-borne illness. Despite its advantages, the technique has been used sparingly because consumers are wary about this technology. A logit model is used to evaluate the impacts of demographic factors on attitudes toward purchasing foods that have been irradiated and toward paying more for irradiated foods. An important finding of this study is that consumers who are familiar with irradiation are significantly more likely to buy and pay more for irradiated products than those who have never heard of irradiation. This implies that educational programs aimed at informing consumers about the benefits of irradiation can work.

Introduction

Food-borne illnesses have attracted increased media coverage in recent years. This has led to heightened public awareness of food safety, which has changed the relationships between companies in the food industry and their customers. The case of Odwalla, a producer of high-quality juices, is one example. In 1996, this company was notified that its products had been epidemiologically linked to an *E. coli* outbreak. The resulting negative publicity and product recalls generated financial problems that very nearly bankrupted the company (*American Vegetable Grower*, 1998). Another example is the 1997 Hudson Foods Company recall of *E. Coli*-contaminated frozen ground beef patties (FSIS, 1997). In April 1998, Iowa Beef Packers announced a voluntary beef recall for the same reason. The Gulf of Mexico raw oyster industry has also received extensive negative publicity because of a bacteria called *Vibrio vulnificus*, which is linked to rare illnesses and even fatalities in high risk, immuno-compromised people. Public concern has extended from this case to seafood in general (ISSC, 1994). For these and other reasons, the challenge of assuring food safety has become an issue of national importance.

Another problem endemic to food safety and security is loss due to contamination and spoilage. It is estimated that factors—such as insects, bacteria, and rodents—destroy as much as 25 percent of the world's food supply. This represents a significant cost in terms of productive resources, including labor, and is particularly serious for low-income countries. In the United States, the Centers for Disease Control (CDC) estimates that 24–99 million cases of diarrheal disease and about 7,000 deaths annually result from food-borne contamination and parasites. In addition, the Food and Drug Administration (FDA) estimates that the U.S. economy loses as much as $17 billion annually due to food-borne illness, a value that disregards spoilage losses (ICGFI, 1991).

Seafood and poultry products are particularly susceptible to spoilage and safety problems. These problems can arise from events that occur prior to processing, from contamination during processing, and from improper handling at later stages in the marketing channel. Canning, pasteurization, and irradiation are alternative methods used to control these problems. For fresh products, irradiation is a process or technology that destroys pathogens that cause spoilage by exposing them to gamma rays (energy waves similar to heat or microwave). Irradiation interferes with bacterial cell processes and reproduction. The process can extend shelf life significantly. Deterioration is prevented because sources of spoilage are removed. Unlike heat processing techniques, irradiation is a cold treatment that causes very little change in appearance or taste. Congress has designated irradiation as a food additive that must meet the requirements applied to food additives.

Irradiation has some disadvantages as well. Pszczola (1990) states, "Opponents of irradiation claim that irradiation will make food radioactive, will reduce levels of essential nutrients, will help to conceal food contamination, will pose serious occu-

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pational and health hazards, and in general, will increase risks to public health." This statement indicates several areas of concern. Even though food products themselves are always a safe distance from the ray source, consumers sense that it is possible that radioactive contamination might be an unwanted by-product. Critics believe that irradiation will permit food companies to be less sanitary in their practices if the product subsequently can be cleaned up by irradiation. Moreover, there is fear that irradiation may lead to a false sense of security since food products can be recontaminated after the irradiation process.

Irradiation has only been used with food products a few times in the United States since the FDA approved the process in the 1960s. Moreover, even though the U.S. Department of Agriculture, the American Medical Association, and the World Health Organization support FDA guidelines, the food industry has been hesitant to use irradiation, fearing that consumers will not accept the process (Pohlman, Wood, and Mason, 1994). The food industry's concerns may be justified. Even though research by food scientists has demonstrated that irradiated products are sterile, irradiation is not well-understood or accepted by many consumers. The objective of this study is to assess the public's awareness and opinions toward food irradiation by evaluating the impact of a set of demographic variables on attitudes toward buying and eating irradiated foods and on paying a price premium for these foods.[1]

Literature Review

Previous research has been conducted on the impact of demographics on attitudes toward irradiation. During a survey in grocery stores, responses by customers who had some knowledge of the irradiation process indicated that they were more likely to purchase products that had been irradiated (Malone, 1990). Females were less likely to accept irradiated products (Schutz, Bruhn, and Diaz-Knauf, 1989). Analysis of educational attainment supports the argument that those with higher educational levels were more likely to accept irradiated foods. Those with less education were more apprehensive about irradiated products (Schutz, Bruhn, and Diaz-Knauf, 1989), and those with a high school education or higher had more desire to purchase irradiated food (Terry and Tabor, 1991). Knowledge of irradiation was not broad, as was documented by studies reporting that about one-half of participants had not heard of the process (Bruhn and Noell, 1987). After sampling irradiated and non-irradiated apples, consumers indicated that taste would be the factor that determined which products they would purchase (Terry and Tabor, 1991). Interest in purchasing irradiated products was higher after the process was explained (Bord and O'Connor, 1989).

Misra, Fletcher, and Huang (1995) studied attitudes of Georgia consumers and found that the responses were similar to previous results. The question of whether persuasive arguments, or educating consumers about the irradiation process, might change opinions was addressed in a series of questions. Results confirmed that information can change attitudes. Sources of information were ranked in terms of trustworthiness. These rankings—in which university scientists were ranked highest, followed by independent laboratories and consumer groups—were used to suggest information channels.

Pohlman, Wood, and Mason (1994) concluded, on the basis of their own work and from published research, that consumers may be receptive to irradiation technology, particularly if they are provided with appropriate information. Their search for informational programs about irradiation revealed some written instruments but not the audiovisual programs that they sought. A nine-minute tape based on various research sources was developed. The researchers used convenience samples to test hypotheses about differences in changes in attitudes by demographic variables that resulted from the influence of this informational form. Prior attitudes were determined; respondents were shown the educational tape and were provided food samples; and then attitudes were re-evaluated. T-tests revealed significantly more favorable attitudes toward irradiation following the educational program and, further, that there was a significantly larger change in attitude when food samples were provided. This study contributes to the body of literature by directly examining the relationships between consumers' willingness to buy and pay premium prices for irradiated foods.

[1] This report is part of a larger study designed to evaluate (1) irradiation's capability to eliminate harmful bacteria on molluscan shellfish, (2) its impact on taste and texture, and (3) consumer attitudes toward the process itself.

Methods

The survey was designed to determine the respondents' knowledge base regarding irradiation. Respondents used a five-point scale to indicate agreement or disagreement with a series of statements intended to assess their attitudes toward irradiated foods. Questions concerning attitudes toward irradiation, beliefs regarding the safety and benefits of irradiation, and respondents' potential market behavior regarding the purchase of irradiated foods were prominent in the questionnaire. Finally, demographic information—which included gender, age, education, race, number of adults, number of children under 18, and income—was collected.

The survey was conducted at a publicly/privately sponsored home and garden show in a large (approximately 1,000,000 population), diverse, nearby southern city. This city was chosen because it has a large and successful home and garden show and because the show's organizers were receptive to the survey activity. During the two-day event, approximately 5,000 people attended, and about 460 useable responses were obtained. A display table, which drew attention to the survey, was prominently positioned at the entrance. A lottery ticket for a chance to win one of two $50 gift certificates was used as an incentive to participate.

The "convenience" sample approach—in which respondents are selected where large groups of people gather or where a stream of people passes—was used in this study. It is the least expensive method available in terms of time and money (Malhotra, 1996) and often is used for focus groups and pilot studies but has been used even for large surveys. However, it is a nonprobability sampling technique, and caution is appropriate when interpreting the results. Self-selection bias is one potential problem. To minimize the effect of this problem, the survey team actively recruited from the stream of persons entering the show, regardless of their apparent interest in the survey. Because this study was exploratory in nature and because resources were limited, the approach was accepted as appropriate.

In the attitude assessment, respondents provided a yes or no answer to questions about whether they would buy and eat irradiated food and whether they would pay a few cents per pound more for irradiated food; therefore, limited dependent variable models are appropriate for analysis. Specifically, the following logit model—which is based on the cumulative logistic probability function—was used:

$$(1) \quad P_i = F(Z_i) = \frac{1}{1+e^{-z_i}} = \frac{1}{1+e^{-(\alpha+\beta X_i)}},$$

where P_i is the probability that the ith individual will make a certain choice, given the observed level of X_i. Moreover, it can be shown that

$$(2) \quad \log\frac{P_i}{1-P_i} = Z_i = \alpha+\beta X_i;$$

therefore, the dependent variable for the regression is the logarithm of the odds that a particular choice P_i will be made given X_i, which is an appropriate specification given (0,1) dependent variables (Pindyck and Rubinfeld).

Two logit models were specified for the analysis:

- Model 1 used respondents' no or yes (0 or 1) answers to whether they would buy and eat irradiated food (BUY) as the dependent variable, and it was specified as

  BUY = f(GENDER, AGE, EDUCATION, RACE, MARITAL, ADULTS, CHILDREN, INCOME, HEARD).

- In Model 2, the data used was the subset of "yes" responses to the question of whether respondents would buy and eat irradiated food.[2] These respondents also had indicated whether they would be willing to pay a few cents per pound more for irradiated food, so this model used the no or yes (0 or 1) variable PAY as the dependent variable. It was specified as

  PAY = f(GENDER, AGE, EDUCATION, RACE, MARITAL, ADULTS, CHILDREN, INCOME, HEARD).

The explanatory variables for both models are defined in Table 1. Demographic factors were evaluated to establish their significance as important influences on the dependent variable. Preliminary

[2]The nested logit specification was considered for the "pay" model since the "buy" response is nested. However, estimation of the nested model was not possible due to computational restrictions imposed by numerous independent categorical variables.

Table 1. Attitude Questions and Socioeconomic Factors.[a]

Variable Name	Description
BUY	I would buy and eat fresh foods that were irradiated. 0=no; 1=yes
PAY	I would be willing to pay a few cents more per pound for irradiated food. 0=no; 1=yes
GENDER	male; **female**
AGE	continuous variable
EDUCATION	**high school degree or less**; some college or associate's degree; bachelor's degree; graduate or professional degree
RACE	**white**; African-American; other
MARITAL STATUS	single; **married**; divorced/separated; widow/widower
ADULTS	How many adults live in your household? one; **two**; more than two
CHILDREN	How many children under the age of 18 live in your household? **zero**; one; two or more
INCOME	<$25,000; **$25,000 to $50,000**; $50,000 to $75,000; $75,000 to $100,000; more than $100,000
HEARD	I have never heard of irradiation before today as a way to preserve foods. false; **true**

[a] Bold type denotes the variable chosen to be the base.

runs were made to test the impact of alternative groupings of categorical variables and to combine categorical variables when the number of observations in particular cells was low. For example, three response categories under the EDUCATION variable were combined to get the EDUCATION HS group that was used in these models. Changes in categories and inclusion or exclusion of variables had little impact on model results. In dummy variable measurements, we used the numerically largest group as the base.

Results

The response frequencies and percentiles for the demographic variables are presented in Table 2. Almost 60 percent of respondents were between 35 and 55 years of age. In educational attainment, about 25 percent had a B.S. degree, and another 34 percent had a graduate or professional degree. Racially, the sample was 92 percent white. A substantial 22 percent was one-adult households though the two-adult household was dominant, with almost 65 percent of the total. About 30 percent of the households had children under 18 years of age, and the percentages of households with one child and two children were about 14 percent and 15 percent, respectively. In terms of annual income, the modal group was between $25,000 and $50,000, at about 31 percent of the total. However, more than 56 percent earned more than $50,000; about 31 percent earned more than $75,000; and about 16 percent had incomes greater than $100,000.

The logit results for Models 1 and 2 are presented in Table 3. Chi-squared statistics indicate that both models are significant at the 0.1 level. The percentage of correct predictions was 64 percent for Model 1 and 65 percent for Model 2. Among the categorical variables tested, the HEARD variable had the highest t-ratio and a positive coefficient in Model 1. This implies that subjects who were somewhat familiar with irradiation as a food preservation technique were significantly more likely to buy and eat irradiated food. This result supports similar findings reported in other studies (Misra, Fletcher, and Huang, 1995). The HEARD variable was not significant in Model 2, indicating that individuals familiar with irradiation were not willing to pay more for irradiated foods.

In Model 1, the coefficient for GENDER M was positive, with the interpretation that men are more likely to buy irradiated foods than women are,

Table 2. Frequencies and Percentages of Survey Respondents by Demographic Characteristics.

Variable and Category	Frequency	Percent
Age		
< 25	28	5.6
25–34	66	13.1
35–44	128	25.5
45–54	163	32.5
55–64	81	16.1
65+	36	7.2
Education		
high school or less	60	12.1
some college	139	28.1
B.S. degree	126	25.5
graduate or professional degree	170	34.3
Race		
white	454	91.3
black	24	4.8
other	19	3.8
Marital status		
single	110	22.1
married	322	64.7
divorced/separated	45	9.0
widow/widower	21	4.2
Adults in household		
one	92	18.5
two	318	64.1
more than 2	86	17.3
Children in household		
zero	320	70.5
one	64	14.1
two or more	70	15.5
Income		
<$25,000	54	11.7
$25,000–$49,000	142	30.7
$50,000–$74,000	121	26.2
>$100,000	52	16.2

Table 3. Parameter Estimates and T-ratios from the Logit Model Analyzing Whether Consumers Would Buy or Pay More for Irradiated Foods, Louisiana, 1996.

	Model 1 (n = 505)[a]		Model 2 (n = 232)[b]	
Variable	estimate	t-ratio	estimate	t-ratio
CONSTANT	-1.113	-1.90[c]	1.132	1.28
HEARD	0.857	4.26[d]	0.033	0.10
GENDER M	0.498	2.37[d]	-0.743	-2.40[d]
AGE	0.022	2.48[d]	0.025	1.93[c]
RACE AA	0.238	0.53	0.297	0.44
RACE OTHER	-0.747	-1.48	-0.106	-0.12
MARITAL S	-0.121	-0.40	0.224	0.47
MARITAL DS	-0.572	-1.46	-0.153	-0.24
MARITAL WW	0.356	0.66	1.692	1.45
ADULTS 1	-0.365	-1.09	-0.277	-0.49
ADULTS > 2	-0.150	-0.58	-0.538	-1.29
CHILDREN 1	-0.188	-0.56	-0.941	-1.70[c]
CHILDREN 2+	0.107	0.35	-0.759	-1.50
INCOME 20K	-0.491	-1.63	-0.042	-0.09
INCOME 60K	-0.200	-0.74	0.405	0.98
INCOME 80K	-0.268	-0.84	0.350	0.71
INCOME 100K	0.091	0.28	0.203	0.44
EDUCATION SC	-0.735	-2.12[d]	-1.429	-2.45[d]
EDUCATION BS	-0.452	-1.23	-1.223	-2.08[d]
EDUCATION GP	-0.392	-1.08	-1.022	-1.78[c]

[a] Model 1: Restricted Log Likelihood model = -346.21; Chi-squared = 61.71 with 19 df Chi-sq p-value = 0.000.

[b] Model 2: Restricted Log Likelihood model = LL(0) = -153.94; Chi-squared = 28.21 with 19 df Chi-sq p-value = 0.079.

[c] Significant at 0.10 level.

[d] Significant at 0.05 level.

an outcome that is consistent with attitudes reported in previous research (Schutz, Bruhn, and Diaz-Knauf, 1989). GENDER was also significant in Model 2, but its sign changed. This suggests that although men are more likely to buy irradiated foods, they are also less willing than women to pay a few cents more for the advantages of irradiation.

AGE was treated as a continuous variable and was significant and positive in Model 1. This indicates that older respondents were more likely to buy and eat irradiated foods. The literature review did not identify other studies in which age was a variable. A possible explanation for the positive sign is that older consumers are less

concerned with issues, such as potential long-term effects on children, but might be more concerned about structuring their diets to avoid potential sources of illness (one of irradiation's benefits). AGE also was significant and positive for Model 2, indicating that older respondents were more likely to pay a few more cents per unit for irradiated foods.

We had expected to find families with CHILDREN to be more concerned about irradiation, but this was not evident in Model 1. However, CHILDREN 1 was negative and significant in Model 2, and the coefficient for CHILDREN 2+ was similar in value to CHILDREN 1 and negative but not significant. Thus, compared to the base group of households without children, households with children appeared less willing to pay any price premium. This finding may reflect the impact of budget constraints facing families with children. The result also provides evidence that is inconsistent with the hypothesis, advanced in the literature, that families with children would be less inclined to take chances from perceived hazards presented by irradiation.

With respect to EDUCATION, there was a very distinct difference between the BUY and PAY models. The base category was the group with high school or less education. In Model 1, the only significant difference from the base group was the EDUCATION SC, or some college category. While the two higher categories were not different, they did have negative coefficients. Thus, the least educated were most likely to say that they would buy and eat irradiated food. For model 2, those with a high school or lower education level were significantly higher compared to the three other education categories, indicating their willingness to pay a higher price for irradiated food. As with Model 1, the contrast between models was strongest between the EDUCATION HS and the EDUCATION SC groups. In Model 2, coefficients became progressively smaller as educational attainment increased. These results are contrary to those of other studies that found a positive relationship between education level and acceptance of irradiation.

Although the survey was not structured to capture the motivations of individual respondents, we can hypothesize potential reasons that higher-educated consumers are less likely to buy and/or pay more for irradiated foods. The higher-educated consumers in this sample may have believed that irradiation would in fact lead to less stringent sanitation practices by food processors, thus leading to increased public health risks. This would be consistent with the arguments advanced by opponents of irradiation. Alternatively, more education might lead respondents to the conclusion that lower spoilage levels would increase total food supplies, leading to price stabilization or decline rather than allowing processors to recapture part or all of the cost.

There was no significant difference between INCOME categories for either of the two models. However, it might be noted that, except for the highest income group (< $100,000), these categories had negative coefficients, indicating a lower likelihood, compared to the base group, of responding that they would buy and eat irradiated food. For the issue of willingness to pay a few cents more for irradiated food, however, the coefficient signs on these categories were positive. There does appear to be some consistent movement toward acceptance of the irradiation technology when the data is subset as was done here.

Marginal Probabilities and Predictive Accuracy

The marginal probabilities for models 1 and 2 are presented in Table 4. For the BUY model, respondents who had heard of irradiation had the largest marginal probability and the highest level of significance. Other statistically significant results revealed that the marginal probabilities were significantly higher for males than for females and that a unit increase in age increased the odds of buying. Among other variables, the some college EDUCATION group had lower marginal probability than the high school graduate group. For the PAY MORE model, the absolute values of the marginal probabilities were larger, and more were significant. The three EDUCATION groups all had a reduced marginal probability that they were willing to pay more compared to the high school group. Having CHILDREN at home also resulted in a finding that these groups had lower marginal probabilities compared to the no children group though only the CHILDREN 1 group was significantly lower. For GENDER, being male reduced the marginal probability while increasing age resulted in an increased marginal probability.

Table 4. Marginal Probabilities of Willingness to Buy and Willingness to Pay More for Irradiated Foods, Louisiana, 1996.

	Model 1 (n = 505)		Model 2 (n = 232)	
Variable	marginal probabilities	t-ratio	marginal probabilities	t-ratio
CONSTANT	-0.126	-1.76	0.264	1.30
HEARD	0.097	10.39[a]	0.008	0.10
GENDER M	0.056	1.91[b]	-0.173	-2.40[a]
AGE	0.002	1.95[b]	0.006	1.93[b]
RACE AA	0.027	0.52	0.069	0.44
RACE OTHER	-0.085	-1.37	-0.025	-0.12
MARITAL S	-0.014	-0.41	0.052	0.47
MARITAL DS	-0.065	-1.37	-0.036	-0.24
MARITAL WW	0.040	0.65	0.395	1.46
ADULTS 1	-0.041	-1.03	-0.065	-0.48
ADULTS >2	-0.017	-0.57	-0.126	-1.29
CHILDREN 1	-0.021	-0.55	-0.219	-1.71[b]
CHILDREN 2+	0.012	0.35	-0.177	-1.51
INCOME 20K	-0.056	-1.47	-0.001	-0.08
INCOME 60K	-0.023	-0.73	0.094	0.98
INCOME 80K	-0.030	-0.82	0.082	0.71
INCOME 100K	0.010	0.28	0.047	0.44
EDUCATION SC	-0.083	-1.88[b]	-0.333	-2.48[a]
EDUCATION BS	-0.051	-1.21	-0.285	-2.10[a]
EDUCATION GP	-0.044	-1.08	-0.238	-1.80[b]

[a] Significant at 0.05 level.

[b] Significant at 0.10 level.

Between the two models, the AGE and EDUCATION variables were consistently significant and had consistent signs. Male respondents were significantly different from females between models but had higher probabilities in Model 1 (BUY) and lower probabilities in Model 2 (PAY).

Summary and Conclusions

The impact of familiarity with food irradiation and various socioeconomic characteristics on consumers' attitudes toward buying and paying more for irradiation of fresh foods have been analyzed in this article. Two logit models were estimated using data collected at a home and garden show in a two-day period in a large southern city. The first model analyzed the consumers' willingness to buy irradiated foods while the second model focused on the willingness to pay for these products.

The results indicated that consumers who have some familiarity with irradiated foods are more

likely to be willing to buy these products. Therefore, the results of this study support the general conclusion that providing information and educating the public about the irradiation process is a key to building consumer confidence in the process. In addition, women, younger respondents, and those with higher education are more skeptical of irradiated foods. Consequently, these consumers are less willing to buy or pay more for these products.

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