# Willingness to Pay for Irradiated Meat Products: A Comparison between Poultry and Pork

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## Introduction

Food safety is a growing concern to consumers. According to the Center for Disease Control and Prevention (CDC), foodborne illnesses are responsible for causing 76 million people to become sick, hospitalizing 300,000 people and 5,000 deaths annually (Mead et al., 1999). While most Americans believe that their food supply is safe, public awareness of food safety and risks associated with foodborne illnesses have increased over the past decade. Food processors are interested in increasing the safety of their food products not only to provide a safer product but to reduce losses associated with a foodborne illness problem. Recalling food products can have dire direct and indirect financial consequences for food processors and retailers alike. Irradiating food products provides one means of addressing the food safety issue by significantly reducing the presence of foodborne bacteria and diseases.

Recent studies have shown that consumers are becoming more interested in irradiated foods. Consumer acceptance of irradiated food products ranges from a low of 15% (Gaynor et al., 2002) to as high as 58% (Nayga et al., 2004). Fingerhut et al. (2001) found that over 75% of consumers surveyed from two Kansas cities preferred irradiation to hot-water pasteurization as a pathogen-reducing technology for ground beef. Similarly, Johnson et al. (2004) suggested that more than twice as many consumers in 2003 (69%) compared to ten years ago (29%) are willing to buy irradiated products to decrease the probability of foodborne illness.

The wide range in the level of consumer acceptability for irradiated products relays uncertainty to food processors making them hesitant to invest resources in irradiation technology (Frenzen et al., 2000). Given the uncertainty associated with consumer acceptance, research in the area of consumer's willingness to pay for irradiated food products comes into question. Previous studies have shown that consumers generally will pay only a small percentage above the traditional purchase price to avoid some perceived risks (Busby et al., 1995). Johnson et al. (2004) reported that more consumers in 2003 than in 1993 indicated that they would buy irradiated food products such as produce, meats and fish if the price remained the same or if there were a 1-5% difference. In contrast, Nayga et al. (2004) found that most respondents were willing to pay a premium between 5 and 50 cents per pound for irradiated beef.

The objective of this study is to determine the likelihood that consumers are willing to buy and how much they are willing to pay for irradiated meat products based on socio-demographics and attitudinal factors. In addition, the study evaluates consumers' level of knowledge about the food irradiation process and their level of concern with the food irradiation process as well as other food safety procedures.

**Empirical Model**

The approach taken in this study recognizes explicitly the importance of consumer perceptions and attitudes as they relate to behavioral intention in the decision-making process. Specifically, it is assumed that consumers formulate their perception or attitudes from available information, knowledge, experiences, and given environmental factors, which may include personal characteristics, social and cultural background. Previous studies suggest that information acquisition, and consequently behavior, is affected by various demographic factors such as age and gender, educational attainment, as well as region and urbanization (Nayga et al., 2004; Hinson et al., 1998; Steger and Witte, 1989). Thus, these factors are hypothesized to be important determinants that influence consumers' decision to buy irradiated products, if available, and the amount of premiums that they are willing to pay.

In order to analyze the interdependent relationships of behavioral intentions, i.e., purchase intention and willingness to pay, in the consumer decision-making process, a two-equation structural model is formulated as follows:

(1) $LTB = f(Z_1, SOC) + \varepsilon_1$,

(2) $WTP = g(LTB, Z_2, SOC) + \varepsilon_2$,

where LTB represents the likelihood of a consumer's intention to buy irradiated meat products; WTP denotes a consumer's willingness to pay for the irradiated products; $Z_i$s are sets of independent variables measuring consumers' beliefs, knowledge, experiences, and attitudes toward irradiation technology; SOC represents socioeconomic and demographic characteristics; and $\varepsilon_i$s are vectors of random errors.

Specifically, the $Z_i$ variables are assumed to include issues related to food safety, respondents' knowledge about irradiation technology and other technology such as using genetically modified (GM) organisms in food production. Consumers' attitudes toward food irradiation and GMO are also considered relevant variables. In addition, the $Z_i$ variables also include how much confidence that consumers have about the sources of their information acquisition, such as U.S. Food and Drug Administration (FDA) or American Medical Association (AMA). The SOC variable is specified to include some of the variables representing primary food shopper, urbanization, age, race and gender, educational attainment, marital status, and household composition and income. The definitions of variables included in equations (1) and (2) are presented in Table 1.

To implement the empirical model, the typical application is to apply Heckman's two-step sample selection procedure in which equation (1) is to be estimated by the probit procedure and equation (2) is to be estimated by ordinary least squares (OLS) procedure based on a subsample of positive observations with the inclusion of inverse Mills ratio obtained from equation (1) as an additional regressor (Heckman, 1979). In this study, the zero observation on WTP is considered a valid answer. Hence, it is necessary to use the entirely sample for WTP instead of a subsample of positive willingness to pay.

The problem of estimating equation (2) with OLS based on the observed data is the correlation between the endogenous binary variable (LTB) and the error term, $\varepsilon_2$. A solution to the inconsistent estimates of OLS is to use the two-stage least squares procedure (Greene, 1995). Huang (1993) also used the two-stage estimation procedure to investigate interrelationships among consumers' risk perceptions, attitudes, and willingness to pay for residue-free produce. In this study, equation (1) is estimated by probit and the predicted probabilities are used as the instrumental variable for LTB in equation (2) in the second stage of the estimation process. The joint parameter estimation of equations (1) and (2) was carried out by using the LIMDEP program (Greene, 1995).

**The Data**

The data used for this analysis were collected from a consumer survey conducted in May 2003 by the University of Georgia's Center for Survey Research.  In the telephone survey, 303 primary food shoppers from a randomly generated sample of Georgia residents were interviewed. The respondents were asked a series of questions to measure their perceptions of specific food safety issues, their level of knowledge with the irradiation process, and their attitude toward food irradiation and its effectiveness in increasing food safety. In addition, information on respondent's intention of purchasing irradiated foods and the additional amount of premium they are willing to pay was collected. Finally, demographic information including gender, age, household income, education, as well as other information was gathered from each respondent to complete the survey.

The double-bounded bidding procedure was used in the survey to elicit consumers' willingness to pay for irradiated poultry and pork products. It was assumed that each respondent has an unobserved (latent) true value of food safety provided by the irradiation technology. Each respondent was provided with an initial offer price that is $1/lb above the market price and asked if they would be willing to pay an additional premium for the food product with bacteria levels greatly reduced by irradiation. The follow-up offer was made which is either higher or lower than the first price depending on the response to the first bid value. If the first response was "yes," then a randomly assigned higher price (ranging from 5%, 10%, 25%, 75%, to 100% above the first value) would be offered. If the first response was "no," then a lower price would be offered. Unlike the single-bounded procedure, where the latent value could be any value more or less than the given single threshold, the double-bounded method provides a follow-up threshold amount which captures the latent value within a certain boundary (Hanemann, 1985).

Due to some refusals and missing information, the sample used for this analysis consists of 212 observations with complete information. The variables constructed from the survey data and sample characteristics are presented in Table 1. Overall, respondents tended to be demographically upscale, with older, better educated, and higher income consumers slightly over-represented. The average household size was about 3 persons. Female, urban residents and people of European origin represent 64%, 67%, and 74% of survey respondents, respectively.

The result shows that about 65% and 58% of Georgia consumers surveyed were at least somewhat likely to buy irradiated poultry and pork products, respectively. They were willing to pay an average of $1.34/lb and $6.62 per month, respectively, in price premium for irradiated chicken breasts and pork. A vast majority of the respondents, or 77%, considered that irradiation process is somewhat necessary and more than 55% of the respondents indicated they would support the use of food irradiation. Surprisingly, more than 80% of the respondents indicated they were at least somewhat willing to consume GM foods, while only about one half of them considered themselves at least somewhat informed about GM foods or organisms (Table 1).

**Results**

The estimation results of equation (1) on the likelihood of a Georgia consumer buying irradiated meat products are presented in Table 2. In the probit analysis, the estimated coefficient by itself does not have any economic meanings. The estimated coefficients for the explanatory variables should be interpreted in the sense that they affect the probability of a certain event would occur. This interpretation can be obtained by computing the marginal probability or marginal effect, which is defined as a product of the estimated parameter and the standard density function evaluated the sample means. Thus, in addition to estimated coefficients and corresponding standard errors, estimates of the marginal effect associated with each independent variable are reported in Table 2. Two goodness-of-fit measures are also reported. One is the log-likelihood ratio. The log-likelihood ratio test statistic indicates that the estimated probit model is statistically significant at less than the 1% significance level. The computed Efron's pseudo $R^2$s of .512 for chicken breasts and .443 for pork also indicate an excellent fit for the model.

Overall, the results are fairly consistent between chicken breasts and pork. In particular, all the signs on the estimated coefficients are identical and a similar set of variables are found to be important factors that affect respondents' willingness to purchase irradiated meats. The estimated coefficient on ADCH is negative as expected and significantly different from zero at less than the 1% significance level for chicken breasts and pork. The result suggests that respondents who are concerned about food safety issues related to additives and chemicals are less likely to buy irradiated meat products than those who do not have a concern with additives and chemicals. The estimated marginal effect suggests the probability of those concerned respondents buying irradiated poultry and pork products are about 34% and 40%, respectively, smaller than their counterparts, *ceteris paribus*.

The estimated coefficients for Irradiation Necessary and Support Irradiation are both positive and highly significant at less than the 1% significance level. Irradiation Necessary and Support Irradiation have the largest marginal effects that increase the probability of a respondent purchasing irradiated poultry by 59% and 51%, respectively. Similarly, Support Irradiation also has the second largest marginal effect on the probability of purchasing irradiated pork. The results suggest that the probability of purchasing irradiated poultry products is increased by about 27%, if the respondent is married or the primary shopper of the household. On the other hand, being married or a primary food shopper will increase the probability of buying irradiated pork by 24% and 21%, respectively.

The estimated coefficients for WHO are statistically significant but negative which is contrary to expectations. The result indicates that a respondent is not likely to buy irradiated meat products if the process is endorsed by WHO. The opposite result of a positive significant effect is found for FDA in the chicken breasts equation and on USDA and AMA variables in the pork equation. This finding appears to suggest that perhaps respondents feel more confident with endorsement made by U.S. government and agency than by an international organization.

The presence of children less than 18 years old in the household is found to have a negative and significant effect on the probability of purchasing irradiated poultry products by 21%. This finding is consistent with the *a priori* expectation and previous studies that show respondents with children are less likely to pay for a premium for irradiated foods than those without children in their household (Nayga et al., 2004; Hinson et al., 1998). Age and household income also significantly reduce the probability of purchasing irradiated poultry products, but their marginal effects are very small. Furthermore, these factors do not appear to have any significant effects on the probability of purchasing irradiated pork.

The estimation results on Georgia consumers' willingness to pay extra for irradiated poultry and pork products are presented in Table 3. In general, most of the estimated coefficients for the explanatory variables are not statistically significant. However, the overall goodness-of-fit statistics indicate that the models performed satisfactory. The log-likelihood ratio test shows that the estimated models are statistically significant at less than the 1% significance level. Furthermore, the adjusted $R^2$s of .207 and .157 for irradiated chicken breasts and pork appear reasonable given that the data are cross sectional in nature and collected from the survey.

As to be expected, one of the most important variables that affect a respondent's willingness to pay is the likelihood of purchasing irradiated products. Thus, if a respondent is willing or likely to buy irradiated products, then those respondents would be willing to pay a higher price for irradiated chicken breast meat for an average of about $1.17/lb. For pork, those respondents would be willing to spend an additional $8.45 per month for irradiated pork. The results show that those respondents who were likely to support irradiation process and willing to consume GM foods would be willing to pay about $.44/lb and $.40/lb extra for irradiated chicken breasts, respectively. The findings support similar results reported in other studies (Frenzen et al., 2000; Hinson et al., 1998). For example, Hinson et al. (1998) suggested that consumers who were somewhat familiar with irradiation process as a food preservation technique were significantly more likely to buy and eat irradiated food. However, these two attitudinal variables exhibit no statistically significant effects on willingness to pay for irradiated pork.

With respect the socio-demographic variables, the results suggest that urban households and larger households are willing to pay an extra amount of $3.26 and $2.59 per month, respectively, for irradiated pork products. As expected, household with children under 18 years of age would be spending $5.33 per month less than their counterparts for irradiated pork. This finding is consistent with previous study suggesting that households with children would be less willing to pay any price premium for irradiated foods (Hinson et al., 1998). For poultry products, Table 3 shows that households with young children are willing to pay about 64 cents more per pound for irradiated chicken breasts. The positive effect of households with young children appears to run contrary to the negative effect found on the likelihood of purchasing poultry products and the *a priori* expectation that having children less than 18 years of age would decrease a respondent's willingness to pay extra for irradiated chicken breasts. A plausible explanation could be those respondents who have young children at home and are willing to buy irradiated poultry products believe the benefits of irradiation in reducing bacterial contamination outweigh the perceived hazards associated with the technology. Thus, their willingness to pay a price premium becomes a dominant effect. All the remaining demographic variables were not significant in determining consumers' willingness to pay extra for irradiated chicken breasts.

**Conclusions and Implications**

The results suggest that the probability of a consumer's purchasing irradiated products is influenced by their perceptions of the necessity for irradiation as well as their support for the process. In addition, the study found that the likelihood to purchase irradiated products is an important and significant predictor of a consumer's willingness to pay for irradiated meats. Therefore, this finding emphasizes the need to develop effective marketing and educational materials to convince consumers that irradiation is necessary for safer food and to gain their support for the process. If the industry can convince the consumers that the process is safe, will provide a safer food product with no minimal side-effects, then they will purchase irradiated products and most likely will be willing to pay extra for the increased level of food safety.

Overall, the results suggest that educating consumer about the benefits of irradiating meat products has the potential to create a positive perception about the process and increase the probability a consumer will purchase and pay a higher price for these products. Food processors and retailers will market irradiated food products if they are convinced that consumers' perception of their products will not be compromised by the use of irradiation technique.

Therefore, an effective educational campaign should relay the benefits of irradiating food products while addressing common misconceptions associated with food irradiation.

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Table 1. Variable definition and sample characteristics

| Variable | Definition | Mean (Std. Dev.) |
|---|---|---|
| Likely to Buy (LTB) Irradiated Poultry Products | = 1 if respondent indicated at least somewhat likely to buy irradiated poultry products if it was treated with approved doses and properly labeled, 0 otherwise. | .646 (.479) |
| Willingness to Pay (WTP) | Amount of price premium $/lb that respondent is willing to pay for irradiated chicken breasts. | 1.344 (1.383) |
| Likely to Buy (LTB) Irradiated Pork Products | = 1 if respondent indicated at least somewhat likely to buy irradiated pork if it was treated with approved doses and properly labeled, 0 otherwise. | .585 (.494) |
| Willingness to Pay (WTP) | Amount of additional expenditures that respondent is willing to spend on irradiated pork per month. | 6.625 (14.611) |
| ADCH | = 1 if additive/chemicals are a food safety concern, 0 otherwise. | .189 (.392) |
| Know Irradiation | = 1 if at least know something about the food irradiation process, 0 otherwise. | .212 (.410) |
| Irradiation Necessary | = 1 if irradiation is considered at least somewhat necessary, 0 otherwise. | .774 (.420) |
| Support Irradiation | = 1 if respondent indicated at least somewhat support the use of food irradiation, 0 otherwise. | .557 (.498) |
| Know GM Foods | = 1 if respondent is at least somewhat informed about genetically modified (GM) foods or organisms, 0 otherwise. | .406 (.4922) |
| Consume GM Foods | = 1 if respondent is at least somewhat willing to consume food produced with GM ingredients, 0 otherwise. | .802 (.400) |
| FDA | = 1 if confidence in the safety of irradiated food increased because it is endorsed by the U.S. Food and Drug Administration (FDA), 0 otherwise. | .524 (.501) |
| USDA | = 1 if confidence in the safety of irradiated food increased because it is endorsed by the U.S. Department of Agriculture (USDA), 0 otherwise. | .519 (.501) |

| | | |
|---|---|---|
| AMA | = 1 if confidence in the safety of irradiated food increased because it is endorsed by the American Medical Association (AMA), 0 otherwise. | .580 (.495) |
| WHO | = 1 if confidence in the safety of irradiated food increased because it is endorsed by the World Health Organization (WHO), 0 otherwise. | .396 (.490) |
| Primary Shopper | = 1 if the respondent is responsible for the household's grocery shopping, 0 otherwise. | .561 (.497) |
| Urban Household | = 1 if household resides in urban area, 0 otherwise. | .670 (.471) |
| White | = 1 if the race of household is white, 0 otherwise. | .740 (.439) |
| Female | = 1 if respondent is female, 0 otherwise. | .640 (.482) |
| Children < 18 Years | = 1 if there are children under 18 years of age living in the household, 0 otherwise. | .425 (.495) |
| Household Size | Number of the persons in the household. | 3.005 (1.469) |
| Married | = 1 if married, 0 otherwise. | .665 (.473) |
| Age | Age of the respondent in years. | 45.387 (15.347) |
| High School Education | = 1 if respondent attended or graduated from high school, 0 otherwise. | .307 (.462) |
| Household Income | Annual income classes before taxes, ranking from 1 being under $15,000 to 9 being $75,000 and over. | 6.307 (2.669) |

Table 2. Estimated probit results of purchasing irradiated meat products

| | Chicken Breasts | | Pork | |
|---|---|---|---|---|
| Variable | Coefficient (Stand Error) | Marginal Effect[a] | Coefficient (Stand Error) | Marginal Effect[a] |
| Constant | -.387 (.733) | | -1.175* (.656) | |
| ADCH | -.936*** (.329) | -.339*** | -1.057*** (.304) | -.403*** |
| Know Irradiation | -.158 (.337) | -.053 | -.310 (.304) | -.120 |
| Irradiation Necessary | 1.657*** (.367) | .587*** | .738*** (.299) | .285*** |
| Support Irradiation | 1.609*** (.304) | .510*** | 1.295*** (.271) | .468*** |
| Know GM Foods | .540* (.282) | .167** | .348 (.253) | .129 |
| FDA | 1.010** (.434) | .322*** | .292 (.381) | .110 |
| USDA | .389 (.383) | .126 | .590* (.355) | .220* |
| AMA | .514 (.380) | .169 | 1.110*** (.358) | .410*** |
| WHO | -1.475*** (.419) | -.486*** | -1.348*** (.361) | -.491*** |
| Primary Shopper | .869*** (.326) | .284*** | .553** (.282) | .208** |
| Urban Household | -.428 (.288) | -.131 | -.207 (.256) | -.770 |
| White | -.009 (.303) | -.003 | -.260 (.276) | -.099 |
| Female | -.395 (.307) | -.122 | -.301 (.276) | -.111 |
| Children < 18 Years | -.651** (.312) | -.214** | -.322 (.280) | -.122 |
| Married | .796*** (.308) | .272*** | .625** (.275) | .239** |
| Age | -.025*** (.010) | -.008*** | -.009 (.888) | -.004 |
| High School Education | -.468 (.299) | -.159 | -.059 (.261) | -.0221 |
| Household Income | -.089* (.054) | -.029* | -.036 (.047) | -.014 |
| -2 x Log-likelihood ratio | 131.463*** | | 114.961*** | |
| Efron's pseudo $R^2$ | .512 | | .443 | |
| Sample size | 212 | | 212 | |

*, **, and *** indicate the estimated coefficients are statistically significant at the 10%, 5%, and 1% significance level, respectively.

[a] Marginal effect is defined as the change in the probability given a change in the explanatory variable. For binary variables, the marginal effect is calculated as the difference in probability for a discrete change of the value of the binary variable from 0 to 1.

Table 3. Estimated regression results of willingness to pay for irradiated meat products

| Variable | Chicken Breasts | Pork Products |
|---|---|---|
| | Coefficient (Standard Error) | Coefficient (Standard Error) |
| Constant | -.045 (.559) | -18.251*** (5.753) |
| LTB | 1.174*** (.383) | 8.453** (4.250) |
| Support Irradiation | .444* (.260) | 2.617 (2.813) |
| Consume GM Foods | .401** (.219) | 2.524 (2.405) |
| Primary Shopper | -.229 (.196) | 1.440 (2.121) |
| Urban Household | .185 (.183) | 3.260* (1.995) |
| White | .182 (.211) | 1.878 (2.317) |
| Female | -.010 (.120) | 1.744 (2.165) |
| Children < 18 Years | .636** (.271) | -5.332* (2.933) |
| Household Size | -.036 (.088) | 2.594*** (.961) |
| Married | -.224 (.203) | 1.703 (2.218) |
| Age | -.001 (.006) | .102 (.069) |
| High School Education | -.005 (.194) | .178 (2.091) |
| Household Income | -.004 (.036) | -.011 (.387) |
| -2 x Log-likelihood ratio | 77.135*** | 66.382*** |
| Adjusted $R^2$ | .207 | .157 |
| Sample size | 212 | 212 |

*, **, and *** indicate the estimated coefficients are statistically significant at the 10%, 5%, and 1% significance level, respectively.