



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Retail Meat Managers' Profitability Expectations for Irradiated Red Meats

By Joe Gaynor, Kim Jensen, and Edward Jaenicke

Presented at the 2002 AAEA Annual Meetings
Long Beach, CA, July 28-31, 2002

*Gaynor and Jensen are a Graduate Research Assistant and Professor, Department of Agricultural Economics, The University of Tennessee; Jaenicke is an Assistant Professor, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University.

Copyright 2002 by Joe Gaynor, Kim Jensen, and Edward Jaenicke. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all copies.

Retail Meat Managers' Profitability Expectations for Irradiated Red Meats Background and Justification

Short Abstract:

This paper uses data from 40 personal interviews with meat department managers at grocery stores and supermarkets to investigate managers' expectations regarding the profitability potential of irradiated red meats. The study models managers' profitability expectations as function of many attributes and factors, such as the meat manager's or store's characteristics, how familiar the meat manager is with irradiation, and opinions held by the manager regarding irradiation's benefits consumer acceptance. The study also examines how profitability expectations may influence the expected timing of adoption by the manager's retail store, the projected percentage of red meats eventually allocated to irradiated red meats, and merchandising strategies.

Recently, USDA's Food Safety and Inspection Service (FSIS) approved the use of ionizing radiation for treating refrigerated or frozen uncooked meat to reduce the levels of foodborne pathogens. Irradiation can reduce *E. coli* (O157:H7), *Salmonella*, and *Campylobacter* occurrence in raw meats, which can cause serious illness and death.¹ Buzby *et al.* estimated the annual cost of premature deaths from *E. coli* in the U.S. to be between \$160 million and \$700 million. Irradiation interferes with bacterial cell processes and reproduction, not only improving the safety of meat products through destruction of microbial pathogens, but also increasing shelf life through removal of spoilage sources (USDA/FSIS, 2001).² Increased shelf life provides greater flexibility and logistical efficiency associated with transportation and distribution, and therefore, could result in reduced marketing costs for food processors, wholesalers, and retailers.

While food irradiation has been widely accepted by the scientific community as a safe method for reducing foodborne pathogens (Sapp, 1995), findings from several studies produced mixed results regarding consumers' acceptance of irradiated red meat products (Bailey, 1996; Fox *et al.*, 1996; Hashim, Resurreccion, and McWatters, 1995; Henson, 1995; Resurreccion *et al.*

1995; Sapp, Harrod, and Zhao, 1995). Industry adoption of red meat irradiation has been cautious, perhaps due to FSIS labeling requirements, uncertainty about consumer reaction, and concerns about costs of the technology. Under current FSIS labeling requirements, grocery retailers most directly face the uncertainties associated with merchandising irradiated products. Furthermore, supermarkets are the primary outlet choice for consumers buying beef (Medina and Ward, 1999).

Concerns about consumer reaction are in part focused on potential reaction to the current FSIS labeling requirements, *i.e.*, a “radura” symbol and phrase “treated with irradiation” or “treated by irradiation” (See Figure 1). Across the U.S., irradiated ground beef has been introduced in some geographic markets only to be withdrawn later due to lack of interest on the part of consumers (Herzog and Daykin, 2000). These concerns are coupled with added costs to processors and retailers of irradiating ground beef estimated at one-half to 6 cents per pound (Bogart and Tolstun, 1999; Engeljohn, 1999; Kaye and Turman, 1999).

Although a number of studies have examined consumers’ perceptions of irradiated products, no studies have analyzed retailers’ perceptions of the profitability potential of irradiated red meats. Because much of the exchange of information regarding irradiated red meat products will occur between retailers and consumers and, more specifically, local meat managers and in-store customers, the perceptions and expectations of the meat managers will provide important insight into the issue of whether irradiated red meat products will become prevalent in U.S. groceries and supermarkets. The purpose of this study is to ascertain grocery retail meat managers’ perceptions regarding profitability potential of irradiated red meats and influences on these perceptions. The study also examines how these profitability expectations

may influence meat managers' views of projected market share, timing of introduction, and market strategy for irradiated red meats.

Studies of Consumer Perceptions

Several recent studies found a wide range of consumer rejection of irradiated products. Estimates of consumer rejection range from 15 to 36 percent (Bailey, 1996; Fox *et al.*, 1996; Hashim, Resurreccion, and McWatters, 1995; Henson 1995; Resurreccion *et al.*, 1995; Sapp, Harrod, and Zhou, 1995). Findings from a study conducted by the Centers for Disease Control and other agencies suggest that nearly half of consumers would be willing to purchase irradiated ground beef, but less than one quarter would be willing to pay a premium (Frenzen *et al.*, 2000). These studies note that the acceptance or rejection of irradiated food products may be affected by consumers' familiarity with irradiation, how the choice is presented, or the level of education about irradiation provided in the experiment. Hinson, Harrison, and Andrews (1998) found that consumers familiar with irradiation were significantly more likely to buy and pay more for irradiated products than those who had never heard of irradiation. Schutz, Bruhn, and Diaz-Knauf (1989) found that consumers preferred irradiated fruit over fruit preserved using chemical fumigants. Hashim, Resurreccion, and McWatters (1995) found an increased percentage of consumers accepted irradiated chicken breasts after viewing educational slide shows or posters. The results from these studies underscore the potential importance of consumer education and the potentially pivotal role of retail meat managers in consumer acceptance or rejection of irradiated meat products.

Study Objectives

The objective of this study is to measure grocery retail meat managers' expectations the profitability potential of irradiated red meats. The study examines factors that influence the

expectations of meat managers, such as meat manager and store characteristics, meat manager familiarity with irradiation, opinions regarding irradiation, and views regarding customer perceptions. The study also examines how the projected timing of adoption by their retail store, projected percent of red meats allocated to irradiated red meats, and merchandising may be influenced by these profitability expectations. The study also examines how this expected profitability potential may influence other marketing decisions, such as whether managers believe their stores will use a branded products strategy, when they believe the product will be introduced, and the store-wide percentage of red meat sales they believe their stores will devote to irradiated products in their store after five years.

Data and Methodology

In the summer of 2001, 40 Knoxville, Tennessee area grocery retailers were surveyed regarding their views on irradiated red meat and meat products. The meat department managers were questioned during personal interviews lasting approximately 30 to 45 minutes. Interviewees were assured that their participation was voluntary and that individual responses would be kept confidential. Meat managers with several types of retailers were represented in the survey, including national chains (47.5 percent), regional chains (20.0 percent), and local independent stores (32.5 percent).

The survey contained several questions about meat managers' views regarding of the profitability potential of irradiated red meat to their stores. To assess the meat managers' views about their knowledge level of irradiation, they were asked about their familiarity with the regulations and technological processes of irradiation. The meat managers' were asked questions about their views of potential risks of irradiation, effects on product shelf life, and costs to retailers. The managers were also asked about their perceptions of how consumers may

react to irradiated red meat products in their stores. Finally, the survey also included questions about the type of retailer (national, regional, or independent), years of experience of the meat manager, and level of education of the meat manager.

Meat managers' perceptions about the profitability of red meat irradiation (*PROFIT*) are hypothesized to be influenced by characteristics of the meat manager (education level and years experience in food retailing), type of store (independent, regional chain, or national chain), meat manager familiarity with the regulatory requirements and technological processes used in red meat irradiation, meat managers' views regarding the safety, effect on spoilage/shelf life, and costs of irradiation, and meat managers' perceptions of how consumers may react to irradiated red meats. The variable names, definitions, and response means are presented in Table 1. The hypothetical model was as follows:

$$\Pr(\text{PROFIT}=i) = f(X) = f(\text{EDUC}, \text{EXPER}, \text{REGION}, \text{NATION}, \text{LEGAL}, \text{PROCESS}, \\ \text{RHEALTH}, \text{RENVIRON}, \text{SHELFLIFE}, \text{TSAVE}, \text{HCOST}, \\ \text{CONSSAF}, \text{CONSACPT}, \text{CONSHPP}, \text{RADURA}),$$

where i =strongly agree, 2=agree, 3=no opinion, 4=disagree, and 5=strongly disagree. If the model is expressed in the cumulative probability form, and the explanatory variables are represented by the vector X then:

$$g(\Pr(\text{PROFIT} \leq i | X)) = \alpha_i + \beta'X, \text{ where } 1 \leq i \leq 4.$$

It is hypothesized that higher education levels (*EDUC*) and more years of experience (*EXPER*) in food retailing will increase the probability of meat managers believing irradiation will have a high profitability potential for retailers. The logic behind this hypothesis is that more educated managers may be more open to the use of new technologies. The effects of being a manager in a regional (*REGION*) or national (*NATION*) chain cannot be hypothesized *a priori*.

Larger chains may try to “test market” irradiated meat first, rather than introduce irradiated meat throughout the entire chain. Also larger chains may be in a better financial position to introduce irradiate red meats compared with smaller chains. However, because independent stores may not have the luxury of a testing the market in small steps, they could be quicker to introduce irradiated meat products on a company-wide basis. On the other hand, larger chains may be more likely to introduce the new product first, because of financial their position.

A manager’s familiarity with the legal, regulatory, (*LEGAL*) and process of irradiation (*PROCESS*) is hypothesized to have a positive effect on the manager's views regarding the profitability of meat irradiation. A manager’s belief that irradiation poses little health (*RHEALTH*) or environmental risks (*RENVIRON*) and will reduce spoilage (*SHELFLIFE*) is hypothesized to have a positive effect on views regarding profitability. A manager’s belief that irradiation of meat products will create a substantial time-savings (*TSAVE*) in the meat department is hypothesized to also have a positive effect on the views regarding the profitability potential of irradiated meats. Managers who believe that their store will have to pay a higher price for irradiated red meats (*HCOST*) are hypothesized to be less likely to believe irradiated red meats have a high profitability potential.

The effect of managers’ perceptions of consumers’ food safety concerns (*CONSSAF*) is unclear because concerns about food safety could have positive effect on sales if consumers are concerned about pathogens in red meat products, or a negative effect if consumers view irradiation negatively. Meat managers’ belief that consumers would be very accepting of irradiated meat (*CONSACPT*) and would pay a higher price for irradiated meat than non-irradiated meat (*CONSHPP*) would likely have a positive influence on meat managers’ views of the potential profitability of irradiated red meats. Meat managers who believe the ‘radura’

symbol (*RADURA*) will have a positive effect on product sales are hypothesized to be more likely to believe the profitability potential for irradiated red meat products is high.

An ordered logistic model can be estimated for the observed ratings by meat mangers regarding potential benefits to food retailers' profitability of red meat irradiation. The opinion rating of potential profitability benefits being high (*PROFIT*) could take on the values of 1 for 'strongly disagree' to 5 for 'strongly agree'. The probabilities of *PROFIT* are then

$$\begin{aligned}\Pr(\textit{PROFIT} = 1) & F(\alpha_1 + \beta'X), \\ \Pr(\textit{PROFIT} = 2) & F(\alpha_2 + \beta'X) - F(\alpha_1 + \beta'X) , \\ \Pr(\textit{PROFIT} = 3) & F(\alpha_3 + \beta'X) - F(\alpha_2 + \beta'X) , \\ \Pr(\textit{PROFIT} = 4) & F(\alpha_4 + \beta'X) - F(\alpha_3 + \beta'X) , \\ \Pr(\textit{PROFIT} = 5) & 1 - F(\alpha_4 + \beta'X),\end{aligned}$$

where F is the logistic distribution or $e^{\beta'X} / (1 + e^{\beta'X})$ (Greene, 1993).

The statistical significance of the overall model is evaluated with the Log Likelihood Ratio test (LLR). The null hypothesis is

$$H_0: \beta_1 = \beta_2 \dots = \beta_k = 0,$$

and the alternative hypothesis is

$$H_a: \beta_1 = \beta_2 \dots = \beta_k \neq 0. \quad \text{Double check -- This is OK right?}$$

The test statistic is found by subtracting the unrestricted $-2 \log L(UR)$ (UR = intercept and k explanatory variables) from the restricted $-2 \log L(R)$ (R = intercept only). The formula is as follows

$$LLR = 2[\log L(UR) - \log L(R)].$$

The test statistics is distributed as chi-square with k degree of freedom. If the calculated statistic is greater than the critical value of Chi-square, then the overall model is statistically significant.

Another measure of overall fit of the model is the percent of responses correctly classified. To

calculate the percent correctly classified, the predicted values for profitability expectations are compared with the actual values and then put into percent form.

Significance of the individual parameter estimates are tested with Wald tests. The null hypothesis is

$$H_0: \beta_i = 0,$$

and the alternative hypothesis is

$$H_a: \beta_i \neq 0.$$

The Wald statistic is calculated by dividing the parameter estimate by the standard error then squaring the value. The formula for the Wald statistic is:

$$Wald = (\hat{\beta} / S_{\hat{\beta}})^2.$$

The calculated Wald statistic is compared with the critical value of the Chi-square distribution to determine whether the estimate is significant. If the calculated statistic is greater than the critical value, then H_0 is rejected. The test is conducted with one degree of freedom.

The values of the parameter estimates cannot be evaluated directly as slopes measuring how the level of profitability expectations changes in response to changes in an explanatory variable. However, the signs and significance of the coefficients do have a useful interpretation. A positive sign on a β coefficient indicates that an increase (decrease) in the X variable causes an increase (decrease) in the probability that the manager will strongly agree that irradiation has high profitability potential. A negative sign on a β coefficient indicates that an increase (decrease) in the X variable causes a decrease (increase) in the probability that the manager will strongly agree that irradiation has high profitability potential. The reverse would be true for the effects on probability that the meat manager strongly disagrees. Without further calculations, no

interpretations of the effects of the explanatory variable on probability of ‘agree’, ‘no opinion’, or ‘disagree’ can be made.

Comparisons of meat managers’ profitability responses against responses on branding strategy and against product introduction predictions are evaluated with frequency tables and Chi-square tests of association. A Chi-square statistic is used to test for association between row and column variables in a frequency table (*i.e.* profitability expectations and whether a branded strategy will be used). The Pearson chi-square statistic is calculated as

$$Q_p = \sum_i \sum_j (n_{ij} - m_{ij})^2 / m_{ij}$$

and compared with the critical value with (number of rows-1)*(number of columns-1) degrees of freedom at the 95 percent confidence level. The values $m_{ij} = (\text{row total} * \text{column total}) / n$ and n_{ij} = the cell frequency in the i^{th} row and j^{th} column (Fienberg, 1977). If the calculated Q_p is greater than the critical value of Chi-square, then the hypothesis of no association between the variables is rejected.

Differences in the mean projected share of red meats that will be comprised of irradiated products is tested with a t-statistic. If the variances are unequal, the two means are compared with

$$t = \left| \bar{y}_1 - \bar{y}_2 \right| / \sqrt{(s_1^2 / n_1) + (s_2^2 / n_2)},$$

where \bar{y}_1 and \bar{y}_2 are the means to be compared, s_1^2 and s_2^2 are the variances of y_1 and y_2 , and n_1 and n_2 are the number of observations used in calculating each mean.³ The degrees of freedom are

$$df = \frac{(s_1^2 / n_1 + s_2^2 / n_2)^2}{\frac{(s_1^2 / n_1)^2}{(n_1 - 1)} + \frac{(s_2^2 / n_2)^2}{(n_2 - 1)}}.$$

Results

Ordered Logistic Model of Profitability Expectations

The results from the estimated ordered logit model are displayed in Table 2. The values in parentheses below each coefficient are the estimated standard errors. A comparison of the Log Likelihood ratio (56.9301) to the critical value of chi-square with 15 degrees of freedom (30.58) indicates that the overall model is statistically significant at the 99 percent confidence level. The model correctly classifies responses regarding profitability expectations 88.4 percent of the time.

Characteristics

The coefficient on education level of the meat manager (*EDUC*) is positive and significantly different from zero at the 90 percent confidence level. This result indicates that, holding other factors constant, meat managers with at least some college education are more likely to strongly agree that irradiation of red meat has high profitability potential than those with less than a college education. While the sign of the coefficient on *EXPER* is positive, it is not significantly different from zero. The coefficients on *REGION* and *NATION* are negative and significantly different from zero at the 95 percent confidence level showing that, compared with local independent grocers, managers at regional or national chains are less likely to strongly agree with high profitability potential of red meat irradiation.

Meat Manager Familiarity With Irradiation

The coefficient on *LEGAL* is positive and significantly different from zero at the 90 percent confidence level. Therefore, meat managers who do not believe they have a high level of

knowledge about legal and regulatory requirements are more likely to strongly agree with high profitability potential of irradiation of red meat than those having a greater perceived familiarity. This result was not expected. The coefficient on *PROCESS* is negative, but insignificant.

Opinions Regarding Irradiation

The coefficient on *RHEALTH* is positive, but not significantly different from zero. The coefficient *RENVIRON* is negative and significantly different from zero at the 95 percent confidence level, indicating meat managers who view irradiation as having little environmental risk are more likely to strongly agree with high profitability potential of red meat irradiation than those who feel irradiation poses a risk. The coefficient *SHELFLIFE* is negative and significantly different from zero at the 90 percent confidence level, suggesting that meat managers who believe that irradiation will increase the product's shelf life are more likely to strongly agree that irradiation of red meat has high profitability potential. The coefficient on *TSAVE* is negative and significantly different from zero at the 99 percent confidence level. Therefore, meat managers who believe irradiation will result in a substantial time-savings in the meat department are more likely to strongly agree with high profitability potential. The coefficient on the variable *HCOST* is not significant at the 90 percent confidence level or greater.

Views Regarding Customer Perceptions

The coefficient on *CONSSAF* is positive and significantly different from zero at the 95 percent confidence level. Therefore, if meat managers believe their customers are highly concerned about food safety, they are less likely to believe irradiation has high profitability potential. The sign on *CONSACPT* is negative and significantly different from zero at the 90 percent confidence level, suggesting that meat managers who view their customers as not accepting of irradiated red meats are less likely to strongly agree that irradiation of red meat has

high profitability. Contrary to expectations, the coefficient on *CONSHPP* is positive and significantly different from zero at the 99 percent confidence level. The variable *RADURA* carries a negative coefficient that is significantly different from zero at the 90 percent confidence level. This suggests that meat managers who believe the radura symbol will have a negative impact on sales are less likely to strongly agree that irradiation of red meat has high profitability potential.

Market Strategy, Timing of Introduction, and Projected Sales Share

The results from the two-way frequency analysis comparing introductory market strategy and profitability expectations are found in Table 3. Regardless of profitability expectations, between 70 and 80 percent of the surveyed managers believed irradiated red meats would be introduced as unbranded products. The Pearson chi-square statistic found from associating profitability expectations with branding strategy (0.086) falls below the critical value of chi-square at a 90 percent confidence level with one degree of freedom (2.71). Therefore, no significant association between whether the manager believes the products would be introduced as branded products and profitability expectations is found.

The results from the two-way table comparing timing of introduction and profitability expectations are found in Table 4. Over 52 percent of those holding positive expectations about profitability believe irradiated red meat products will be introduced in their store within the next three years. Less than 30 percent of those holding neutral or negative views about profitability believe irradiated products will be introduced in their store within the next three years. However, the calculated Pearson chi-square statistic is 4.018, while the critical value of the Chi-square at a 90 percent confidence level with 3 degrees of freedom is 6.25. Hence, no

statistically significant association between anticipated timing of introduction and profitability expectations is found.

The results from the differences in the mean projected share of irradiated red meat across profitability expectations are found in Table 5. Managers agreeing with high profitability potential of irradiated red meats forecast irradiated meats to capture 24 percent of total red meat sales after five years. Managers with negative or neutral opinions of profitability potential forecast irradiated meats to comprise 13.1 percent of total red meat sales after five years. When the mean shares are compared statistically, the calculated t is -1.26 , while the critical value of t at the 90 percent confidence level with 18 degrees of freedom is 1.330 .⁴ Therefore, no statistical difference in mean shares across the two groups is found.

Conclusions and Implications

While over a third of meat managers expect high profitability potential for irradiated red meats, the greatest percentage (43 percent) are neutral about its profitability potential. The remainder (20 percent) hold negative opinions about the profitability potential of irradiated red meat. Most believe the irradiated products will be sold using an unbranded strategy, with irradiated products eventually comprising less than a quarter of red meat sales.

Findings from the study suggest that managers in independent local stores have more positive profitability expectations than those in regional or national chains. This could imply that managers in independent stores see irradiated red meat products as a potential market niche. Education level of the meat manager also influences their perceptions, reinforcing the idea that education efforts for irradiated meat products at the store level may be appropriate. Unexpectedly, familiarity with legal and regulatory aspects of irradiation was found to have a negative influence on the likelihood of high profitability expectations. One possible explanation

for this finding is that managers most familiar with the legal and regulatory aspects may be more familiar with the labeling requirements for irradiated products. The food industry has expressed concerns about use of the term "irradiated" and how consumers may react.

Views about potential environmental risks, benefits of shelf-life, and time-savings influence meat managers' profitability expectations. Educational materials supplied to meat managers and meat department personnel might outline environmental risk levels, as well as the potential benefits of shelf-life and time-savings that could accrue from selling irradiated red meats.

Perceptions of consumers' concerns about food safety and potential negative market effects of the radura symbol influence managers' profitability expectations. These results could reflect meat managers beliefs that consumers' concerns about pathogens in red meat products may be outweighed by perceived health risks from irradiation, and that the radura symbol may adversely affect sales. These results reinforce the importance of having information readily available to meat department customers about potential food safety benefits of irradiation and the meaning of the radura symbol.

One caveat to the findings from this study is that they are for one geographic area. Further research should investigate meat managers' profitability expectations on a national level.

References

- Andrews, L., M. Ahmedna, R. Grodner, J. Liuzzo, P. Murano, E. Murano, R. Rao, S. Shane, and P. Wilson, 1998 "Food Preservation Using Ionizing Radiation." *Review of Environmental Contaminant Toxicology*, 154: 1-53.
- Bailey, W. 1996. "Comparative Study of the Willingness to Pay for Organic and Irradiated Meat Products: An Experimental Design." *Consumer Interests Annual*, 42: 407-410.
- Bogart, S. and N. Tolstum, 1999. "Economic Aspects of Cold Food Pasteurization." Pp. 603-605 in A. Luccio and W. MacKay, eds., *Proceedings of the 1999 Particle Accelerator Conference*. New York: Institute of Electrical and Electronics Engineers.
- Buzby, J., J. Fox, R. Ready, and S. Crutchfield, 1998. "Measuring Consumer Benefits of Food Safety Risk Reductions." *Journal of Agricultural and Applied Economics*, 30:69-82.
- Dillman, D. 1978. *Mail and Telephone Surveys: The Total Design Method*. New York: John Wiley and Sons.
- Engeljohn, D. 1999. *Irradiation of Meat and Meat Products*. U.S. Department of Agriculture, Food Safety and Inspection Service (USDA/FSIS), February 25.
- Fienberg, S. 1977. *The Analysis of Cross-Classified Data*. Cambridge, MA: MIT Press.
- Frenzen, P., A. Majchrowicz, J. Buzby, and B. Imhoff, 2000. "Consumer Acceptance of Irradiated Meat and Poultry Products." *Issues in Food Safety Economics*. United States Department of Agriculture, Agricultural Information Bulletin No. 757.
- Fox, J., D. Hayes, J. Shogren, and J. Klieberstein, 1996. "Experimental Methods in Consumer Preference Studies." *Journal of Food Distribution Research*, 27: 1-7.
- Greene, W. 1993. *Econometric Analysis*. Second Edition. New York: Macmillan Publishing Company.
- Hashim, I., A. Resurreccion, and K. McWatters. 1995. "Consumer Acceptance of Irradiated Poultry." *Poultry Science*, 74:1287-1294
- Henson, S. 1995. "Demand-Side Constraints on the Introduction of New Food Technologies: The Case of Food Irradiation." *Food Policy*, 20:111-127.
- Herzog, K. and T. Daykin, 2000. "Irradiated beef starting to show up in state groceries." *Milwaukee Journal Sentinel*, August 1.
- Hinson, R., W. Harrison, and L. Andrews, 1998. "Impact of Socio-Economic Characteristics on Attitudes Toward Food Irradiation." *Journal of Food Distribution Research*, 29,3:26-34.

- Kaye, R. and B. Turman, 1999. "Issues for Bringing Electron Beam Irradiators On-Line." paper presented at *Food Irradiation Conference*, Washington, D.C., May 12-14.
- Medina, S., and R. Ward. 1999. "A Model of Retail Outlet Selection for Beef." *International Food and Agribusiness Management Review*, 2,2: 195-219.
- Murano, E. 1995. "Microbiology of Irradiated Foods." In E.A. Murano, ed., *Food Irradiation: A Source Book*. Ames, IA: Iowa State University Press.
- Resurreccion, A., F. Galvez, S. Fletcher, and S. Misra, 1995. "Consumer Attitudes Toward Irradiated Food: Results of a New Study." *Journal of Food Protection*, 58:193-196.
- Sapp, S. 1995. "Consumer Acceptance of Irradiated Foods." In E.A. Murano, ed., *Food Irradiation: A Source Book*. Ames, IA: Iowa State University Press.
- Sapp, S., W. Harrod, and L. Zhao, 1995. "Social Demographic and Attitudinal Determinants of Consumer Acceptance of Food Irradiation." *Agribusiness*, 11: 117-130.
- Schutz, H.G., C.M. Bruhn, and K.V. Diaz-Knauf, 1989. "Consumer Attitudes Toward Irradiated Foods: Effects of Labeling and Benefits Information." *Food Technology*, 43:80-86.
- U.S. Department of Agriculture, Food Safety and Inspection Service (USDA/FSIS), 2001. "USDA Issues Final Rule on Meat and Poultry Irradiation." Backgrounders, issued December 1999 at http://www.fsis.usda.gov/OA/background/irrad_final.htm, last visited October 2001.

Table 1. Variable Descriptions, Names, Definitions, and Means.

Variable Description/Name	Definition	Mean (N=40)
<i>Dependent</i>		
Potential Benefits to Food Retailers' Profitability is High (<i>PROFIT</i>)	1 if strongly agree, ..., 5 if strongly disagree	2.675
<i>Characteristics</i>		
Education Level: Some College or Greater (<i>EDUC</i>)	1 if education level some college or greater, 0 otherwise	.375
Years Experience in Food Retailing (<i>EXPER</i>)	Years	18.575
<i>Store Type</i>		
Regional Chain (<i>REGION</i>)	1 if regional grocery or supermarket chain, 0 otherwise	.200
National Chain (<i>NATION</i>)	1 if national grocery or supermarket chain, 0 otherwise	.475
<i>Meat Manager Familiarity With Irradiation</i>		
Extremely Familiar with Legal, Regulatory Requirements (<i>LEGAL</i>)	1 if strongly agree, ..., 5 if strongly disagree	4.225
Could Clearly Explain How Irradiation Process Works To Customers (<i>PROCESS</i>)	1 if strongly agree, ..., 5 if strongly disagree	4.500
<i>Opinions Regarding Irradiation</i>		
Irradiation Poses Virtually No Risk to Human Health (<i>RHEALTH</i>)	1 if strongly agree, ..., 5 if strongly disagree	2.950
Irradiation Poses Virtually No Risk to Environment (<i>RENVIRON</i>)	1 if strongly agree, ..., 5 if strongly disagree	3.200
Irradiation Will Substantially Increase Shelf Life of Red Meat Products and Reduce Spoilage (<i>SHELFLIFE</i>)	1 if strongly agree, ..., 5 if strongly disagree	2.150
Offering an Irradiated Red Meat Product Will Result in a Substantial Time Savings in the meat department (<i>TSAVE</i>)	1 if strongly agree, ..., 5 if strongly disagree	2.825
Store Will Have to Pay a Higher Price for Irradiated Meat Products than for Non-Irradiated Ones (<i>HCOST</i>)	1 if strongly agree, ..., 5 if strongly disagree	2.275

Table 1. Continued.

Variable Description/Name	Definition	Mean (N=40)
<i>Views Regarding Customer Perceptions</i>		
Customers are Extremely Concerned About Food Safety (<i>CONSSAF</i>)	1 if strongly agree, ..., 5 if strongly disagree	1.200
Customers Would be Very Accepting of Irradiated Red Meat (<i>CONSACPT</i>)	1 if strongly agree, ..., 5 if strongly disagree	3.850
Customers Would be Willing to Pay a Much Higher Price for Irradiated Red Meat Product than Non-Irradiated Red Meat (<i>CONSHPP</i>)	1 if strongly agree, ..., 5 if strongly disagree	4.275
Expected Impact of “Radura Symbol” on Sales of Irradiated Meat Product (<i>RADURA</i>)	1=very positive, ..., 5=very negative	3.125

Table 2. Estimated Ordered Logit Model for Meat Managers' Opinions of Profitability of Irradiated Red Meat Products.^a

Variable	Estimated Coefficient	
α_1	8.5941 (4.2593)	**
α_2	10.7015 (4.3020)	**
α_3	16.2918 (5.0663)	***
α_4	20.4213 (5.8272)	***
Characteristics		
<i>EDUC</i>	2.4227 (1.2915)	*
<i>EXPER</i>	.0286 (.0405)	
Store Type		
<i>REGION</i>	-3.1431 (1.3896)	**
<i>NATION</i>	-2.9343 (1.1302)	***
Meat Manager Familiarity With Irradiation		
<i>LEGAL</i>	1.4539 (.8128)	*
<i>PROCESS</i>	-1.6263 (1.0102)	
Opinions Regarding Irradiation		
<i>RHEALTH</i>	.1534 (.7405)	
<i>RENVIRON</i>	-1.3012 (.6637)	**
<i>SHELFLIFE</i>	-1.5161 (.7760)	*
<i>TSAVE</i>	-1.5856 (.4683)	***
<i>HCOST</i>	-.2994 (.3655)	

Table 2. Continued.

Variable	Estimated Coefficient	
Views Regarding Customer Perceptions		
<i>CONSSAF</i>	2.4785 (1.0290)	**
<i>CONSACPT</i>	-1.5850 (.8417)	*
<i>CONSHPP</i>	1.9867 (.7575)	***
<i>RADURA</i>	-1.2847 (.6448)	**
Log Likelihood Ratio	56.9301	***
Percent Correctly Classified	88.4	

Notes: ^a ‘***’ indicates significance at the 99 percent confidence level, ‘**’ indicates significance at the 95 percent confidence level, and ‘*’ indicates significance at the 90 percent confidence level.

Table 3. Frequency Table: Type of Market Strategy vs. Profitability Potential

Profitability Potential is High	<i>Type of Strategy</i>	
	Branded	Not Branded
	(Percent of Responses)	
Strongly Agree or Agree (N=15)	20.0	80.0
No Opinion, Disagree, or Strongly Disagree (N=25)	24.0	76.0
<hr/>		
Q	.086	

Table 4. Frequency Table: Likely Timing of Introduction vs. Profitability Potential

Profitability Potential is High	<i>When Irradiated Red Meat Will Likely Be Introduced in Their Store</i>			
	In the Next Year	In the Next Three Years	Greater than Three Years	Never
	(Percent of Responses)			
Strongly Agree or Agree (N=15)	6.7	46.7	33.3	13.3
No Opinion, Disagree, or Strongly Disagree (N=25)	0.0	28.0	40.0	32.0
<hr/>				
Q	4.018			

Table 5. Mean Irradiated Red Meat Sales Share Across Profitability Potential

Profitability Potential is High	Mean Share of Red Meat Products Sales that Will Be Irradiated Within Five Years
Strongly Agree or Agree (N=15)	.240
No Opinion, Disagree, or Strongly Disagree (N=25)	.131
t	-1.26



Figure 1. Radura Symbol

Notes

-
- ¹ Ionizing radiation, which is approved for other food products, hospital equipment and other products, has recently been in the news as a proposed method to sterilize the U.S. mail from Anthrax contamination.
- ² Andrews *et al.* report that shelf life increased from 8-10 weeks for non-irradiated ground beef to 26-28 weeks for ground beef exposed to a 1.54 kGy dose of irradiation. Shelf life increased to as much as 70 weeks for various beef cuts exposed to a 2.0 kGy dose of irradiation while under vacuum.
- ³ The equality of variances is tested using an F-test prior to the t-test. The calculated $F = \text{larger variance} / \text{smaller variance}$, with $n - 1$ for the larger variance (numerator) and $n - 1$ for the smaller variance (denominator) degrees of freedom.
- ⁴ The calculated F to test equality of variances is 3.51, while the critical value of the F-test with 13 degrees of freedom (numerator) and 20 degrees of freedom (denominator) is approximately 3.23, therefore the variances across the two groups are not equal.