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Evaluation of the Effectiveness of Food Irradiation Messages

ABSTRACT

Food irradiation is a promising food safety technology that can significantly reduce disease-causing organisms in foods. Research has found that insufficient information about the risks, benefits, and safety were major factors driving consumers' reluctance to buy. This study examines the impact of information about food irradiation on consumers' willingness to purchase irradiated ground beef and poultry. Three information statements about food irradiation were developed, based on FDA and USDA Web sites. The topics were "benefits of food irradiation," "consumers' most frequent questions" and "authorities approving food irradiation." The effect of the messages, individually and in combination, were evaluated through an on-line web survey. Information related to "benefits of food irradiation," including reducing harmful bacteria, was the most effective in changing consumers' perception of irradiated food. The information addressed in "consumers' most frequent questions," including not inducing radioactivity and no significant nutrition loss, was less powerful in changing perceptions, but better than information on "authorities approving food irradiation." The combination of all three messages generated the largest increase in the number interested in selecting irradiated food. These findings can be used as a guide by policy makers, educators, and marketers to accurately describe irradiated food products and increase utilization of this safety enhancing technology.

INTRODUCTION

Food irradiation is an effective way to destroy both pathogenic and nonpathogenic bacteria, as well as parasites. Like pasteurization of milk, treating food with ionizing radiation enhances product safety and protects consumers from foodborne illness *(13)*. The potential benefits and toxicological safety of food irradiation have been extensively investigated *(28, 31)*. Irradiation can inactivate foodborne pathogens such as shiga toxin-producing *Escherichia coli*

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(STEC), *Listeria, Salmonella, Campylobacter* and others *(23, 25, 29)*. Any change in nutritional value does not significantly affect the nutritional adequacy of the diet. Toxicological evaluations have found that irradiated foods do not differ significantly from their non-irradiated counterparts. The US Food and Drug Administration (FDA), Department of Agriculture (USDA), Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO) and other authorities around the world have approved the use of this technology *(11, 32)*.

Although irradiated meat, poultry, and produce are available in some areas, the technology is not widely implemented. Some believe the public will not accept irradiated food, and indeed when specifically asked about willingness to buy irradiated products, with little or no information provided, fewer than half responded affirmatively *(15, 16, 36)*. Research has found that insufficient information about the risks, benefits and safety concerns are major factors driving consumers' reluctance to buy irradiated food *(17, 18)*. Consumers also wonder if irradiation affects taste, nutrition, and safety. Because irradiated food is not widely available in the marketplace, few consumers have had a chance to personally verify the sensory qualities of irradiated items.

Food taste, convenience, and price are key factors that influence consumer purchases in the marketplace *(4, 5)*. Educating consumers about new technologies may be critical to ensuring that they recognize and are willing to pay for enhanced value *(12)*. Communication about food irradiation includes both education and risk communication. Effective risk communication is dependent on many factors, including trust in the source of information, scientific uncertainty, interaction with the public, cultural variation, and consumer perception of benefits and risks of the technology and the risk it is reputed to reduce. The message language and style of delivery can also affect perception *(17, 30)*. Researchers have used willingness-to-purchase studies to measure how much consumer would consider paying for irradiated food. Fox and colleagues *(16)* found that positive information significantly increased willingness to buy, whereas negative information reduced willingness. When presented with both positive and negative information, the effect of negative information dominated. Researchers did not determine response to individual positive statements.

If the food processing and retail industries believe that consumers are willing to buy irradiated food, they are more likely to offer it for sale *(2, 6, 27)*. Nayga and colleagues' found that females and those who think that improper handling contributes to food poisoning are more likely than others to pay a premium of 50 cents per pound of irradiated beef. Those who trust the irradiation technology are also more likely to pay a premium of between 5 to 25 cents per pound for irradiated beef *(2, 6, 26, 27)*.

Consumer acceptance of irradiated food after exposure to specific risk and benefits information or safety reassurance information has not been evaluated recently. To fill this void, this study evaluates the effect of information about food irradiation on consumers' perceptions about and willingness to purchase irradiated meat and poultry products.

MATERIALS AND METHODS

Participants (n = 765) over the age of 18 from both San Francisco and Chicago were recruited from a consultant's database (Tragon Inc.), through E-mail. Participants were selected to reflect the ethnicity ratio of the region, based on data from the 2010 U.S. Census Bureau *(19)*. All survey data were collected online from participants who used personal computers. Inclusion criteria required participants to be the primary meal preparer and consume meat (no vegetarians or vegans). Participants were advised that they could discontinue participating in the study at any time. The study received clearance through the Institutional Review Board, University of California-Davis. Questions were pilot tested prior to administration to assess consumer understanding.

The effect of three messages and their combination were evaluated in the study *(Table 1)*. The three messages were safety assurances from authorities, as illustrated by listing United States and international authorities who approved irradiated food (referred to as "Authority"), answers to common doubts of consumers, such as the impact of irradiation on nutrition loss and the fact that irradiation does not induce radioactivity (referred to as "Nutrition"), and food safety benefits of irradiated food (referred to as "Benefits"). Participants received either a single message ("Authority," "Nutrition" or "Benefits"), a double message ("Benefits + Nutrition," "Benefits + Authority" or "Nutrition + Authority"), or a triple message ("Authority + Nutrition + Benefits"), for a total of seven intervention groups. Participants were assigned randomly to groups, with approximately one hundred participants in each group. All participants also completed a survey addressing general food safety knowledge and intent to purchase irradiated food. All survey questions were the same, except for the message that participants were assigned to read.

Survey design

There were 19 multiple-choice questions in the survey, the first four of which were screening questions to confirm eligibility. These were followed by four general food safety questions adapted from the International Food Information Council (IFIC) *(20)*, which addressed trustworthiness of information sources, ways to make food that might contain harmful bacteria safe, current food handling practices, and use of a cooking thermometer *(Table 2)*.

To better associate attitudes toward irradiated food to the participants' life experiences, participants were asked whether ground beef or poultry presented the greatest risk

Table 1. Intervention statements describing irradiation attributes

Brief name	Statement details
Authority	Who says irradiation is safe?
	• Food irradiation has been approved in over 40 countries, including France, the Netherlands, Portugal, Israel, Thailand, Russia, China, and South Africa. • U.S. Food and Drug Administration (FDA) determined that irradiated food is safe. • The World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC) and the U.S. Department of Agriculture (USDA) have also endorsed the safety of irradiated food.
Nutrition	What does irradiation do to food?
	• Irradiation is currently used for some spices, food packages, medical and hospital supplies (Band-Aids, cotton balls, baby pacifiers, etc.) • Irradiation does not make foods radioactive, compromise the foods' nutritional quality, or produce noticeable changes to the taste, texture, or appearance. • Changes made by irradiation are so minimal that you have to read the label to know if it has been irradiated.
Benefits	What are the benefits of irradiation?
	• Irradiation can prevent foodborne illness (stomach flu) because it greatly reduces harmful bacteria like *Salmonella, E. coli* and *Listeria*. It also replaces toxic chemicals used to destroy bacteria on spices. • Food stays fresh longer because irradiation reduces the number of bacteria that cause spoilage. • Irradiation can even replace toxic chemicals currently used to destroy insects that hitchhike on fresh fruits.

for foodborne illness. If a participant answered ground beef, all the following questions related to irradiated food referred to irradiated ground beef. Similarly, if the participants responded that poultry presented the greatest risk, subsequent questions referenced irradiated poultry. Therefore, the participants were segmented into ground beef and poultry groups. Since subsequent analysis showed no difference in attitudes toward irradiation or in food safety knowledge, data analysis combined these two groups. After asking participants if they had heard about irradiated food, they were asked to indicated if they would buy products labeled "Irradiated ground beef" or "ground beef, cook to 160˚F"or "ground beef". If participant had checked that poultry presents the greater food safety risk, then the three options referenced poultry instead of ground beef, and the temperature was 165˚F instead of 160˚F.

Participants were then asked to read a brief statement describing food irradiation as follows: "Irradiation makes food safer by reducing harmful bacteria that could cause illness." Participants were then asked to respond to three willingness-to-purchase questions, adapted from previous studies *(2, 16)*. The questions were "Based on the description above, would you buy irradiated ground beef/poultry if it was the same price per pound as non-irradiated ground beef/poultry?" with the options, 'yes', 'not certain' and 'no'. If respondents indicated 'yes', the next question asked, "would you buy irradiated ground beef/poultry if it was 10% more expensive per pound than non-irradiated ground beef/poultry?" If the participants indicated yes, the next question asked, "would you buy irradiated ground beef/poultry if it was 20% more expensive per pound than non-irradiated ground beef/poultry?" If a participant checked 'not certain' or 'no' in any of the three questions, he/she was directed to the next section and would skip the willingness-to-purchase section.

Participants were then directed to read the assigned message set, after the same willingness-to-purchase questions were asked. If the participant checked 'no' or 'not certain' to the "same price" question, the next question was "Why are you not interested in buying irradiated food?" The participant could check all that apply from multiple options developed from the author's previous qualitative study *(14)*. Next, participants who indicated that they were either not sure or would not buy were asked if they would purchase irradiated meat/poultry if it was 10% cheaper than the non-irradiated counterpart.

Table 2. Food safety perceptions and practices

	Responses % (n)
Perception of handling practices that would make something safe to eat if it had harmful bacteria (i.e., *Salmonella* or *E. coli*) on it*	
Cooking it	48(367)
Food containing *Salmonella* or *E. coli* bacteria cannot be made safe to eat	43(329)
Washing it	25(191)
Adding vinegar or lemon juice	7(54)
Freezing it	7(54)
Not sure	7(54)
Actions practiced by participants regularly when cooking, preparing, and eating*	
Wash my hands with soap and water	99(757)
Wash cutting board(s) with soap and water or bleach	94(719)
Separate raw meat, poultry and seafood from ready-to-eat products	90(689)
Cook to required temperature (such as 160°F for ground beef or 165°F for poultry)	88(673)
Properly store leftovers within 2 hours of serving	87(666)
Use different or freshly-cleaned cutting boards for each product (such as raw meat or poultry and produce)	72(551)
Defrost foods in the refrigerator or microwave	68(520)
Use a food thermometer to check the "doneness" of meat and poultry	50(383)
None of the above	0
Factors participants say would encourage them to use a food thermometer more often*	
If recipes in my cookbooks and on websites listed temperatures in the directions	87(666)
If I was given a free food thermometer	83(635)
If my friends used a thermometer and recommended it	55(421)
If my favorite cooking show or chef used a thermometer	54(413)
If thermometers were easier to find and buy in stores	50(383)
Food participants perceived as greater food safety risk	
Ground Beef	30(230)
Poultry	70(536)
*Multiple answers accepted	

Statistical analysis

Data were analyzed using Excel and SPSS for Windows. The chi-square test (33) was used to obtain significance levels. The difference between response to irradiation after reading the general description and the specific message was analyzed within each message.

Table 3. Demographic and food-handling practice of participants

	Responses % (n)
Household grocery shopping frequency	
I don't do any of the household grocery shopping	0
Someone else does the majority of the grocery shopping	0
I share the responsibility equally with someone else	14(107)
I do the majority of the household grocery shopping	28(214)
I do all of the household grocery shopping	58(444)
Household meal preparation and cooking frequency	
I don't do any of the household meal preparation	0
Someone else does the majority of the household meal preparation	0
I share the responsibility equally with someone else	19(145)
I do the majority of the household meal preparation	32(245)
I do all of the household meal preparation	49(375)
Food participants who would NOT consider consuming	
Meat	0
Vegetables	0
Refined grains	3(23)
Non-organic foods	1(8)
Frozen meals	5(38)
I would consider consuming any / all of the above food products	93(711)
Gender	
Male	51(391)
Female	49(374)
Ethnicity	
White (non-Hispanic)	65(497)
Hispanic or Latino	17(130)
Black or African-American	10(77)
Asian	5(38)
Or something else	2(15)
Native Hawaiian or Other Pacific Islander	1(8)
American Indian or Alaska Native	0

RESULTS

Demographics

A total of 765 participants (age range 18 to 65 years old) 374 of whom were female, completed the study. Over half of the participants identified themselves as Caucasians (n = 497, 65%), 17% (n = 130) as Hispanic, 10% (n = 76) as African-American descent, and 5% (n = 38) as Asian descent *(Table 3)*.

General food safety knowledge

When participants were asked about trustworthiness regarding sources of food safety information, on a 5-point Likert scale, participants reported the greatest trust in information from health professionals, with 93% rating this group as 'somewhat trustworthy' or 'very trustworthy.' Both 'family and friends' and 'government' earned the same percentage of somewhat and very trustworthy (63%) *(Fig. 1)*.

Most (70%) of participants thought poultry posed a greater food safety risk than ground beef. When asked to check all options that apply to make food safe if it had *Salmonella* or *E. coli*, only 48% thought 'cooking' would enhance safety. However, nearly half of the participants thought food containing *Salmonella* or *E. coli* bacteria could not be made safe to eat (43%), while 25% thought 'washing' could make it safe.

Using a food thermometer, as well as handwashing, are important aspects of safe food handling. While 99% of the participants reported that they washed their hands with soap and water, only half of the participants reported that they used a food thermometer to check the "doneness" of meat and poultry. When a follow-up question was asked, "what can encourage you to use a food thermometer more frequently?" the answers checked most frequently were "If recipes in my cookbooks and on websites listed temperatures in the directions" (87%), and "If I was given a free food thermometer" (83%).

Familiarity with food irradiation and initial response to labeled products

Significantly fewer female and younger generation participants (18–45 yrs) had heard about food irradiation, compared to males and older respondents (45–65 yrs); $P < 0.05$.

Although more than 40% of the participants said they had heard about food irradiation, when they were asked which product they would buy in the absence of information about irradiation, only about one-fifth chose irradiated ground beef or poultry *(Fig. 2)*. When provided with the basic information about irradiation (that irradiation makes food safer by reducing harmful bacteria that could cause illness), interest in purchase increased to 55%, or only 10% fewer than said they would buy products labeled with the recommended cooking temperature *(Table 4)*. Fewer chose ground beef or poultry labeled with the recommended end-point temperature, compared with those without this information.

Figure 1. Sources of food safety information considered trustworthy (n = 765)

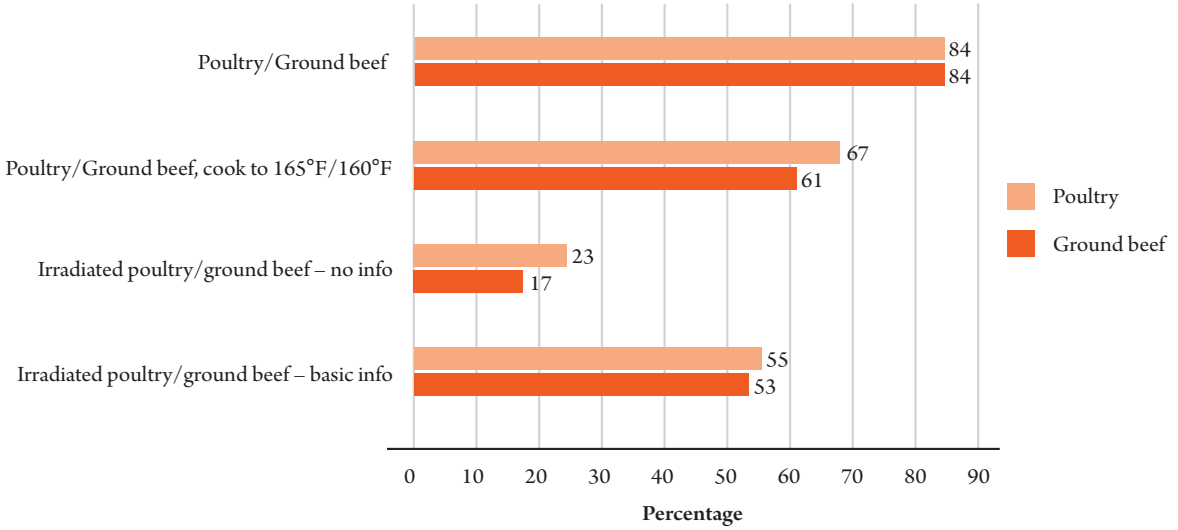

Figure 2. Will you buy products labeled as below? (n = 765)

Willingness-to-buy irradiated food

Questions regarding participant response to irradiated food elicited four types of response:

1. Very positive consumers, who are willing to purchase irradiated product, even if it was 20% more expensive than the non-irradiated counterpart.
2. Positive consumers, who were willing to purchase an irradiated product, even if it was 10% more expensive than the non-irradiated alternative.
3. Price-sensitive consumers, who are willing to purchase an irradiated product, only when it was the same price as the non-irradiated alternative.
4. Negative consumers, who are unwilling to purchase an irradiated product, even at the same price or a lower price than the non-irradiated one.

Even though significance does not depend solely on the size of the change, comparisons as to message effectiveness can be made, since the sample sizes in each group were approximately the same. A chi-square analysis indicated that the seven groups' initial attitudes toward irradiation did not differ significantly. This suggests that participants subsequent response to irradiation depended on the statements they read *(Table 5)*. Among the single statements, the message of "Benefits" was the most persuasive; this implies that the participants responded more positively to statements about food safety benefits of irradiated food. When pairs of statements were presented, those including "Benefits" were more persuasive, while the most persuasive of all was the condition using all three statements *(Table 5)*. Consistent with this finding, significantly fewer participants responded negatively after the intervention "Benefits" only, intervention "Benefits + Authority", intervention "Benefits + Nutrition" and "Benefits + Nutrition + Authority" ($P < 0.01$) *(Table 6)*. In other words, these interventions increased participants' willingness to purchase irradiated food.

The "10% cheaper" question was asked to measure resistance to selecting irradiated food *(Table 5)*. About one-quarter (27%, n = 205) of participants chose not to buy irradiated food, even if it was 10% cheaper than non-irradiated food. Reasons for not selecting irradiated food *(Fig. 3)* were combined for all information statements, because there was no significant difference by message. The most common responses were: "I need more information before deciding" (78%) and "I already cook my food properly" (60%). Few viewed irradiation as not safe (2% total sample/6% refusers) and not natural (10% total sample/38% refusers).

DISCUSSION

Consumers understand that food containing harmful bacteria is 'dangerous', however, they can still make food handling errors, especially if their knowledge about foodborne pathogens is not complete. These findings confirmed the work by IFIC *(22)*, in that nearly half of the consumers thought food containing *Salmonella* or *E. coli* cannot be made safe. Similarly, Woodburn and colleagues reported that consumers said they would thoroughly cook food contaminated with bacteria to make it safe to eat (56% for *Salmonella* and 59% for *E. coli*) but 40% responded either that the foods couldn't be made safe or that they didn't know how to make it safe *(35)*. These findings confirm that consumers remain confused or misinformed about microbiological food safety.

In this study, a high percentage of consumer reported safe food handling practices. However, this could be a result of 'check-all-that-apply' question bias. Consumers answered the question to meet the researchers' expectation. For example,

Table 4. Familiarity with irradiation and willingness to purchase irradiated ground beef or poultry

Question	Ground Beef n = 228 %(n)	Poultry n = 537 %(n)	Total Sample n = 765 %(n)
Have you ever heard of irradiated food?			
Yes	41(93)	42(226)	41(314)
No	59(135)	58(311)	59(451)
Will you buy products labeled as below? (Yes answers)			
Irradiated Ground Beef (or Poultry)	17(38)	23(125)	21(163)
Ground Beef (or Poultry), cook to 160°F (or 165°F)	61(138)	67(360)	65(498)
Ground Beef (or Poultry)	84(192)	84(450)	84(642)
Willingness to buy irradiated ground beef/poultry if it were the same price per pound as non-irradiated ground beef/poultry.			
Yes	53(121)	55(297)	55(418)
Not Certain	39(88)	35(190)	36(278)
No	8(19)	9(50)	9(69)
Among those who said yes, willing to pay the same price	**n = 121 %(n)**	**n = 297 %(n)**	**n = 418 %(n)**
Willingness to buy irradiated ground beef/poultry, if it were 10% more expensive than non-irradiated ground beef/poultry.			
Yes	72(87)	66(197)	68(284)
No	28(34)	34(100)	32(134)
Among those who said yes, willing to pay 10% more	**n = 87 %(n)**	**n = 197 %(n)**	**n = 284 %(n)**
Willingness to buy irradiated ground beef/poultry, if it were 20% more expensive than non-irradiated ground beef/poultry.			
Yes	60(52)	53(105)	55(157)
No	40(35)	47(92)	45(127)

this study reported 87% of the participants properly store leftovers within 2 hours of serving. However, a previous study *(14)*, using a "choose-the-right-answer" question, showed that only 31% of people with diabetes and 40% of pregnant women knew that food should be stored within 2 hours of serving. Consumers tend to overestimate their safe food handling behavior when answering a survey question. This study showed a very high percentage (99%) of consumers reported that they wash their hands. However, based on results of a recent observational study *(6)*, less than 40% wash their hands before starting meal preparation and only 60% wash their hands after touching raw poultry.

Consumers tend to be very sensitive to certain food safety topics if a recent outbreak or food safety incident has been widely communicated. For example, in 2006, the *E. coli* O157:H7 outbreak traced to spinach, led consumers to reduce spinach purchases because of safety concerns. Arnade and colleagues *(3)* reported that over a period of sixty-eight

Table 5. Effect of messages on willingness to buy irradiated food

Questions	A* only n = 104 %(n)	N* only n = 106 %(n)	B* only n = 102 %(n)	A+N n = 106 %(n)	A+B n = 123 %(n)	N+B n = 102 %(n)	A+N+B n = 122 %(n)
Willingness to buy irradiated ground beef/poultry if it were the same price per pound as non-irradiated ground beef/poultry.							
Yes	61(63)	57(60)	72(73)	61(65)	67(82)	74(75)	70(86)
Not Certain	30(31)	32(34)	24(24)	25(27)	24(30)	18(18)	19(23)
No	10(10)	11(12)	5(5)	13(14)	9(11)	9(9)	11(13)
Among those who said no or not certain, willing to pay the same price	**n = 41 %(n)**	**n = 46 %(n)**	**n = 29 %(n)**	**n = 41 %(n)**	**n = 41 %(n)**	**n = 2 7 %(n)**	**n = 36 %(n)**
Willingness to buy irradiated ground beef/poultry, if it were 10% cheaper than non-irradiated ground beef / poultry.							
Yes	22(9)	28(13)	17(5)	20(8)	22(9)	11(3)	25(9)
No	78(32)	72(33)	83(24)	80(33)	78(32)	89(24)	75(27)
Among those who said yes, willing to pay the same price	**n = 63 %(n)**	**n = 60 %(n)**	**n = 73 %(n)**	**n = 65 %(n)**	**n = 82 %(n)**	**n = 75 %(n)**	**n = 86 %(n)**
Willingness to buy irradiated ground beef/poultry, if it were 10% more expensive than non-irradiated ground beef/poultry.							
Yes	65(41)	64(39)	76(55)	67(44)	65(53)	68(51)	70(61)
No	35(22)	36(21)	24(18)	33(21)	35(29)	32(24)	30(25)
Among those who said yes, willing to pay 10% more	**n = 41 %(n)**	**n = 39 %(n)**	**n = 55 %(n)**	**n = 44 %(n)**	**n = 53 %(n)**	**n = 51 %(n)**	**n = 61 %(n)**
Willingness to buy irradiated ground beef/poultry, if it were 20% more expensive than non-irradiated ground beef/poultry.							
Yes	56(23)	47(18)	58(32)	49(21)	53(28)	64(33)	66(40)
No	44(18)	53(21)	42(23)	51(22)	47(25)	36(18)	34(21)

A = "Authority"
B = "Benefit"
N = "Nutrition"

Table 6. Price premium participants would pay based upon message received

Price Alternative	A* only n = 104 %(n)	N* only n = 106 %(n)	B* only n = 102 %(n)	A+N n = 106 %(n)	A+B n = 123 %(n)	N+B n = 102 %(n)	A+N+B n = 122 %(n)
20% more	26(27)	21(22)	33(34)	23(24)	25(31)	33(34)	36(44)
10% more	19(20)	24(25)	25(25)	24(25)	23(28)	19(19)	19(23)
Only same price	15(16)	12(13)	14(14)	15(16)	19(23)	22(22)	16(19)
No or not certain, at the same price	39(41)	43(46)	28(29)	39(41)	33(41)	27(27)	30(36)
Baseline data	NS	NS	0.001	0.032	0.007	< 0.001	0.002

A = "Authority"
B = "Benefit"
N = "Nutrition"
NS = no significant difference from baseline data
Chi-square test was used to determine the significance level

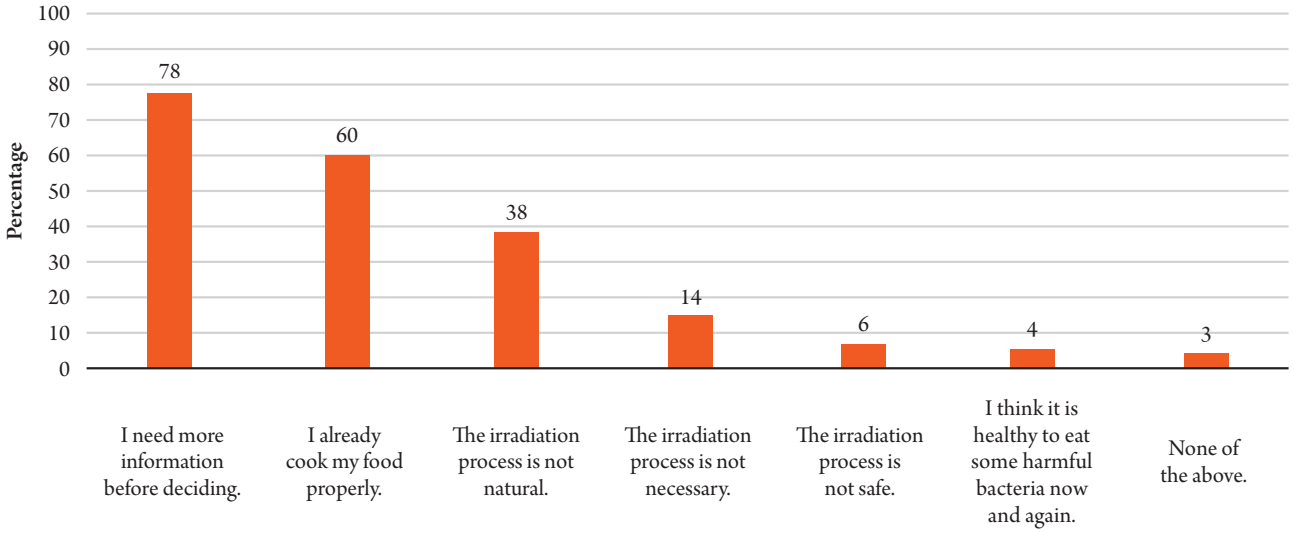

Figure 3. Reasons consumers (n = 205) chose not to buy irradiated food

weeks, retail expenditures decreased 20% for bagged spinach and 1% for bulk spinach. The Centers for Disease Control and Prevention (CDC) reported an outbreak of salmonellosis linked to a single poultry producer in 2013 which resulted in 134 cases and 33 hospitalization *(10)*. In this study, conducted in the spring of 2014, about 70% of participants thought poultry posed a greater food safety risk than ground beef. This may have been influenced by the 2013–2014 *Salmonella* outbreak linked to chicken products. Clearly, it is necessary to consider food safety coverage in the media when evaluating consumer sensitivity to potential hazards.

Consumers place the greatest trust in food safety information delivered by health professionals. This finding is similar to those of the 2013 and 2011 Food and Health Surveys *(21)*, in which health professionals received the highest trust for food safety information (93%), followed by friends and family (76%). Similarly, focus group studies found that consumers would benefit most by seeking advice from health experts who are trained and knowledgeable in the area of food safety, specifically for the populations that are highly susceptible to foodborne illness *(1, 7)*.

However, not all professionals are aware of their patients' increased vulnerability to foodborne illness, and many do not consider themselves experts in the area of food safety education. Wong and colleagues showed that nearly 40% of physicians were not confident in their general knowledge about foodborne illness *(34)*. A study in British Columbia indicated that most prenatal care providers were unaware that their pregnant consumers were at increased risk for listeriosis and did not provide food-safety education to them *(24)*. Even when the patients initiated the topic of food safety themselves, only around 40% of registered dietitians (RDs) and registered nurses (RNs) provided food safety education to high-risk consumers, such as pregnant women or immune-compromised patients *(7)*, and fewer than 10% of RDs and RNs used structured classes or videos to provide education to pregnant patients. This suggests that while health professionals are a trusted source of information, as a group they do not appear to be actively engaging in food safety education communication.

Information describing the "benefits of food irradiation," including eliminating harmful bacteria, was the most effective in changing consumers' perception of irradiated food. The messages addressing consumers' most frequent questions, including reassurances regarding induced radioactivity and nutritional quality, were less effective than statements describing the benefits of irradiation, but better than information about authorities who endorse food irradiation. This suggests that reassurances may have sensitized consumers to possible issues with the technology. The findings are consistent with those of Frenzen and colleagues *(17)*, who found that insufficient information about the risks and benefits and safety concerns are major factors driving consumers' reluctance to buy irradiated food.

Among all reasons consumers chose not to buy irradiated food, "I need more information before deciding" ranked as the most frequent. Fewer participants viewed irradiation as not safe and not natural. This suggests that most consumers who would not buy irradiated food were still open to information. Future research should explore the type and sources of information these consumers are seeking. Many participants believed irradiation was not necessary, because they thought they were already cooking and preparing food adequately. However, previous observational studies *(6, 8, 27)* showed that consumers tended to over estimate their food handling knowledge and practices.

That relatively few people indicate that they will not purchase irradiated food is consistent with the 2009 findings from IFIC, which revealed that only 13% of 1000 consumers were not interesting in buying irradiated food. When asked what information could improve their opinions about food irradiation, around 30% responded positively to the statements, "Irradiated foods are not radioactive" and "food irradiation eliminates harmful bacteria, insects and molds that can make you sick." Messages as to agency approval were less effective in changing perceptions. That the FDA has approved food irradiation increased interest among 22% of respondents, and that food irradiation is approved in over 40 countries worldwide, including the US' increased interest among 26% *(21)*. That approval from authorities or government agencies did not affect consumers' decision as much as the other information may reflect trust in information sources and the desire to decide independently. In this study, government was not considered the more trustworthy source of food safety information. Consumers today appear to prefer to seek information and make decisions by themselves instead of relying solely on government agencies. Previous research by the Center for Food Integrity (CFI) showed that consumers placed the greatest trust in organizations that shared their personal values. Competency alone was less effective. To build trust, CFI recommends that the food system demonstrate that while the use of technology has increased, the food industry is committed to offering safe food *(9)*.

Irradiation provides extra protection to consumers from foodborne illness. The information about food irradiation should be more accessible to consumers and health professionals. Health professionals, as a trusted source of information, have a role to play in communicating information about potential benefits and risks. Wider availability of science-based information on foodborne pathogens and methods to reduce risk can help consumers make decision on irradiated food purchasing and in turn, lead the food industry toward greater use of this safety-enhancing technology.

The participants of this study were recruited from two large metropolitan areas. While it is assumed that the individuals responding represent consumers in general, there may be differences in attitudes between this sample and general population. There could also be specific subgroups whose views toward foodborne illness and technological innovations differ.

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