Chapter 10

CONSUMER ACCEPTANCE AND MARKETING OF IRRADIATED FOODS

Ronald F. Eustice[1] and Christine M. Bruhn[2]
[1]Minnesota Beef Council, Minneapolis, USA
[2]Center for Consumer Research, Department of Food Science & Technology, University of California, Davis, USA

Abstract: Public concern about food safety has increased. Despite efforts to control food spoilage and improve safety, food microbiological hazards still exist. Meat and poultry account for a large number of foodborne illnesses and deaths; however, the amount of illness related to pathogens in produce now is greater. Educating consumers about the risks involved with improper handling and cooking of raw meat and poultry may help reduce foodborne illness; however, some consumers are unaware of recommended practices or unwilling to improve their food preparation methods. Food eaten raw, such as lettuce or spinach, lack a pathogen-kill step. Food irradiation can enhance safety by reducing or eliminating microorganisms that contaminate food or cause spoilage. Demand for irradiated food products depends on acceptance by consumers. Although public knowledge about irradiation continues to be limited, interest in purchasing safety-enhanced irradiated food is increasing, especially after people receive information about potential benefits and risks. While negative information about irradiation reduces willingness to buy, generally the more consumers know about this technology, the more willing they are to embrace it. Even a minimal presentation of the facts related to food irradiation can lead to a significantly greater support for this technology. A public education program originating in Minnesota demonstrates the positive impact of an educational program coupled with market availability of irradiated food.

Food Irradiation Research and Technology, Second Edition. Edited by Xuetong Fan and Christopher H. Sommers.

Published 2013 by Blackwell Publishing.

Keywords: consumer acceptance; disinfestation; *Escherichia coli* O157:H7; electron beam; foodborne illness; foodborne pathogens; gamma rays; ground beef; irradiation; postharvest interventions; preharvest interventions; shelf-life extension; sterilization; radura; *Salmonella*; X-rays

Introduction

Food irradiation, sometimes called "cold pasteurization," has been described as the "most extensively studied food processing technology in the history of humankind" and is endorsed or supported by virtually all medical and scientific organizations (see Table 10.1), yet the process is still considered a relatively "new" technology.

Irradiation is approved in more than 50 countries around the globe for a wide variety of food products (ICGFI 2005). Irradiation has been widely used to reduce contamination of spices, herbs, and botanicals for many years. During the past decade the interest in food irradiation has increased dramatically because of its potential to reduce or eliminate pathogenic bacteria and its effectiveness as a disinfestation tool. These two separate forces are currently driving the worldwide momentum towards commercial use of food irradiation.

What Is Food Irradiation?

Food irradiation is the treatment of foods by exposing them to a controlled amount of ionizing energy for a specific amount of time to achieve certain technical objectives. Food is irradiated in a special processing facility where it is exposed to gamma rays, electron beams, or X-rays. The food is closely monitored to assure that the exact dosage or treatment level is achieved. When used in this manner, irradiation is comparable to pasteurization of milk, in that the product is left fresh but much safer.

Why Is Food Irradiated?

Irradiation kills harmful bacteria and other organisms in meat, poultry, and seafood, disinfests spices, extends shelf life of fresh fruits and vegetables, and controls sprouting in tubers and bulbs such as potatoes and onions. For example, very small amounts of ionizing energy are used to eliminate insect pests from fruit, somewhat greater amounts are used on meat or poultry to kill harmful bacteria, and significantly higher amounts are

Table 10.1. List of organizations that approve or endorse irradiation.

American Council on Science and Health
American Dietetic Association
American Farm Bureau Federation
American Feed Industry Association
American Meat Institute
American Medical Association
American Veterinary Medical Association
Animal Health Institute
Apple Processors Association
Centers for Disease Control & Prevention
Chocolate Manufacturers Association
Codex Alimentarius
Council for Agricultural Science and Technology
Florida Fruit and Vegetable Association
Food and Drug Administration
Food Distributors International
Food and Agriculture Organization (FAO)
Grocery Manufacturers of America
Health Physics Society
Institute of Food Science & Technology
Institute of Food Technologists
International Atomic Energy Agency
International Food Information Council (IFIC)
The Mayo Clinic
Millers' National Federation
National Confectioners' Association
National Cattlemen's Beef Association
National Food Processors Association
National Fisheries Institute
National Meat Association
National Food Processors Association
National Turkey Federation
National Pork Producers Council
Northwest Horticulture Association
Produce Marketing Association
Scientific Committee of the European Union
United Egg Association
United Fresh Fruit & Vegetable Association
United Egg Producers
United Kingdom Institute of Food Science & Technology
United States Chamber of Commerce
US Department of Agriculture
Western Growers Association
World Health Organization (WHO)

used to fully sterilize food. Irradiation complements good manufacturing practices without compromising food quality or nutrition.

Marketing of Irradiation Foods

During the past decade a steadily increasing amount of irradiated food has entered commercial channels. Although irradiated fruits, vegetables, and poultry have been available commercially on a limited basis since the early 1990s, the introduction of irradiated ground beef in Minnesota during May 2000 significantly increased awareness and interest in the technology. According to Jim Jones, Food Tech Services, Mulberry, FL, approximately 15–18 million pounds of irradiated ground beef and poultry were marketed in the United States during 2011. The volume of irradiated meat and poultry sold in the United States has remained steady during recent years. Irradiated ground beef is available from several retail outlets including Wegman's Food Markets in the Northeast US, Publix in the Southeast, nationally through Schwan's home delivery service, and by mail order and retail sale through Nebraska-based Omaha Steaks.

Estimates are that some 30-35 million pounds of irradiated fruits and vegetables, mainly mango, mangosteen, papaya, and guava, are sold annually by US retailers. Hawaii Pride based in Keeau, Hawaii, exports more than 10 million pounds of irradiated produce annually including papayas, rambutan, star fruit, purple sweet potatoes, and bananas to major supermarkets on the US mainland.

USDA Framework Equivalency Work Plans (FEWPs) have been signed with nine countries including India, Mexico, Thailand, Viet Nam, Laos, South Africa, Pakistan, Philippines, and Malaysia. These agreements allow importation into the United States of produce from cooperating countries that was previously prohibited due to the risk of importing pests along with the produce.

Mangoes from India have been available at selected stores in the United States since 2007. Irradiated mangosteen from Thailand and dragon fruit from Viet Nam are also starting to appear at Asian specialty stores nationwide. In early 2009, Mexico began to export irradiated guavas to the United States after that product received USDA approval in October 2008. Irradiated mangoes from Mexico began to enter the US market in early 2009. Certain specialty mangoes cannot stand hot water treatment phytosanitary procedures and as a consequence must be irradiated.

The availability of irradiated produce will increase due to an expanding market for tropical produce from Asian countries. Although irradiation was approved by the US FDA for spinach and iceberg lettuce, use of the

technology for this application has not commenced, probably because lettuce for the consumer market is packaged with small amounts of other vegetables, like carrots and cabbage (FDA 2008). These items have not been approved by FDA at the dose used to destroy pathogens.

Spices have been commercially irradiated since 1986. Approximately one-third of the commercial spices consumed in the United States, some 80 000 metric tons (175 000 000 lbs), are irradiated annually, according to John Masefield, Executive Advisor of Steris IsoMedix Services, Mentor, Ohio.

Commercial Acceptance of Irradiation Foods

Despite widespread media attention from food recalls, serious illness, and death, food irradiation technology remains underutilized and sometimes misunderstood.

Acceptance of irradiation has been slowed by several factors (Osterholm and Norgan 2004). First, the term "irradiation" is sometimes confusing or alarming to consumers because of its perceived association with radioactivity. Second, the causes, incidence, and prevention of foodborne disease are poorly understood by the general public. Third, health professionals and the media are largely unaware of the benefits of food irradiation. Finally, an anti-irradiation campaign has been conducted by certain special interest groups because of their beliefs about food production issues, nuclear power, international trade, and industrialization, as well as their resistance to the introduction of technologies.

Many innovations, even those with obvious advantages, require a lengthy period of time between when they become available and when they are widely accepted (Rogers 1983).

Technologies such as pasteurization, immunization, and chlorination are now considered by experts to be "pillars of public health," yet each of these lifesaving innovations was met with suspicion and resistance when first introduced.

Although Louis Pasteur discovered that bacteria could be eliminated by heating during the 1850s, he did not live long enough to realize the impact resulting from his discovery. As late as the 1930s, many in the dairy industry resisted pasteurization. One of multiple concerns expressed was that the promotion of pasteurized milk would cast a negative shadow over the nonpasteurized product and force milk handlers to install "expensive" equipment to pasteurize milk.

During the 1920s, the US dairy industry and insurance companies were promoting so-called certified raw milk as a more acceptable alternative to

pasteurization (Metropolitan Life Insurance Company 1923). It was only through the insistence of medical and scientific groups and government regulators that the dairy industry abandoned its "good milk" versus "bad milk" concerns and embraced pasteurization as a lifesaving technology that would help to make all milk safe.

Pasteurization took nearly 70 years to be fully accepted in the United States, and the arguments against it were almost identical to those used today against food irradiation (Hall and Trout 1968). Among some 70 concerns raised by the critics of pasteurization were the following:

- "We must not meddle with nature."
- "This process changes the properties of the food."
- "Dangerous substances could be formed."
- "This process could be carelessly done and accidents could happen."
- "Pasteurization will increase the price of the product. We have a direct and prompt food distribution system."
- "It is not necessary."

None of these doomsday predictions turned out to be true; however, the campaign against pasteurization, including resistance from dairy producers and processors, significantly delayed its introduction, with the effect that thousands of people suffered chronic illness, developed long-term health consequences, or died. The question of legal responsibility for inflicting this suffering was never explored.

Resistance to "New" Technology

It is human nature to resist change and to fear the "unknown." Exploration of the "new world" was stifled by critics who believed the earth was flat. Arguments against constructive change take many forms. University of Houston economics professor and noted author Thomas R. DeGregori says:

> One common argument against change is the search for a *riskless* alternative. Every change has its risks; some real, others imagined. Whether a change is political, scientific, or technological, a simple assertion of risk should not in and of itself be an argument against that change. We must measure the benefits of change against the risks of not changing.
>
> DeGregori 2002

Impossible demands for a zero-risk society are often made by those who wish to maintain the status quo and convince others that the risks

outweigh benefits. Those who choose to believe that the earth is flat despite overwhelming scientific evidence to the contrary have every right to do so. Christopher Columbus and other explorers faced a multitude of risks, but their ships did not drop off the edge of the earth even though many believed that the earth was flat.

In a free society, proponents of the "Flat Earth Theory" have a right to their own set of opinions, but those opinions do not alter the fact that the earth is demonstrably and unequivocally spherical.

Risks versus Benefits

DeGregori says:

> If we examine the many changes over the past century—changes that have reduced infant and child mortality by more than 90%, have given Americans nearly 30 years of added life expectancy, have recently caused an even more rapid growth in disability-free years of life, and have allowed comparable or greater advances in other countries—we will find that all those changes carried risks.

Technologies such as chlorination of water, pasteurization of milk, application of synthetic fertilizers, chemical pesticides, modern medicine, genetically enhanced organisms, immunization, and irradiation, to name a few, all faced and continue to face various levels of opposition. Most cities use chlorine to purify their water, most parents want their children immunized against dreaded diseases, and very few people would consider drinking unpasteurized (raw) milk because of the known risks. Yet, these lifesaving technologies all have their risks. Chlorine is toxic, and immunization can sometimes cause the disease it was intended to prevent. Pasteurized milk tastes different than milk straight from the cow, can be recontaminated, and will spoil if not refrigerated. By comparison, the risks of irradiation, if there are any, are "unknown" because after years of study, scientists have not found any (Wisconsin State Journal Editorial Board 2003). Weigh that against the known risks of contracting bacterial illnesses from the consumption of food that harbors unseen pathogens.

World's Safest Food Supply, But Not Safe Enough

In early 2009, Dr. Robert Tauxe, MD, MPH, deputy director of US Centers for Disease (CDCs) Division of Foodborne, Bacterial and Mycotic Diseases

reported the progress to reduce foodborne illness in the United States had reached a plateau. Tauxe said:

> We recognize that we have reached a plateau in the prevention of foodborne disease and there must be new efforts to develop and evaluate food safety practices from farm to table.

The meat and poultry industry's surveillance and intervention efforts have reduced, but not eliminated, microbial contamination of meat and poultry carcasses (http://www.fsis.usda.gov/Science/Ecoli_Raw_Beef_Testing_Data_YTD/index.asp). The number of ground beef samples testing positive to *Escherichia coli* O157:H7 has decreased but emerging non-O157 serotypes of E. coli are beginning to be a food safety problem. Salmonella is a significant problem in poultry and ground beef and the US Centers for Disease Control reports that progress has stalled in reducing the incidence of this pathogen.

If contaminated ground beef is not properly cooked to 71°C (160°F), it can cause serious injury or death. Furthermore, pathogens that may be on the meat could potentially contaminate other foods in the kitchen. If the product were irradiated, the pathogens would be destroyed before entering the home or food service kitchen.

The situation becomes more serious when we consider recent research by FDA/FSIS that shows that although some 60% of households have a meat thermometer, only 6% of US consumers report using it often or always (Cates 2002). Research at Utah State University further confirms this data (Anderson et al. 2004). The study, completed in 2003 and published in the *Journal of the American Dietetic Association*, showed that only 5 of 99 participants used a thermometer to determine doneness of meat, poultry, or seafood and only 6 of those who owned a thermometer reported using it often/always. Nearly half of study participants reported not knowing the recommended cooking temperature for chicken (43%) and ground beef (44%).

Recent widely publicized recalls of fresh spinach, jalapeño peppers, iceberg lettuce, peanut paste, pistachios, alfalfa sprouts, and other vegetables have damaged the produce industry's reputation and cost the food companies many millions of dollars in lost sales. It is not unusual for a company to be forced out of business following a serious food safety incident because of the cost of product recalls, resulting victim claims and litigation. It is imperative that the food industry further enhances efforts to provide the public with the protection they expect and deserve against foodborne illness.

Irradiation: A Powerful and Effective Tool to Improve Food Safety

Although irradiation cannot prevent primary contamination, it is the most effective tool available to significantly reduce or eliminate harmful bacteria in raw product and make sure that contaminated meat and produce does not reach the marketplace. At doses that are commonly used, we can expect pathogen reduction of 99–99.999% depending on product and applied dosage.

Food irradiation has the potential to dramatically decrease the incidence of foodborne disease and has earned virtually unanimous support or approval from international and national medical, scientific, and public health organizations, as well as food processors and related industry groups. Dr. Robert Tauxe of the US Centers for Disease Control and Prevention estimates that if 50% of poultry, ground beef, pork, and processed meats in the United States were irradiated, the potential benefit of the irradiation would be a 25% reduction in the morbidity and mortality rate caused by these infections. This estimated net benefit is substantial; the measure could prevent nearly 900 000 cases of infection, 8500 hospitalizations, more than 6000 catastrophic illnesses, and over 400 deaths each year (Tauxe 2001). Given the probable number of unreported and undetected foodborne illnesses, this reduction is likely to be even greater (Table 10.2).

Table 10.2. Food irradiation: potential annual public health benefits by specific pathogen.

Pathogen	Prevented cases	Prevented hospitalizations	Prevented major complications	Prevented deaths
E. coli O157:H7 and other STEC	23 000	700	250 HUS cases	20
Campylobacter	500 000	2 600	250 GBS cases	25
Salmonella	330 000	4 000	6 000 RA cases	140
Listeria	625	575	60 miscarriages	125
Toxoplasma	28 000	625	100–1 000 cases Cong. toxo	94
Total	881 625	8 500	6 660 major illnesses	404

Source: Tauxe (2001).

The globalization of trade in food and agricultural commodities and the increasing demand for food safety and security from "Farm to Fork" represent new challenges to the food industry (Satin 2003). Morton Satin, former Chief of Food and Agro-Industries, FAO, Rome, Italy, describes the dismantling of national barriers to trade as opportunities for greater efficiencies in economic growth, but says that as free trade increases, foodborne disease organisms cross international borders with relative impunity. Satin says:

> Pathogens journey along with finished food products, raw agricultural commodities, handlers, travelers, and hidden insects. When one considers that these organisms travel with the tiniest particles of dust carried in the wind and are easily swept along international waterways, it is apparent that even the most rigorous quarantine procedures cannot prevent the movement of foodborne pathogens between countries. Routine use of irradiation of fruits, vegetables, and raw meat at border crossings should be seriously considered as an intervention strategy.

Education: The Key to Consumer Acceptance

Numerous consumer studies clearly show that when given a choice and even a small amount of accurate information, consumers are not only willing to buy irradiated foods but also often prefer them over food treated by conventional means. A variety of market research studies conducted over the past two decades repeatedly demonstrate that 80–90% of consumers will choose irradiated products over nonirradiated after they hear the facts and understand the benefits.

In a 1995–1996 University of California, Davis, study, interest in buying irradiated foods among California and Indiana consumers increased from 57% to 82% after seeing a 10-minute video describing irradiation.

A survey conducted for the Foodborne Disease Active Surveillance Network in 2000 found that about half of the consumers at FoodNet sites said they would buy irradiated ground beef or chicken, and a fourth would pay a premium (Frezen et al. 2000). Attitude surveys and simulated market trials associated with educational programs report acceptance levels for irradiated meat and poultry at 70–90% or more (Aiew et al. 2003; Fox 2002; Martin and Albrecht 2003; Pohlman et al. 1994; Zienkewicz and Penner 2004).

A 2001 study funded by the Cattlemen's Beef Board (CBB) (National Cattlemen's Beef Association 2002) showed that consumer acceptance of irradiated ground beef is growing. The study, which measured consumer

perceptions about irradiated ground beef, revealed a sizeable potential market for the product. Researchers found that a person's acceptance of irradiated beef was greatly influenced by initial perceptions. Four consumer segments were identified: (1) strong buyers (27% of the test group), (2) interested (34%), (3) doubters (24%), and (4) rejecters (15%). The first three were identified as potential markets for irradiated ground beef, and the study suggested that by implementing consumer education programs and continuing product quality research, the market for irradiated ground beef should continue to grow. Nearly all the "strong buyers" were ready to buy irradiated ground beef before the study, more likely to buy it after trying it, and willing to pay 10 cents a pound more for it. The "rejecter" segment snubbed placebo ground beef patties—nonirradiated burgers that were labeled as irradiated in the study—as often as the irradiated patties. The study said that no amount of information would convince this group, which generally rejects any new product.

A spring 2002 study by Texas A & M University (TAMU) (Aiew et al. 2003) investigated Texas consumers' knowledge and acceptance of food irradiation and the effects of information about food irradiation on consumer acceptance and willingness to pay for irradiated ground beef (Figure 10.1).

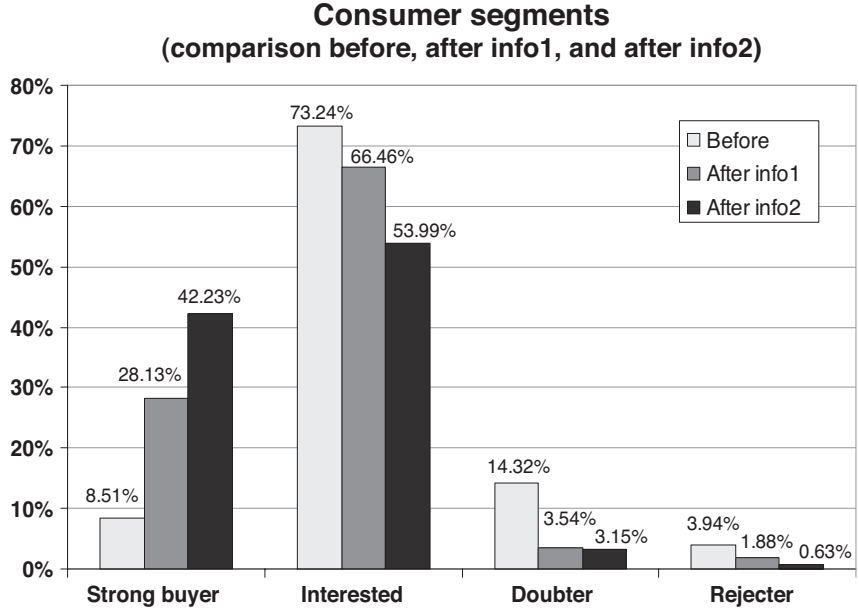

Figure 10.1. Consumer willingness to buy and pay for irradiated ground beef (Aiew et al. 2003; reprinted with permission).

Before the presentation of any information in the TAMU study, about half of the respondents indicated a willingness to purchase irradiated ground beef. After receiving information about food irradiation, 88.5% of the respondents were willing purchasers. Even more (94.12%) indicated a willingness to buy irradiated ground beef after a second set of information on food irradiation was presented. The willingness-to-buy percentages in the Texas A & M study appears higher than estimates from the FoodNet Population Survey (1998–1999) conducted by the Centers for Disease Control and Prevention (CDC). The CDC also estimate that at least half of consumers will buy irradiated food, if given a choice between irradiated and nonirradiated; also, if consumers are first educated about irradiation, about 80% will buy irradiated products.

Scientists at the University of Georgia conducted a survey to determine current consumer attitudes toward irradiation after consuming irradiated ready-to-eat poultry meat products and to evaluate differences in consumer acceptance, if any, over a 10-year period (1993 versus 2003) (Johnson et al. 2004). Surveys were completed by 50 consumers in the metro-Atlanta area. More than twice as many consumers were willing to buy irradiated products in 2003 than in 1993 (69% and 29%, respectively). The majority (66%) of the respondents were aware of irradiation; among these, 71% indicated that they were either "somewhat informed" or "had heard about irradiation, but do not know much about it." Consumers in both studies expressed more concern for pesticide and animal residues, growth hormones, food additives, bacteria, and naturally occurring toxins than irradiation. Consumers expressed slight concern regarding irradiation; however, this concern had decreased significantly over the past 10 years. Approximately 76% preferred to buy irradiated pork and 68% preferred to buy irradiated poultry to decrease the probability of illness from *Trichinella* and *Salmonella,* respectively.

The University of Georgia study also found that a fourth (24–25%) of all consumers said they would buy more beef, poultry, and pork if these were irradiated and labeled. This figure reflects an 80–85% increase, over the 10-year period, in the number of consumers who would buy more poultry and beef, respectively.

Jefferson Davis Associates (2003) showed that 68% of 396 respondents in six Midwestern states were aware of irradiation and 78% considered irradiated ground beef a "good thing." Vickers and Wang tested the overall taste likeness, toughness, flavor, and texture of irradiated and nonirradiated ground beef and found equal preference for both samples. Subjects rated the irradiated beef patties juicier than the nonirradiated ground beef and found flavor, texture, and toughness equal for both samples.

Benefit information and sample identification increased the hedonic attribute ratings of the patties, when compared with the group that received no benefit information and no sample identification.

An information program delivered to a sample of 300 consumers in California found most had not heard about irradiation despite recent discussions of the technology by the state legislature (Bhumiratana et al. 2007). The program increased awareness of harmful bacteria and the risk of foodborne illness. Only 3% of participants were opposed to irradiation, over 60% indicated they would choose irradiated products, and almost 40% said they would pay a premium for irradiated meat.

The results of dozens of studies at leading universities consistently show that information about the nature and benefits of irradiation is a major factor affecting consumers' perception of and attitudes toward irradiated foods. The findings reflect the importance of educating the public about the hazards of foodborne pathogens and the potential benefits of consuming irradiated foods. Studies consistently show that information plays an important role in consumer buying decisions, and consumers are generally receptive to irradiated foods when the benefits of irradiation are explained. Negative information about the process can reduce demand for irradiated foods, but that negative information can be honestly and effectively countered.

Effect of Unfavorable Information

Fox et al. (2001) describe how consumers respond to the presence of unfavorable information about food irradiation. In a choice experiment, 87 consumers were given a typical pork sandwich and asked to bid in a repeated auction for an upgrade to an irradiated pork sandwich. Participants were required to consume either the typical or the irradiated pork at the end of the experiment, and the auction was nonhypothetical—that is, the winner was required to pay for the upgrade to the irradiated pork. For the first five of a total of 10 rounds in the auction, participants were provided with a description of irradiation based on Food and Drug Administration information. Based on that description, approximately 60% of participants bid some amount to upgrade from a typical to an irradiated pork sandwich.

The same participants were then provided with either a favorable or unfavorable description of irradiation, or both simultaneously. The favorable description (from the American Council on Science and Health) emphasized the benefits and safety of the process and its contribution

to controlling foodborne illness. The unfavorable description (from Food & Water, Inc., a Vermont-based anti-irradiation advocacy group) falsely claimed that irradiation produced carcinogens called radiolytic products, that it caused vitamin losses, that it would eliminate warning signs of *botulin toxin*, and that the use of radioactive materials would put workers and nearby communities at risk.

As expected, the favorable description alone resulted in more bids to upgrade to irradiated pork and the unfavorable description alone caused bids to decrease. When given only the favorable description, close to 90% of the participants bid for the upgrade to the irradiated product. Among those who were given only the unfavorable description, the proportion bidding for irradiated pork fell from 60% to 10–15%. But the disappointing result was that when subjects were provided with both sets of information, the effect of negative information dominated that of the positive and the proportion bidding for irradiated pork fell by approximately 20 percentage points. In fact, of 50 subjects who received both descriptions, only one subsequently submitted a higher bid to obtain an irradiated pork sandwich.

Can Unfavorable Information Be Counteracted?

The results mentioned in Section "Effect of Unfavorable Information" demonstrate how negative information tends to dominate positive information and illustrates the need to honestly and aggressively counter false claims. Assuming that consumers will be exposed to unfavorable information about irradiation, this suggests that it is not sufficient for industry to promote food irradiation only on its own merits; it will also need to counter the claims made by opponents. The question then is whether the anti-irradiation message can be effectively countered—that is, whether consumers, once exposed to anti-irradiation propaganda, can be reassured about the technology.

To address that question, investigators conducted experiments in which consumers could purchase irradiated or nonirradiated chicken breasts. In the experiments (Shogren et al. 1999; Fox 2002; Fox et al. 2001), 96 consumers were provided with a US Department of Agriculture brochure describing the food irradiation process and then asked to make a purchase choice between irradiated or nonirradiated (typical) chicken breasts. When all subjects had made their decision, they purchased and paid for the product they had chosen—and 79% purchased irradiated chicken.

The participants were then provided with a copy of the unfavorable description of irradiation used in the earlier experiment and asked whether, if allowed, they would make a different purchase decision—and the proportion choosing irradiated chicken fell to 43%.

Investigators were then interested to find out whether the negative claims could be countered and if confidence in the irradiated product could be restored. To counter the negative information, investigators used a televised report on food irradiation hosted by John Stossel of ABC News for the 20/20 news program. The report, entitled "The Power of Fear," first broadcast on 13 December 1991, focused on protests at a food irradiation facility in Florida. Stossel interviewed the plant's developer and representatives of Food & Water, Inc. who were leading the protest. The report concluded that food irradiation was a safe process, and Stossel indicated that, given the choice, he would actually prefer irradiated to nonirradiated meat. Furthermore, the report concluded that many of the claims made by Food & Water, Inc. were at best misleading or based on irrelevant science.

Following the video segment, the investigators emphasized to the participants that (1) irradiated foods do not become radioactive; (2) radiolytic products, similar to those produced by irradiation, were also produced when foods were grilled or fried; (3) no studies had shown a connection between food irradiation and cancer or birth defects; (4) vitamin losses were insignificant and lower than those found in processes such as canning or freezing; (5) irradiation at approved doses did not sterilize food and spoilage warning signs were not lost; (6) there were no links between food irradiation and nuclear weapons or nuclear power; and (7) irradiation had been used to sterilize medical devices and consumer products for several decades with no problems related to the use or transportation of radioactive materials. Once again, investigators asked consumers to indicate what their purchase decision would be if they were allowed to repeat it—and 82% said they would choose irradiated chicken.

Consumer attitudes toward technologies may be influenced by sources of information. Teisl et al. (2009) found people who claimed to know about organic methods also considered themselves knowledgeable about irradiation. This is a concern in that those promoting organic often speak negatively about irradiation. Nevertheless, consumers surveyed saw a positive value of irradiation in that it reduces the danger of bacterial contamination.

These results illustrate that although the anti-irradiation message is powerful, it can be effectively counteracted and confidence in the safety of the irradiation process can be restored.

Effects of Gender, Income, and Children

Studies examining the effects of demographics on decisions to purchase irradiated food have found some consistent results. Typically, they find that females are more concerned about irradiation than males and, in most but not all cases, that individuals with more formal education are more accepting of the technology. Regarding the effects of age and income, results are mixed and generally not statistically significant (Lusk et al. 1999).

To determine the effect of gender, household income, and the presence of children, Fox (2002) examined results from two studies. First, the set of experiments referred to previously in which consumers were exposed in sequence to positive, negative, and again positive information was examined, and the consumers were classified into different categories. Second, the results from a mail survey in which respondents made similar, albeit hypothetical, choices about purchasing irradiated chicken were examined.

First, consistent with the results of other studies, males were more likely to be classified as proponents of irradiation. Second, the presence of children under 18 is associated with opposition to irradiation. Frezen et al. (2000) also reported a negative impact associated with the presence of children (under age 5), but their result was not statistically significant at the traditionally reported levels.

Most studies find higher education associated with more favorable attitudes toward irradiation. It is worth noting that the effect of more education in the Kansas study showed more highly educated consumers more likely to be either "opponents" or "proponents" and less likely to be classified as "undecided." This result is intuitively appealing because one does not generally associate opposition to technology with less education, and it may also explain why other studies do not always find a consistent linear impact for education.

Finally, age of the respondent has no effect on classification, and, as expected, the higher the perceived risk from nonirradiated chicken, the more likely one is to be a proponent of irradiation.

Barriers to Acceptance

The most significant obstacle to increased consumer acceptance of irradiated foods may well be the lack of availability in the marketplace. A survey of retail and foodservice beef purchasers was conducted in January and February 2004 by the National Cattlemen's Beef Association to

measure awareness of, and attitudes toward, irradiation technology among foodservice and retail establishments that do and do not offer irradiated beef, measure the willingness to offer irradiated ground beef among those that do not offer it, identify barriers/issues to offering irradiated ground beef including researchable knowledge gaps, and both identify successful retailers and determine which practices help them sell this product (National Cattlemen's Beef Association 2004).

The study showed that about four in ten knowledgeable past users and nonusers of irradiated ground beef reported lack of availability as the main reason for not offering irradiated ground beef to their customers. This same study showed that respondents were relatively positive about purchasing irradiated ground beef. Almost half of past users were very (14%) or somewhat (33%) likely to purchase the product within the next year, and more than a fourth of the knowledgeable nonusers were very (4%) or somewhat (23%) likely to do so. In addition, a majority of the current purchasers (58%) indicated they would increase the amount of irradiated ground beef they would buy (versus 23% intending to decrease the amount). These data show a growing rather than a shrinking market.

The "Minnesota Model" of Consumer Acceptance

Studies clearly show that an overwhelming majority of educated consumers will buy and in many cases prefer irradiated food products. These studies also point out a growing need to educate the public about the benefits of irradiation. The educational effort that began in Minnesota during the fall of 1997 has helped pave the way toward the successful introduction of irradiated ground beef and other foods not only in the United States but also in a growing number of foreign countries.

Following the largest recall of ground beef in history, Minnesota health experts, beef industry officials, and educators began to present consumers, opinion leaders, and others with facts and solid science about irradiation through a series of educational activities, product sampling demonstrations, information workshops, press releases, and media interviews. For example, in 1998, when John Glenn flew into outer space on Shuttle Discovery to help research how weightlessness affects the body of an older person, the Minnesota Beef Council sent out a press release calling attention to the fact that NASA has served irradiated foods on space shuttles since 1972.

A team of experts from the Minnesota Department of Health, the University of Minnesota, and the food industry were quick to hold the critics accountable by challenging misinformation, half truths, and distorted

information about irradiation through letters to the editor, opinion pieces, and media interviews.

No opportunity was missed to serve samples of irradiated ground beef and inform the public about the benefits of food irradiation. More than 2 000 000 samples of irradiated ground beef have been served to consumers at various events in Minnesota and 30 other states since 1999. An Irradiated Ground Beef Education Initiative was conducted by the American National Cattlewomen during 2003 and 2004. The project involved product sampling and educational activities at women's expos, food shows, and other events to increase the knowledge of irradiated ground beef. More than 260 000 consumers/influencers were reached at 61 events in 20 states. Survey results were obtained from over 7000 respondents and showed the following:

- The majority of respondents (74% of 4668) correctly said that irradiation does not eliminate the necessity for safe food handling practices.
- The overwhelming majority (87% of 4603) of respondents correctly stated that irradiation does not change the nutritional value of ground beef.
- Ninety percent of 4463 respondents correctly said that irradiation raises the food safety level of ground beef.
- An unexpected finding was that almost half of respondents (46% of 4728) did not know the proper cooking temperature for ground beef.
- About 98% of respondents (3286 out of a total of 3347) at 25 events tabulated rated the taste of the irradiated ground beef samples with a positive score. The most frequent response was Good (1382), followed by Great (335), Tasty/Very Good (186), and Excellent (168). A neutral score was given by 48 respondents (1.4%) with 22 respondents rating the product as Average. Negative evaluations were given by 25 individuals (0.7%). The average score was 8.2 on a 10-point scale.

These informal taste tests combined with research at the University of Minnesota (Vickers and Wang 2002) have clearly demonstrated that irradiated ground beef is just as flavorful as typical, nonirradiated ground beef.

A survey conducted at the 2001 Minnesota State Fair showed that only 39% of 201 participants would buy irradiated ground beef without sampling it first. After tasting the irradiated ground beef at the state fair, 89% said they would be willing to purchase irradiated ground beef. The importance of education, product sampling, and public/private partnerships is further confirmed by the previously mentioned Jefferson Davis Associates study (Shogren et al. 1999) showing that 85% of Minnesota

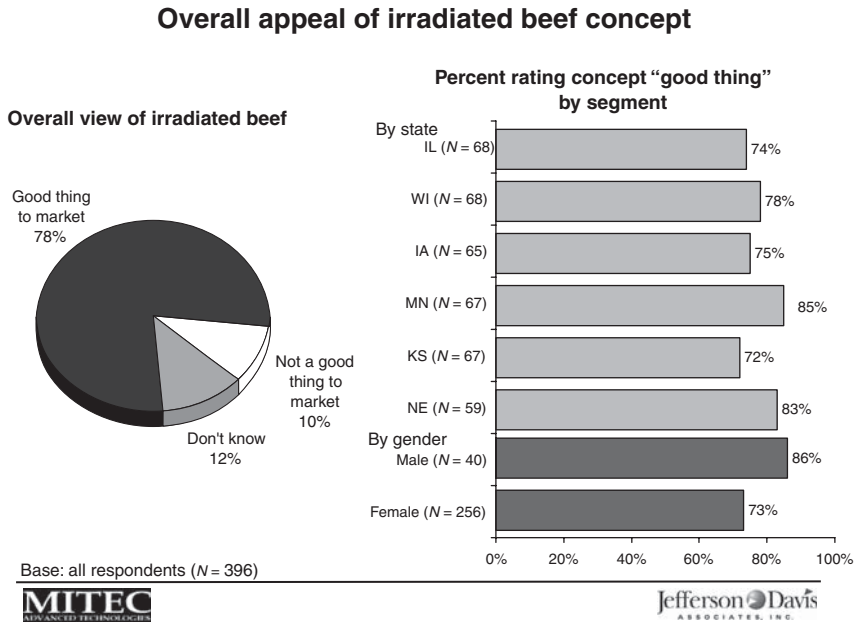

Figure 10.2. Overall appeal of irradiated beef concept.

respondents consider irradiated ground beef a "good thing," compared to 78% overall (Figure 10.2). Irradiation education continues to be a major focus of a cooperative effort between the Minnesota Department of Health, the Minnesota Beef Research & Promotion Council, and ground beef manufacturers.

A Defining Moment in Food Safety

The successful commercial introduction of irradiated meat, poultry, and produce in US supermarkets has gone largely unnoticed. According to food safety expert Morton Satin, when irradiated ground beef was introduced, consumers gained a reasonable expectation of buying products that offered much greater food safety and lower risk. As a consequence, untreated ground beef acquired the character legally defining a product having a built-in defect (Osterholm and Norgan 2004).

Satin cites the American Legal Institute's Third Restatement of the Law, Torts: Products Liability, adopted in 1998, which states in Section 2, "Categories of Product Defect":

A product is defective when, at the time of sale or distribution, it contains a manufacturing defect . . . . A product:

- contains a manufacturing defect when the product departs from its intended design even though all possible care was exercised in the preparation and marketing of the product;
- is defective in design when the foreseeable risks of harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design by the seller or other distributor, or a predecessor in the commercial chain of distribution, and the omission of the alternative design renders the product not reasonably safe.

Is It Farm to Fork, or Turf to Tort?

Lawsuits and the threat of litigation as a result of recalls and sickness from *E. coli 0157:H7*, *Salmonella*, *Listeria*, and other pathogens will be a significant factor that will drive more retailers, restaurant chains, and manufacturers toward the use of irradiation (Eustice 2004). The financial liability for selling, using, lending, or simply having unsafe products rests with the business marketing the product. "If they sell it, they're liable, period," says Frances Zollers, a professor in the law and public policy department of the Whitman School of Management at Syracuse University in New York (Henricks 2005).

For a victim, one case of foodborne illness is one too many. For a manufacturer, one recall is one too many. For a school district, one sick or dead child is a tragedy. For everyone but the attorneys prosecuting the case, one lawsuit is a nightmare!

Faced with liability from selling contaminated products that can legally be defined as "defective," the food industry will have to weigh the cost of using irradiation against the cost of product recalls, lawsuits, loss of brand equity, or even bankruptcy caused by such contaminated products (Satin 2003; Loaharanu 2003).

Conclusion

No one single intervention can provide 100% assurance of the safety of a food product. That is why meat, poultry, and produce processing plants use a multiple barrier (hurdle) approach utilizing several types of interventions such as washes, rinses, and thermal processes combined with chemical and antimicrobial treatment to achieve pathogen reduction.

These technologies have successfully reduced, but not eliminated, the amount of harmful bacteria in meats and produce. Food irradiation does not eliminate the need for established, safe food handling and cooking practices, but when used in combination with other technologies including an effective Hazard Analysis Critical Control Points (HACCP) program, irradiation becomes a highly effective and viable sanitary and phytosanitary treatment for food and agricultural products. Irradiation is one of the most effective interventions available because it significantly reduces the dangers of primary and cross-contamination without compromising nutritional or sensory attributes.

Despite the progress made in the introduction of irradiated foods into the marketplace, many consumers and even highly placed policy-makers around the world are still unaware of the effectiveness, safety, and functional benefits that irradiation can bring to foods. Education and skilled marketing efforts are needed to remedy this lack of awareness.

Morton Satin says:

> Pathogens do not follow political imperatives or moral philosophies—they simply want to remain biologically active. Strategies to control them, which are based on political ideals or myth-information, will not be effective. If we want to get rid of pathogens, we have to destroy them before they harm us. Food irradiation is one of the safest and most effective ways to do this. An international coordinated effort to develop effective knowledge transfer mechanisms to provide accurate information on food irradiation to policymakers, industry, consumers, and trade groups are vital to meet today's food safety needs.
>
> Satin 2003

During the twentieth century, life expectancy in the United States increased from 47 to 77 years (CDC 2004). Many public health experts attribute this dramatic increase to the "pillars" of public health: pasteurization, immunization, and chlorination. Some of these same experts predict that food irradiation will become the fourth pillar of public health. Time will tell whether this prediction is correct.

References

Aiew, W., Nayga, R. & Nichols, J. (2003) The promise of food irradiation: will consumers accept it? Choices, Third Quarter, 31–34.

Anderson, J., Schuster, T., Hansen, K.E., Levy, A.S. & Volk, A. (2004) A camera view of consumer food handling behaviors. *Journal of American Dietetic Association*, **104**, 186–191.

Bhumiratana, N., Belten, L.K. & Bruhn, C.M. (2007) Effect of an educational program on attitudes of California consumers toward food irradiation. *Food Protection Trends,* **27** (10), 744–748.

Cates, S. (2002) Reported Safe Handling Practices: Cooking (FDA/FSIS Food Safety Survey-2001). Changes in Consumer Knowledge, Behavior, and Confidence Since 1996 PR/HACCP Final Rule. Thinking Globally—Working Locally: A Conference on Food Safety Education, 18 September 2002, Orlando, FL.

Centers for Disease Control (CDC). (2004) National Center for Health Statistics, Centers for Disease Control and Prevention. Health, United States Available at: http://www.cdc.gov/nchs/data/hus/hus04trend.pdf#027.

DeGregori, T.R. (2002) *Zero Risk Fiction*. American Council on Science and Health, New York.

Eustice, R.F. (2004) *The Market for Irradiated Meat; Survey Reveals Lack of Knowledge: Meat & Seafood Merchandising*. pp. 18–19. Vance Publishing, Lenexa, KS.

Food and Drug Administration (FDA). (2008) Irradiation in the production, processing and handling of food. CRF 21 Part 179. *Federal Register*, **73** (164), 49593–49603.

Fox, J.A., Bruhn, C.M. & Sapp, S. (2001) Consumer acceptance of irradiated meats. In: *Interdisciplinary Food Safety Research* (eds E. Murano & N. Hooker). pp. 139–158. CRC Press, Boca Raton, FL.

Fox, JA. (2002) Influences on purchases of irradiated foods. *Food Technology*, **56** (11), 34–37.

Frezen, P., Majchrowicz, D.A., Buzby, J.C., & Imhoff, B. (2000) Consumer acceptance of irradiated meat and poultry products. *Issues in Food Safety Economics*, **757**, 1–8.

Hall, C.W. & Trout, G.M. (1968) Objections to pasteurization. In: *Milk Pasteurization*. pp. 5–8. The AVI Publishing Company, Westport, CT.

Henricks, M. (2005) Risky business; before a defective product becomes your downfall, learn to protect yourself. Entrepeneur Magazine, March 2005, p. 32.

ICGFI (2005) Clearance Database. Available at: http://www-naweb.iaea.org/nafa/fep/index.html

Jefferson Davis Associates (2003) Consumer Awareness of and Attitudes toward Irradiated Ground Beef. pp. 1–7. Presented to Mitec Advanced Technologies, Cedar Rapids, IA.

Johnson, A., Estes, R.A., Jinru, C. & Resureccion, A.V.A. (2004)Consumer attitudes toward irradiated food: 2003 vs. (1993) *Food Protection Trends*, **24** (6), 408–418.

Loaharanu, P. (2003) *Irradiated Foods; 5th edn 41*. Q9 American Council on Science and Health, New York. Available at: http://www.acsh.org/publications/pubID.198/pub_detail.asp.

Lusk, J.L., Fox, J.A. & McIlvain, C.L. (1999) Consumer acceptance of irradiated meat. *Food Technology*, **53** (3), 56–59.

Martin, T. & Albrecht, J.A. (2003) Meat irradiation education program. *Journal of the American Dietetic Association*, **103**, A30.

Metropolitan Life Insurance Company. (1923) *All About Milk*. Metropolitan Life Insurance Company, New York. p. 1–24.

National Cattlemen's Beef Association. (2002) Irradiation: Consumer Perceptions. On Behalf of Cattlemen's Beef Board, Centennial, CO. Available at: http://www.beefusa.org/uDocs/irradiation.pdf.

National Cattlemen's Beef Association. (2004) Irradiation Beef Industry Study. National Cattlemen's Beef Association on Behalf of Cattlemen's Beef Board, Centennial, Co. Available at: http://www.beef.org/uDocs/Executive%20Summary%20Beef%20Industry%20Irradiation.pdf.

Osterholm, M.T. & Norgan, A.P. (2004) The role of irradiation in food safety (perspectives). *New England Journal of Medicine*, **350** (28), 1898–1901.

Pohlman, A., Wood, O. & Mason, A. (1994) Influence of audiovisuals and food samples on consumer acceptance of food irradiation. *Food Technology*, **48**, 46–49.

Rogers, E.M. (1983) *Diffusion of Innovations*, 3rd edn. The Free Press, New York.

Satin, M. (2003) *Future Outlook: International Food Safety and the Role of Irradiation*. World Congress on Food Irradiation: Meeting the Challengs of Food Safety and Trade. May, Chicago, IL.

Shogren, J.F., Fox, J.A., Hayes, D.J. & Roosen, J. (1999)Observed choices for food safety in retail, survey and auction markets. *American Journal of Agricultural Economics*, **81** (5), 1192–1199.

Tauxe, R.V. (2001)Food safety and irradiation: protecting the public from foodborne infections. Presentation from the 2000 Emerging Infectious Diseases Conference in Atlanta, GA. *Emerging Infectious Disease*, **7** (3) 516–521.

Teisl, M.F., Fein, S.B. & Levy, A.S. (2009) Information effects on consumer attitudes toward three food technologies: organic production, biotechnology, and irradiation. *Food Quality and Preference*, **20** (2009), 586–596.

Vickers, Z.M. & Wang, J. (2002) Liking of ground beef patties is not affected by irradiation. *Journal of Food Science*, **67**, 380–383.

Wisconsin State Journal Editorial Board. (2003)Let irradiation improve safety of school food. Wisconsin State Journal, May 1, 2003. Madison, WI.

Zienkewicz, L.S.H. and Penner, K.P. (2004) Consumers' perceptions of irradiated ground beef after education and product exposure. *Food Protection Trends*, **24**, 740–745.