



IRRADIATION: CONSUMER PERCEPTIONS



HISTORY OF IRRADIATION

Great effort has been devoted to finding ways of preserving food and protecting it against microbial contamination and spoilage.

Techniques developed include drying, heating, fermenting, salting, smoking, use of preservatives (other than salt), canning, freezing and refrigeration.

Irradiation is a promising food safety technology that can reduce pathogens in foods. Irradiation and its effects on food, animals and the people eating irradiated foods have been studied extensively for more than 40 years and has been proven safe and effective.

Irradiated wheat flour, potatoes and spices have been available for more than 15 years.

When used as approved on food, irradiation:

- ◆ Reduces food-borne pathogens
- ◆ Does not make the food radioactive
- ◆ Does not introduce dangerous substances into food
- ◆ Maintains the integrity of the food and its nutritional value

And although other processing plant measures can reduce bacteria levels in raw foods, irradiation is more effective because it can reduce pathogens such as *E. coli* O157:H7. Food irradiation serves as a complement to good manufacturing practices—quality control and pathogen reduction—and is part of an overall food safety protection system.

Food irradiation uses ionizing energy and levels of absorbed radiation are measured in kilograys (kGy).

E-beam is the most popular technology used today to irradiate food and beef products. The process damages or destroys the DNA of the bacterial microbes preventing them from reproducing or continuing to exist. The Electron Beam Linear Accelerator machine generates and accelerates electrons to energies of 5, 7.5, or 10 MeV with a beam power of up to 10kW. The electrons are concentrated and accelerated to 99 percent of the speed of light. This produces rapid reactions on the molecules within the product. A cart system moves the beef product being irradiated under the electron beam at a predetermined speed to obtain the desired dosage. Multiple carts move product in and out of the irradiation area continuously with throughput up to 500 pounds per hour. Maximum product dimensions are 24 inches wide and 36 inches long. Product thickness depends on density and electron energy.

Irradiation is not the same as radiation. Older versions of irradiation used radioactive isotopes (special atoms), raising concerns among those who saw anything radioactive as being too closely related to nuclear reactors, although these methods were safe. E-beam irradiation is also used extensively to sterilize medical instruments and surgical implants to reduce risk of infection.

*Safety is a foremost concern of the beef industry and beef consumers. Available scientific data indicates that irradiation can significantly reduce the levels of many of the pathogenic microorganisms of particular concern to meat producers including various species of *Salmonella*, *E. coli* O157:H7, *Clostridium perfringens*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Campylobacter jejuni* and the protozoan parasite *Toxoplasma gondii*.*

In December 1997, the Food and Drug Administration (FDA) amended the food additive regulations, providing the safe use of irradiation to treat refrigerated (4.5 kGy maximum permitted dose) or frozen (7.0 kGy maximum permitted dose) uncooked meat, meat by-products and certain meat food products (e.g., ground beef) to control food-borne pathogens and extend product shelf life.

CONSUMER PERCEPTIONS: IRRADIATION PROJECT

Beef Safety continues to be a high concern for the industry. Studies by the Public Health Service Centers for Disease Control (CDC) show that approximately 5,000 deaths occur each year from food-borne illness. Bacterial contamination starts as a surface phenomenon on all meats, with the surface area to volume ratio being the major consideration for microbial risk. With steaks or other whole muscle meats, the interior of the cut remains sterile and the surface area to volume ratio is smaller, so the microbial risk is low. When cuts of meat are ground, the surface contamination is distributed throughout the entire volume and the surface area to volume ratio is very large, so the microbial risk becomes much greater.

“The Food and Drug Administration approved irradiation of meat products for controlling food-borne pathogens in December 1997. The approval applies to fresh and frozen red meats such as beef, lamb and pork. The USDA approved these regulations in December of 1999.”

*Center for
Consumer
Research*

STUDY I

The Sterling-Rice Group and Talmey-Drake Research and Strategy, Inc. studied a group of consumers in Denver and Atlanta to assess consumer acceptance and attitudes of irradiated ground beef with two objectives in mind:

- ◆ *to measure the palatability of low dose irradiated ground beef (from 1.3 kGy to 1.5 kGy), and*
- ◆ *to determine an optimal way of communicating with consumers about irradiation, ultimately developing industry rollout expectations.*

Four hundred seventy-five consumers were polled in both Denver and Atlanta, using 80 percent lean and 20 percent fat ground beef chubs. Consumers were provided frozen patties for in-home preparation: 152 households received non-irradiated and placebo patties (labeled as irradiated, but actually not irradiated) and 323 households received non-irradiated (control) and irradiated patties, both correctly labeled. The ground beef patties were frozen prior to irradiation and were kept frozen until distributed to participants. Participants recorded their findings in a written questionnaire which was completed as they prepared and sampled the product. Additionally, their findings were recorded in post-use callbacks and in six different focus groups between the two markets. Patties presented in Atlanta were treated with rosemary oleoresin to correct any color difference between the irradiated patties and the non-irradiated or placebo patties, muting much of the color difference between the various patties. No rosemary oleoresin was added to the patties in the Denver test group. The color of irradiated beef was found to impact post-use preference in the Denver households.

Findings

The main factor influencing satisfaction was consumer predisposition to irradiation. However, when no antioxidant was added, the color of irradiated beef did impact post-use preference. But, the addition of rosemary oleoresin antioxidant muted much of the color difference. Interestingly, in this case, the irradiated burger was preferred over the placebo burger, suggesting a preconceived perception by some consumers concerning irradiated products (by a higher percentage than preferred the placebo.)

The Hedonic Scores on aroma, juiciness and flavor for the irradiated, non-irradiated and placebo patties were not statistically different. Yet, customers expressed very positive and/or negative taste perceptions for the placebo vs. the non-irradiated burgers. On one trait, leanness, the irradiated burger significantly outscored that of the non-irradiated patty in Atlanta.

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Consumers were segmented into four attitude segment groups: Strong Buyers, Interested, Doubters and Rejectors.

Strong Buyers (which consisted of 27 percent of the test group) identified irradiated beef as a superior product in all areas—taste, value and safety. They have strong food safety concerns and are motivated by the premise that irradiated ground beef will safeguard health. They believe that the product tastes better and trust government and public health organizations.

The Interested group (34 percent) liked irradiation, but not intensely. They have a milder level of concern about food safety than do Strong Buyers. They want to be reassured about irradiation, need to know the taste will not be impacted, and say that endorsements by government and public health authorities adds credibility.

Doubters (24 percent) like the concept of irradiation because of its health benefits, but they do not trust the current irradiated product. They want to remain neutral until safety is confirmed and are likely to order irradiated beef in a restaurant or fast food setting and less likely to buy it for home consumption.

Rejectors (15 percent) are the most vocal and entrenched in their attitudes about irradiation. They object to every aspect of irradiation, see no benefits to irradiation, and suspect that irradiation involves long-term health risk concerns. They do not trust endorsers of irradiation and even suggested that irradiation is a “plot”.

Conclusions

Strong Buyers, Interesteds and Doubters—a total of 85 percent of all participants—will accept irradiated beef to a greater extent if a number of the following improvements are made:

- ◆ *Change the word “irradiation” to sound less like “radiation”.*
- ◆ *Explain the irradiation process to consumers.*
- ◆ *Provide consumers with a choice between irradiated and non-irradiated beef at grocery stores.*
- ◆ *Continue research and improvements in product quality.*

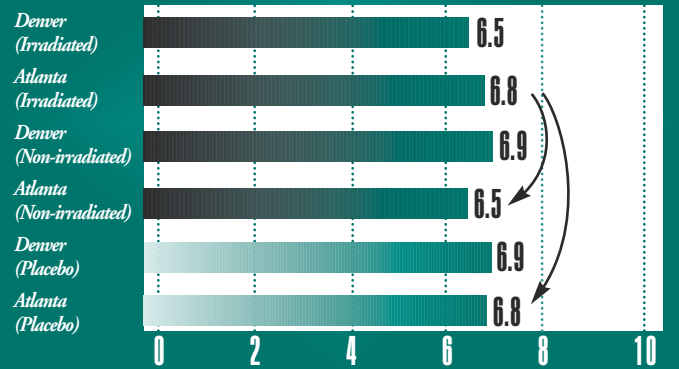
Strong Buyers are the most favorable towards irradiation. They see irradiated ground beef as a statement that the beef industry cares about their safety, and they are relatively quick to adopt and willing to pay more for irradiated ground beef. Interested and Strong Buyers could be influenced to switch to irradiated beef for in-home consumption and report a potential for increasing their purchases of ground beef if irradiated product is made available. Strong Buyers, Interested Buyers and Doubters are all interested in irradiated ground beef in the food-service industry and believe it should be offered to consumers as a choice. The Interested group will be fairly quick to adopt irradiated ground beef once they are reassured about taste issues and understand the process. Doubters do not want to pay any additional money for irradiated product. Doubters would require time to switch to irradiated meats.

Rejectors are unlikely to ever purchase or support irradiated beef, despite knowing that they commonly use other irradiated products such as spices, fruits and vegetables. This highly vocal group stated that if irradiated ground beef was made available, they would reduce their ground beef purchases. This group objects to additional processing of meat and perceives a risk with irradiation (long-term health issues especially) with no major benefit. This group cannot be encouraged to buy irradiated product through expanded education. (Note: the Rejector group in this study is disproportionately small as an additional 7 percent of would-be participants declined to participate because the subject was irradiation.)

USING ANTIOXIDANTS - A SOLUTION

In Atlanta, irradiated burger outperformed non-irradiated
 ◆ *also tested comparably to the placebo patty*

BURGER ATTRIBUTE RATINGS: OVERALL SATISFACTION WITH BURGER - POST USE

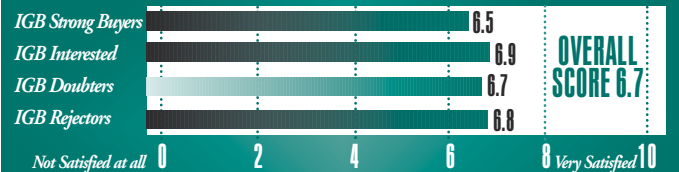


PERCEPTIONS AND THE PLACEBO

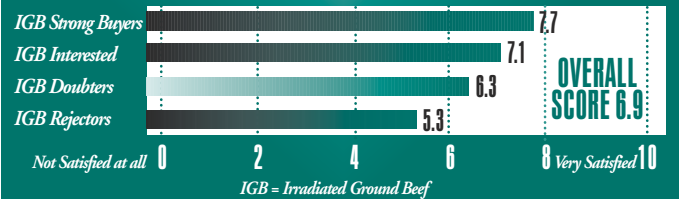
The most striking result in the study was the variation in palatability scores based on assigned segments

- ◆ *Lower scores given the placebo product by Doubters and Rejectors*
- ◆ *Higher Score given by “Strong Buyers”*

OVERALL SATISFACTION: NON-IRRADIATED BURGER - POST USE



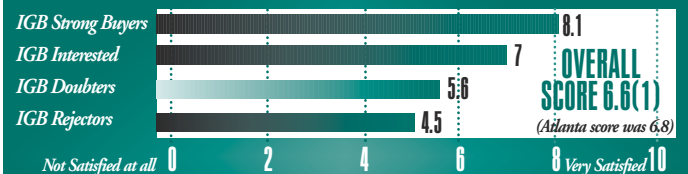
OVERALL SATISFACTION: PLACEBO - POST USE



IRRADIATION ATTITUDES PLAY A ROLE IN PALATABILITY REACTION

Identical pattern was seen for the irradiated product that was sampled.

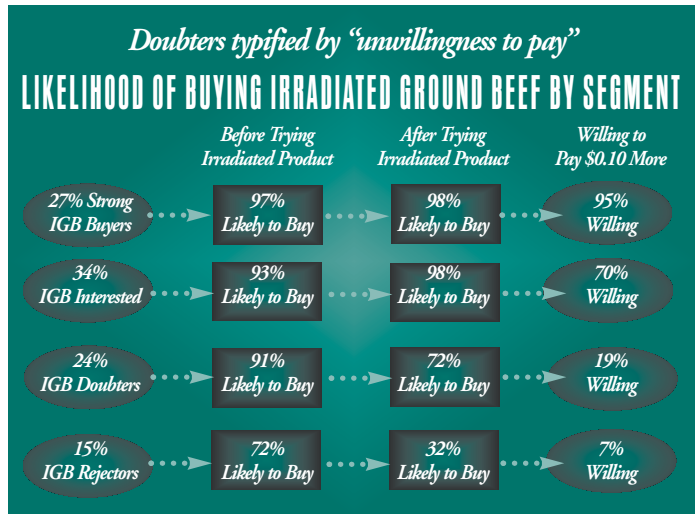
OVERALL SATISFACTION: IRRADIATED BURGER - POST USE



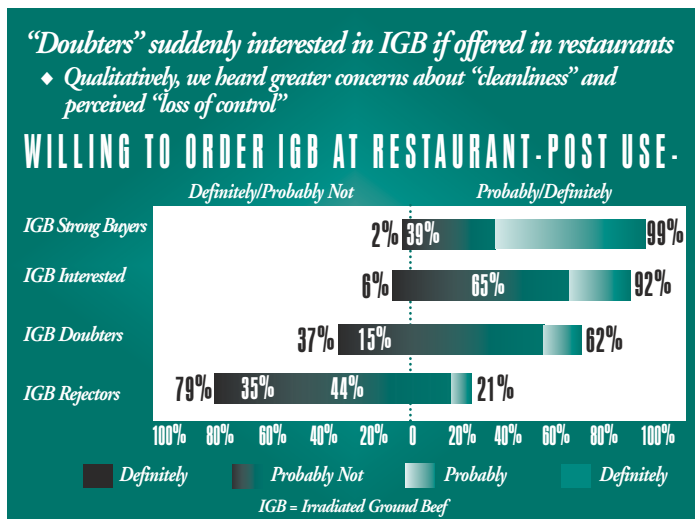
OVERALL SATISFACTION: PLACEBO - POST USE



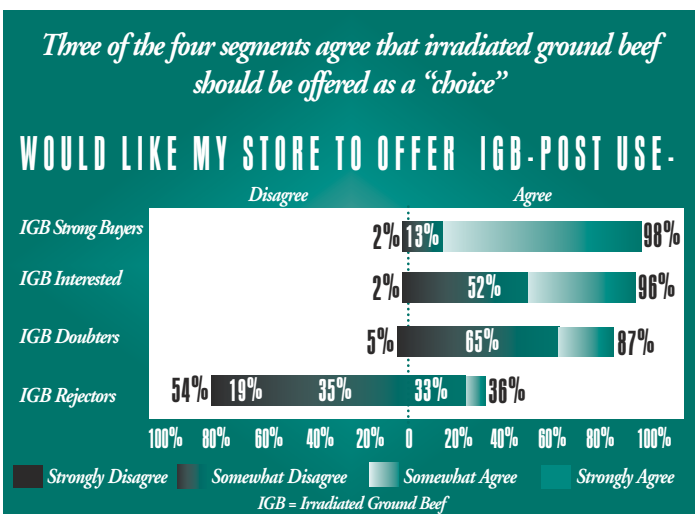
WILLINGNESS TO PAY BY SEGMENT



SEGMENTS AND FOODSERVICE



SEGMENTS AND GROCERY DISTRIBUTION



Overall, irradiation is a benefit that consumers want. The potential to enhance ground beef safety is viewed in a positive manner, by a majority of the segmented attitudinal groups. However, it is important to note that significant differences exist between the segments regarding the appeal of irradiation. Reassurance that another layer of protection will be provided without impacting the quality of the product in both the retail and foodservice sectors will influence that acceptance of this technology.

STUDY II & STUDY III

In STUDY II, two sensory panels- one trained and a second consumer panel at the University of Missouri in Columbia evaluated the color and overall appeal of irradiated and non-irradiated ground beef patties as well as irradiated and non-irradiated beef patties with antioxidants added. Due to color issues that occurred in the initial in-home study, further investigation was warranted in the sensory attribute and product quality area. Panelists sampled the patties and verbally described the differences between them. The list of sample attributes was modified by panel consensus. The panel evaluated patties including non-irradiated control, non-irradiated placebo, irradiated good color, irradiated poor color, non-irradiated with rosemary extract added and irradiated with rosemary extract added. The patties were thawed at 4 degrees C for approximately 18 hours prior to cooking and prepared on a MagiKitch'n conveyor belt grill at 135 degrees C for 2.5 minutes to achieve a target internal temperature of 68.3 degrees C.

Findings

The trained panel found that the irradiated patties with poor color had a drier ($P < .05$) surface appearance than non-irradiated controls and irradiated patties with acceptable color. However, non-irradiated control patties were not different ($P > .05$) from irradiated patties for moistness. This is the only flavor or texture attribute in which good colored irradiated patties had a higher rating than poor colored irradiated patties. There were no other differences in flavor or texture reported. Panel participants liked the irradiated and non-irradiated patties equally.

STUDY III, conducted at the University of Florida, surveyed the effect of e-beam irradiation levels and chill state (frozen or thawed) on odor, flavor and color. The objectives of the study were twofold:

- ◆ To determine the effect of 0 to 4 kGy ionizing irradiation on off-odor and off-flavor development in frozen, packaged ground beef patties cooked from the thawed and frozen states.
- ◆ To determine the effect of 0 to 4 kGy ionizing irradiation on the color of packaged ground beef patties in the frozen and thawed state.

Ground beef patties, formulated as 80/20 lean to fat ratio with rosemary extract added, were vacuum packaged in Theromform Laminate shrink (provided by Cryovac Sealed Air Corporation) then quick-frozen. The patties were then transported to Florida Accelerator Services and irradiated with electron beam technology to one of six dosage levels: 0, 0.5, 1, 2, 3 and 4 kGy.

Panelists were asked to evaluate off-flavor intensity on a 1 to 6 scale with 6 being no off-odor and 1 being extremely intense off-odor. They then scored thawed and frozen patties for color and discoloration from each treatment combination. Thawed and frozen patties were also objectively evaluated by a Minolta CR-310 Chroma Meter with a 50 mm measuring head to identify Hunter L*, a* and b* color values.

Findings

Color and discoloration were dramatically impacted as irradiation levels increased. Color, evaluated visually and objectively, became darker and more reddish brown in appearance. The color of the patties irradiated at low doses (0.5-1.1 kGy) was no different between treatments but did show slight color differences when compared to the non-irradiated patties. Irradiation levels investigated in this study did not significantly impact off-odor in cooked ground beef patties, but patties cooked from the thawed state did have slightly lower off-odors. Off-flavors in ground beef were noted in this study, but could not be attributed to irradiation levels.

Conclusions

In summary, both STUDY II & STUDY III support the premise that consumer acceptance of irradiated beef can be achieved as long as the products are irradiated at low doses. Continued research to improve or reduce any color change would further increase the marketability of irradiated beef.

STUDY IV

ABC Research Corporation conducted a study to determine the reduction rates of *Listeria monocytogenes*, *Salmonella typhimurium* and *E. coli* O157:H7, in vacuum packaged, frozen ground beef patties when treated with electron beam irradiation at doses of 1.1 to 4.4 kGy. The ground beef was fabricated following the same procedures outlined in STUDY III, additionally, the ground beef was inoculated, fabricated into patties, frozen, vacuum packaged and stored at 4° F for 24 hours at the ABC laboratory prior to initiation of the study.

Findings

In frozen ground beef patties with initial pathogen levels of 1 to 3 log₁₀ cfu/g for *Listeria monocytogenes*, *Salmonella typhimurium* and *E. coli* O157:H7 the application of electron beam irradiation at a dose of 1.1 kGy resulted in the reduction of the pathogens to non-detectable levels, i.e., less than 1 log₁₀ cfu/g.

COUNT REDUCTIONS (Log cfu/g) with HIGH INOCULUM LEVELS (3-7 log ₁₀ cfu/g of product)		
TESTED PATHOGENS	DOSE OF ELECTRON BEAM IRRADIATION	
	1.1 kGy	2.2 kGy
<i>L. monocytogenes</i>	0.88 - 1.55	>1.75 - >3.56
<i>S. typhimurium</i>	1.59 - 2.00	>2.10 - >3.20
<i>E. coli</i> O157:H7	1.83 - 2.92	>3.38 - >4.66

Ground beef patties inoculated with high levels of the three tested pathogens and treated with electron beam irradiation at a dose of 2.2 kGy resulted in the reduction of the pathogens to non-detectable levels, i.e., greater than 1.75 to greater than 4.66 log₁₀ cfu/g.

D ₁₀ -VALUES (kGy) IN FRESH RED MEATS		
TESTED PATHOGENS	NCBA Gr. BEEF STUDY	LITERATURE
<i>L. monocytogenes</i>	0.72 - 1.25	0.45 - 1.21
<i>S. typhimurium</i>	0.69 - 1.18	0.55 - 1.28
<i>E. coli</i> O157:H7	0.38 - 0.60	0.24 - 0.88

D₁₀ values can be defined as the dose in kGy required to inactivate 90% of the microbial population.

Conclusions

Electron beam irradiation was effective at reducing low and high pathogen concentrations in frozen ground beef patties at low doses (1.1-2.2 kGy). In turn, irradiation may serve as an additional method for enhancing the safety of ground beef products.

In 1992, the USDA approved the irradiation of fresh and frozen poultry at doses from 1.5 kGy to 3.0 kGy. And, the USDA approved irradiation for red meat at 4.5 kGy and 7.0 kGy for frozen beef, pork, veal and lamb in late 1999. The first patents for food irradiation were granted in the United States and the United Kingdom in 1905. Since then, the United States and other governments worldwide have reviewed hundreds of studies on the effects of food irradiation. The United States has one of the most restrictive policies on food irradiation processes in the world.

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