2010

The effect of visuals on recall, attitude and behavioral intention toward irradiated foods

Elizabeth Wilson
Iowa State University

The effect of visuals on recall, attitude and behavioral intention toward irradiated foods

by

Elizabeth Ann Wilson

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Journalism and Mass Communication

Program of Study Committee:
Lulu Rodriguez, Major Professor
Sela Sar
Robyn Cooper

Iowa State University

Ames, Iowa

2010

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

This study aims to compare two modes of presenting information about food irradiation on audience's recall, attitude and behavioral intentions toward this food safety innovation. The manipulation of a one-page brochure served as the study's experimental treatment. Half of the study's respondents were presented with a brochure that used only text to describe the processes, risks and benefits associated with food irradiation. The other half of the respondents received a brochure that used visuals, combined with text, to describe the same information.

The findings suggest that when readers are presented with risk information using a combination of text and visuals, recall of objective facts is increased. Respondents demonstrated fairly neutral attitudinal dispositions and behavioral intentions toward items related to food irradiation. However, the findings indicate that with a more accessible way of presenting complicated scientific information and technological risks, an audience is better equipped to structure appropriate attitudes and make informed behavioral decisions about a relatively unknown food safety practice.

The results also indicate that using visuals to explain medical, technological, and natural hazards has great influence on knowledge gain. With greater recall, audiences are better positioned to make informed decisions about how to mitigate risks related to safety of the foods they eat. Therefore, developing risk communication messages in ways that cater to the needs of different learners (i.e., those who respond more to text and those who respond more to visuals) is a worthy objective for public investments.

Keywords: food irradiation, risk communication, visual communication

CHAPTER 1
INTRODUCTION AND STATEMENT OF THE PROBLEM

Outbreaks of food-borne illnesses caused by pathogenic bacteria are fast becoming mainstays in American life. Such incidences bring with them considerable public alarm because the contamination of foods, especially those of animal origin, can cause extreme public health problems (Farkas, 1998). According to the Centers for Disease Control and Prevention (CDC), food-borne diseases caused by salmonella, listeria, toxoplasma and *Escherichia coli* O157:H7 account for approximately 76 million illnesses, 325,000 hospitalizations and 5,000 deaths in the country annually (Mead et al., 1999). Besides posing serious public health threats, contaminated food can also result in tremendous economic losses (Farkas, 1998). The U.S. estimates annual medical expenses and lost productivity due to food-related illnesses to range from $6.6 billion to $37.1 billion dollars annually (Loaharanu & Thomas, 2001).

The food industry's concern for public health and economic wellbeing has led to extensive research into decontamination processes, including pasteurization and the use of pesticides. While pasteurization is already well established and has been shown to be satisfactory as a decontamination treatment for liquid foods, it is not well suited for solid foods and dry ingredients. Additionally, chemical sanitizing procedures using pesticides and fumigants have inherent problems concerning residues and environmental pollution (Farkas, 1998). A third decontamination process, food irradiation, has also received extensive research attention in the U.S. since the 1940s.

Irradiation is a food treatment process in which ionizing radiation is passed through food, damaging and destroying bacteria and organisms that cause food-borne illnesses, including those resulting from salmonella and *E. coli* contamination. The destruction of living cells simultaneously extends the shelf life of foods by reducing spoilage, sprouting and ripening. Three radiation sources are currently approved for this purpose—gamma rays, electron beams and x-rays. Food candidates for radiation decontamination include wheat, potatoes, flour, herbs and spices, tea, fresh fruits and vegetables, fresh and frozen uncooked poultry, beef and pork (CDC, 2005; Food Marketing Institute, 2000; ISU Extension, 2006; EPA, 2008).

Despite the obvious advantages, irradiation is not widely used due to uncertain consumer acceptance, caused largely by inadequate information about this process. Little has been disseminated to the general public regarding food irradiation processes, especially their risks and benefits. As such, it is possible that negative reactions to food irradiation stem from anxiety previously encountered and associated with risks related to exposure to radioactive matters such as nuclear reactors, atomic weapons and other medical devices. While irradiation is not directly linked to these technologies, it has been "stigmatized" by the public's prior experiences with and memory of anything nuclear (Mehta, 2002).

Among the most noteworthy of these experiences is the bombing of Hiroshima and Nagasaki in August 1945, an incident that foreshadowed the end of World War II in the Pacific. To that incident has been attributed illnesses and deaths on a massive scale due to exposure to radiation (U.S. Strategic Bombing Survey, 1946). Another incident occurred 40 years later, when a reactor accident in the Chernobyl nuclear power plant in the Soviet Union released four hundred times more radiation into the atmosphere than the bombings of Hiroshima and Nagasaki, resulting in deaths, illnesses and extreme birth defects in the thousands (Stone, 2006).

Most people learned about or experienced these hazards vicariously through the news media, which more often than not document mishaps and threats rather than uphold standards and excellent protection practices (Slovic, 1987). According to the media agenda setting theory proposed by McCombs and Shaw (1972), the mass media have a powerful influence on how people view the world. Media attention to or coverage of topics has been shown to correlate with the public's perception of important new stories. Unfortunately for nuclear technologies, media coverage has not been overly positive. Physicist Bernard Cohen argues, "Journalists have grossly misinformed the American public about the dangers of radiation and of nuclear power with their highly unbalanced treatments and their incorrect or misleading interpretations of scientific information. This misinformation is costing our nation thousands of unnecessary deaths and wasting billions of dollars each year" (as cited in Slovic, 1986, p. 404). While this statement places an inordinate amount of blame on the media, it suggests the need for accurate information disseminated to the general public on most matters related to science and technology.

The name given to the processes itself – irradiation – may elicit schemas (Graber, 1984) associated with nuclear hazards, producing a higher perception of risk than proposed by technical risk assessors (Slovic, 1987). Analyses of risk interpretations have continuously shown that risk perceptions are not automatically calculated using probabilities and statistics put forth by risk assessors. Rather, perceptions are affected by an individual's experiences, intuitions, emotions and experiential thinking (Rothman & Kiviniemi, 1999; Graber, 1984). Given these circumstances, erroneous risk estimates can be made based on various "outrage" factors, including a risk event's perceived controllability, familiarity, and other concomitant "dread" factors (Sandman, 1989; Slovic, 1987; Covello, 2001). In order to combat these negative perceptions, educational messages about the safety and benefits of food irradiation are necessary.

How the processes of food irradiation are presented is one factor that may have a profound bearing on people's perceptions of risk related to this technology. In most risk communication campaigns, risks are conveyed numerically in conjunction with textual explanations. However, a study by the National Work Group of Literacy and Health (1998) found that half of the U.S. population has rudimentary or limited reading skills. Simultaneously, these citizens lack what are considered necessary skills to apply arithmetic operations to numbers embedded in printed materials. This is especially true for fractions and proportions, two of the most common measurements used to describe risk probabilities (International Adult Literacy Survey, 2000; Burkell 2004). Given these findings, there is a need for alternative forms of presentation that can be readily understood by the largest possible audience regardless of the level of sophistication they possess in understanding text and numbers.

Graphics are effective aids in communicating risks, offering advantages beyond what text and statistics can provide. Several studies have shown that the use of visual displays enhances learning. Perhaps graphics' most important attribute is their ability to attract and hold audience attention above and beyond what is achieved through the use of textual and statistical data by displaying information in concrete visual terms (Eagly & Chaiken, 1993; Nisbett & Ross, 1980; Lipkus & Hollands, 1999). To make the visual communication of risk useful, a mix of techniques that accommodates the varying preferences and information processing abilities of different audience segments is necessary. This includes, but is not limited to, the use of information graphics such as tables, bar graphs, line graphs, pie charts, maps, and diagrams.

These visual displays can serve as tools to reduce the complexities of textual information, especially information of a quantitative or categorical nature. In order to develop accurate visual representations, the information must be encoded through position, shape, size, symbols and color (Cleveland & McGill, 1985). When viewing visual displays, audiences decode information in ways that are more memorable and illuminating. Visual decoding, as defined by Cleveland and McGill (1985) is “the instantaneous perception of the visual field that comes without apparent mental effort” (p. 828). If the viewer interprets the information inaccurately, the visual has failed. Thus, it is important to analyze if visual displays are interpreted accurately in regards to the task at hand—whether it is intended to increase recall, alter attitude or promote behavioral change.

Beyond displaying complex textual information, graphics assist viewers with memory and recall by building mental models of what the text is about (Glenburg & Langston, 1992). The human brain applies different ways of processing textual and visual information. For most people, the left hemisphere of the brain specializes in language, processing information in a linear mode one piece at a time. The right hemisphere, on the other hand, processes visual and spatial information in a holistic manner, taking in large amounts of information at a time. This holistic view of visual processing places the information items in long-term memory and makes them available for recall when necessary. The speed of visual processing and the accuracy of visual recognition suggest a mode of communication superior to that of solely textual presentation (Lodding, 1983).

While research has been conducted on the use of visuals to represent information, little is known about how visual displays of risk—presented independently or in combination with numerical or narrative translations—affect perceived risk (Lipkus & Hollands, 1999). Therefore, this study aims to analyze the impact of graphics on audiences' knowledge of the process, risks and benefits associated with food irradiation. The objective is to evaluate if visual representations influence perceived risks when combined with narrative and numerical expressions. Are graphical presentations more successful in assisting individuals to develop appropriate risk estimates? It is hypothesized that the use of graphics will increase people's positive perception of food irradiation and their ability to form appropriate risk estimates.

This study also aims to evaluate if the use of graphics simultaneously affects people's attitudes and behavioral intentions with regards to food irradiation. For example, is a more graphical presentation of information more persuasive in making people purchase irradiated foods if they were available? Similarly, will this make them more willing to serve irradiated food to their families? It is hypothesized that the use of graphics will increase people's positive perception of food irradiation, which in turn will affect their behavioral intentions toward irradiated foods.

The findings of this study are expected to assist risk communicators in varying fields to develop more effective campaigns that deploy graphics as information and persuasion devices. The objective is to provide insights as to how visuals can be deployed to bridge the gap between the scientific experts and the general public regarding a technology that offers tremendous potential to reduce public health threats from food-borne pathogens.

CHAPTER 2
LITERATURE REVIEW AND THEORETICAL FRAMEWORK

"One of the most perplexing problems in risk analysis is why some relatively minor risks or risk events, as assessed by technical experts, often elicit strong public concerns and result in substantial impacts upon society and economy" (Kasperson et al., 1988, p. 177). Indeed, accurately communicating risks that have a relatively low probability of occurrence but is seen by the public as more risky than its name suggests, such as the case with food irradiation, poses a considerable challenge to communicators (Lipkus & Hollands, 1999). Communicators are often faced with the task of either attenuating public risk perception of technologies, objects or events that entails high risk based on technical judgments. Conversely, communicators also must guard against the amplification of low risk situations that may be misconstrued so that it engenders widespread panic.

The National Research Council (1989) defines risk communication as "an interactive process of exchange of information and opinion among individuals, groups, and institutions. It often involves multiple messages about the nature of risk or expressing concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management" (p. 322). Not all risk communication is a direct response to a crisis situation; it can also include preemptive campaigns against potential or developing crisis events, also referred to as "care communication." When individuals are educated about technical processes and appropriate responses to risk situations, their likelihood of overestimating risk is reduced. It is anticipated that with appropriate educational materials that contain factual risk assessments, an individual's knowledge of food irradiation will improve, as will their perception, attitude and behavioral intentions toward food products that have been subjected to the process.

Food Irradiation: Process and History

Food irradiation is a treatment process in which radiation is passed through food. The radiation affects the food at the molecular level, destroying bacteria, mold, parasites and other living organisms. First introduced in the 1930s by a French scientist, the process has been extensively studied by the U.S. government since the 1940s and has been proven to control or completely eliminate bacteria and organisms that cause spoilage and millions of food-borne illnesses annually. Three radiation techniques are currently approved for use in food irradiation—those that use gamma rays, electron beams and x-rays (CDC, 2005; Food Marketing Institute, 2000; ISU Extension, 2006; USDA, 2000).

The first and most common method of irradiating food uses radioactive substances such as Cobalt 60 and Cesium 137. These materials emit gamma rays, which have the ability to penetrate food at several feet, even after packaging. Given their radioactive nature, the materials are stored in pools of water surrounded by a secure concrete chamber. In this method, the food is brought into the secure chamber and the radioactive substances are pulled up from the water and exposed to the food for a specific period of time. Gamma rays do not produce neutrons, meaning at no point in the irradiation process does the food become radioactive. Additionally, the Nuclear Regulatory Commission and the Department of Transportation enforce severe regulations for the use and transport of such materials (CDC, 2005).

The second method of irradiation uses an electron beam to propel a stream of high-energy electrons through food. Different from gamma rays, electrons can only penetrate food items that are a little more than an inch thick. Thus, foods treated with this method must be thin enough to be fully irradiated. A simple on and off button controls the stream; no radioactivity is involved in the process (CDC, 2005).

X-ray irradiating machines used on food are similar to those employed in the medical profession, but are much more powerful. To produce x-rays, a beam of electrons is sent through a thin plate of gold or other metal, producing a stream of x-rays out the other side. Like gamma rays, this method can pass through thick foods and requires heavy shielding. However, like the electron beam, it can be switched on and off, and no radioactive substances are involved (CDC, 2005).

Since 1963, the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) have approved several food items for irradiation (Table 1). The approval process limits the levels of absorbed radiation allowed for each food item. There are currently three defined levels of food irradiation that consider radiation intensity measured in kilograys (kGy). Low doses go up to 1 kGy and have the ability to kill insects in fruits and grains. These doses can also eliminate or prevent the maturation of *Trichinella* in pork. Medium doses are anywhere from 1 to 10 kGy and have the ability to kill most bacteria that cause food-borne illnesses and spoilage. A high dose is anything above 10 kGy and has the ability to decontaminate meats, herbs and spices. Irradiation at high doses is also currently used to sterilize more than half of all medical supplies, including adhesive strips and medical implants, along with cotton swabs, contact lenses, saline solutions, tampons, teething rings and cosmetics (Food Marketing Institute, 2000; Tauxe, 2001).

Not all foods and food products can be irradiated without affecting their natural states. For example, meats with a high fat content may develop unpleasant odors, the whites of eggs may become runny, grapefruits may become mushy, alfalfa seeds may not sprout well, and raw oysters may die as a result of irradiation (Tauxe, 2001).

Table 1. Foods permitted to be irradiated under Food and Drug Administration regulations (FDA, 2008)

Food	**Purpose**	**Dose (kGy)**
Fresh, non-heated processed pork	Control *Trichinella spiralis*	0.3 - 1
Fresh foods	Growth and maturation inhibition	1 max
Foods	Arthropod disinfection	1 max
Dry or dehydrated enzyme preparations	Microbial disinfection	10 max
Dry or dehydrated spices and seasonings	Microbial disinfection	30 max
Fresh or frozen uncooked poultry products	Pathogen control	3 max
Frozen packaged meats (solely for NASA)	Sterilization	44 max
Refrigerated, uncooked meat products	Pathogen control	4.5 max
Frozen uncooked meat products	Pathogen control	7 max
Fresh shell eggs	Control of *Salmonella*	3 max
Seeds for sprouting	Control of microbial pathogens	8 max
Fresh or frozen molluscan shellfish	Control of *Vibrio* species and other food-borne pathogens	5.5 max
Fresh iceberg lettuce and fresh spinach	Control of food-borne pathogens and extension of shelf-life	4 max

Theoretical Framework

Although food irradiation has several practical applications, a relatively small number and amount of irradiated food items are currently available to the general public. This is due largely to undetermined consumer acceptance caused by the lack of consumer knowledge about the processes involved. People are also generally unaware of the benefits of this practice. These include (1) the destruction of pathogenic bacteria and parasites of public health significance, (2) decontamination of spices and dried vegetable seasonings, (3) insect disinfestations of grains and other stored products, (4) inhibition of sprouting in bulb, tuber and root crops, (5) shelf-life extension of fresh fruits and vegetables by delaying maturation, ripening and microbial spoilage, (6) control of insect pests in fresh fruits and vegetables for quarantine purposes, and (7) enhancement of the refrigerated shelf-life of meat, poultry, seafood and fresh fruits and vegetables (Loaharanu & Thomas, 2001).

Based on personal and collective experiences, the public may be hesitant to adopt this practice because anything that involves the use of radioactive substances has been relegated to negative territory within their world view or mental schema. According to Graber (1984), individuals continuously accumulate information, ideas and conclusions about various topics that they use to evaluate new information. These schematas are developed through life experiences, social interactions and psychological predispositions. However, if individuals have not directly encountered a relevant phenomenon— as is often the case with nuclear technologies— mass-media accounts may substitute for such experiences (Gamson & Modigliani, 1989).

Studies of the agenda-setting function of the media suggest that the mass media can indeed play a primary role in alerting the public to events or trends about which they are previously unaware (McCombs & Shaw, 1972). With the presentation of information, images and metaphors, the media imbue importance on specific news events or issues (McCombs & Shaw, 1972; Cohen, 1963).

The United States' adventures in nuclear power were permanently marked by the aftermath of the bombings of Hiroshima and Nagasaki in a bold attempt to end World War II. Suddenly, the public was made aware of the potential catastrophic potential of atomic energy as images of instantaneous and enormous destruction, symbolized by the rising mushroom cloud of a nuclear bomb blast became a common icon (Gamson & Modigliani, 1989). The disastrous Three Mile Island accident in 1979 and the Chernobyl incident in 1986 solidified public schemas of destruction synonymous with nuclear power. These already established filters guide not only how new information regarding anything radioactive is classified but also what information is attended to.

Schema theory asserts that when complete data are not available about a topic, individuals may use experiences to develop conclusions about incoming information. For example, if food irradiation were simply described as a "food treatment process that uses radiation," such a description may elicit understandings associated with extreme radiation exposure, including illnesses, birth defects and death. For this reason, it is important for risk communicators to disseminate accurate and thorough information about the processes, risks and benefits related to food irradiation. Such information is needed for individuals to make informed conclusions and behavioral decisions, such as whether to purchase and consume irradiated foods.

Anything that involves the use of nuclear power has been shown to elicit significantly high-risk perceptions regardless of the actual risk estimates. Nuclear power's perceived potential to cause catastrophic and long-term damage to living organisms make it difficult for a process that makes use of radiation to be readily accepted (Slovic, 1987). Although food irradiation does not pose the same threats as other nuclear technologies, already developed social constructs and schemas could lead individuals to assign unnecessarily high-risk estimates to this technology.

The public's heightened risk estimates related to food irradiation could also be explained by what Slovic (1987) calls "outrage factors" associated with anything that may be perceived as risky. Appropriate message design and construction requires careful audience analysis to which the psychometric paradigm can assist (Slovic, 1987). This risk perception model addresses the psychological reasons why people process risk in a way that may differ substantially from scientific risk assessments. Fifteen risk perception factors associated with the characteristics of a risky object or event have been identified to explain an audience's attitudinal and behavioral response to risk. The psychometric factors that would most likely be amplified when presented with food irradiation messages include the perceived controllability of a risk event, its familiarity, uncertainty, dread characteristics, the level of trust the public holds about institutions that are supposed to safeguard its food supply, and whether the risky event has a human versus a natural origin (Slovic, 1987).

For instance, food irradiation may be less readily accepted and perceived as riskier if it were under the control of non-experts as opposed to experts in trusted government regulatory agencies. Food irradiation processes are also relativity unfamiliar to the general public, and may therefore be conceived as less safe than a more familiar practice, such as pasteurization. Although extensive research on food irradiation has been conducted for decades in the United States, little information has been made available to the public, which still leaves a shroud of uncertainty surrounding the technology. Technologies perceived as possessing characteristics that evoke fear, terror or anxiety are perceived as posing greater risks than those that do not produce such strong emotions. And risks perceived as originating from human errors, such as another radioactive fallout, are less readily accepted than naturally-occurring risks (Covello, 2001). In a nutshell, food irradiation is “relatively unknown and poorly understood; it involves a process associated with weapons of war, cancer, and other dreaded health problems and its risks are [perceived as] long-term, probabilistic, and uncertain” (Bord & O’Connor, 1989, p. 499).

The psychological origins of the opposition to food irradiation have been borne out by survey findings. People have expressed concerns about (1) the depletion of nutritional quality of foods, (2) the fear that food producers, manufacturers and distributors may practice less aggressive sanitation practices if the use of irradiation becomes widespread, (3) the adverse health effects of radiolytic products such as benzene and formaldehyde, (4) potential harm to employees and those living near an irradiation facility that uses radioactive substances, (5) the potential dangers to the public during the transport of radioactive substances, (6) higher food costs, and (7) and smell tests rendered untenable by the elimination of odor-causing spoilage, among others (Food Marketing Institute, 2000; Bruhn, 1994).

Implementing new technologies and new standards for food safety has historically been a slow process. For example, the pasteurization of milk, developed in 1900, faced stiff opposition from a public that thought pasteurized milk was ”dirtier” and saw reduced nutritional value from pasteurization. Today, 99% of U.S. milk is pasteurized (Tauxe, 2001). Considering this historical precedent, it should come as no surprise that food irradiation is now waging an uphill battle for public acceptance.

However, previous research has shown a positive correlation between consumer acceptance of food irradiation and levels of awareness of the irradiation process. Unfortunately, according to a nationwide survey conducted at Iowa State University, only 51 percent of the public has at least some knowledge of food irradiation (Rodriguez, 2007). Somewhat promising are the results of surveys conducted by the Food Marketing Institute (2000) and FoodNet sites (USDA, 2000), which suggest that about 50% of the U.S. population is ready to buy irradiated foods. This acceptance level is expected to rise to a high of 90% if consumers understand that irradiation reduces harmful bacteria in food.

It is imperative that risk communicators constantly supply the system with accurate information using all available means so that the largest possible audience is exposed to the benefits of irradiation procedures. A solid information campaign must be developed that highlights both positive and negative characteristics of food irradiation, so that validity is not in question and audiences are fully prepared to make enlightened risk estimates. The presentation of these educational materials could greatly influence the public's perception and eventual acceptance of food irradiation.

Presentation of Materials

Most communicators present the probability of risks either qualitatively (with terms such as "rare" or "infrequent" potential of exposure to harm) or quantitatively (with expressions such as 1 in 100 probability of a risky event occurring). "Qualitative descriptions of probability have the attraction of using common words that seem to be generally understood" (Bogardus, Holmboe, & Jekel, 1999, p. 1039). However, because these terms represent no standard or specific quantitative measurement, they can be understood at varying levels, often producing incorrect lay risk estimates. This difficulty has led many to favor numerical expressions. However, this can also cause confusion in terms of risk framing. For example, outcomes can be framed in terms of survival rates or mortality rates. To average readers, a death rate of 10% may seem quite different from a survival rate of 90% (Bogardus, Holmboe & Jekel, 1999). Using verbal labels both of a quantitative and qualitative nature suggests interpretations that are highly variable and dependent on specific contexts. Clearly, verbal labels cannot be used as an effective standard with which to communicate risk estimates.

In order to remedy the inconsistencies developed by textual and statistical presentations, visual aids can be applied. "At their best, graphics are instruments for reasoning about quantitative information. Often the most effective way to describe, explore and summarize a set of numbers—even a very large set—is to look at pictures of those numbers" (Tufte, 1983, p. 9). Visuals allow one's mind to receive, process and hold more information in a fraction of a second (Dondis, 1973). The immediacy of visuals suggests they are powerful tools with which to display statistical information (Tufte, 1983).

Visual information constitutes the oldest record of human history, used to understand and communicate human nature (Dondis, 1973). The theories applied to graphic design and visual communication are taken from the study of signs, known as semiotics. At its very basic, semiotics attempts to understand the components of a sign that enables an audience to develop signals that translate into comprehensible messages. "There are three main areas which form what we understand as semiotics: the sign themselves, the way they are organized into the system, and the context in which they appear" (Crow, 2003, p. 16).

Visual messages are sent and received on three different levels. These levels have been labeled differently throughout time, but their underlying definitions remain consistent. The first level of decoding a visual message is through representation or with the use of icons. An icon is a sign that is recognizable from environment and experience, as it physically represents meaning. For example, a photograph of an individual serves as an icon of that person. The second level of producing visual syntax is through abstraction or the use of indexical signs. This level proposes a link between a sign and an object, using similar visual components. For example, smoke is an index of fire, much like a seed is an index of a plant. The third level of visual understanding, and perhaps the most complex, is the use of symbols. The messages created from symbols have arbitrary meaning, with no logical connection between the sign and its meaning, and rely solely on a viewer's learned connection between the two. For example, a red cross is a learned symbol representing humanitarian aid. Letters and numbers are also considered symbols in that people imbue them with meaning quite different from what they actually physically represent. For example, it is understood that the number 10 is greater than 1 based on a learned understanding of counting (Dondis, 1973; Crow, 2003; Lodding, 1983).

"All these levels of information retrieval are interconnected and overlapping, but can be sufficiently distinguished from each other so that they can be analyzed both as to their value as potential tactics for message-making and their quality in the process of seeing" (Dondis, 1973, p. 67). Using the interactive design elements of lines, colors, shapes, textures, tone, proportions, direction and dimension, signs can be created to assist a viewer in understanding the underlying meaning of a graphic. This leads to the many reasons for considering the potential of visual graphics. These include their: 1) universal comprehension beyond verbal literacy, 2) memory and processing capabilities, 3) ability to summarize large data sets in a compressed format, 4) ability to reveal trends, 5) ability to compare multiple variables, and 6) immediacy to grab and hold viewers' attention (Lodding, 1983; Tufte, 1973).

The most commonly used information graphics in science serve as instruments to describe quantitative information. These graphics include tables, bar graphs, line charts, data maps and diagrams. To exploit the communication capabilities of these graphics, Tufte (1973) proposed several design principles:

> Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency. Graphical displays should (1) show the data; (2) induce the viewer to think about the substance rather than about the methodology, graphic design, the technology of graphic production, or something else; (3) avoid distorting what the data have to say; (4) present many numbers in a small space; (5)

> make large data sets coherent; (6) encourage the eye to compare different pieces of data; (7) reveal the data at several levels of detail, from a broad overview to the fine structure; (8) serve a reasonable clear purpose (which may be description, exploration, tabulation, or decoration) and be closely integrated with the statistical and verbal descriptions of a data set (p. 13).

Beyond the advantages listed above, visuals, have the ability to communicate different risk characteristics, such as risk magnitude or absolute risk (how large or how small the risk is), relative risk (compared to other risks), cumulative risk (accumulation over time), uncertainty (the amount of variability and range of scores) and interactions (synergy) of risk factors (Lipkus & Hollands, J.G., 1999). “Visual representation of likelihood [of harm] has the obvious advantage that visual information is salient and relatively easy to understand, suggesting that both comprehension and recall of information about likelihood could be improved” (Burkell, 2004, p. 204).

Several studies have been conducted to determine reader preferences for risk graphics. A study conducted by Fortin et al. (2001) found that patients attempting to make health care decisions preferred health risks to be framed in absolute terms rather than in relative terms using bar graphs, and calculated over their expected lifetime. Additionally, a study conducted by Lipkus and Holland (1999) suggests that risk ladders can effectively assist people in anchoring a risk with upper and lower boundaries, while histograms induce risk aversion compared with numbers alone. While these findings are useful, research on the effectiveness of graphics as decision support tools is sparse (Dickson, DeSanctis & McBriade, 1986).

It is important to note that graphic displays of information should be accompanied by text. By communicating information using words, numbers and pictures, messages can cater to audience members with different preferences (text versus visuals) and learning styles.

Hypotheses

This study aims to compare two modes of presenting information about food irradiation on audience's perception of this relatively unknown process. Considering the foregoing literature, it is hypothesized that:

H1: Visuals combined with text will outperform purely textual presentations in helping audience members *recall* the processes, risks and benefits associated with food irradiation.

Informational materials should promote the personal relevance of food irradiation among audiences that are likely to have heard very little about this innovation. With heightened understanding, individuals will be better equipped to develop positive evaluations and perceptions of food irradiation. Thus, this study posits that:

H2: Visuals combined with text will outperform purely textual presentations in helping audience members develop more positive *attitudes* toward food irradiation.

The literature also suggests that visuals have the capacity to induce people to follow a recommended practice or behavior. More specifically, individuals presented with visuals will be more willing to purchase and consume irradiated foods. Therefore, it is also pertinent to hypothesize that:

H3: Visuals combined with text will outperform purely textual presentations in producing more positive *behavioral intentions* toward food irradiation.

Beyond increased recall, attitude and behavioral response, the literature also suggests that visuals are useful tools in assisting individual's understanding of relatively complex materials. Therefore, it is hypothesized that:

H4: Visuals combined with text will outperform purely textual presentations in producing a positive evaluation of the brochure as an effective informational aid.

CHAPTER 3
METHOD

This study aims to compare two modes of presenting information about food irradiation on audience's knowledge of, as well as attitude and behavioral intention, toward this relatively unknown process. To gather data, a field experiment was conducted in which the presentation of food irradiation information in a one-page brochure was manipulated. The field experiment was conducted online.

The Sample

To arrive at a sample appropriate for an experimental procedure, the names of 2,000 graduate and undergraduate students were randomly selected from the student registration list provided by the Registrar's Office of a Midwest university. Of these, 75 were recruited for the study through a recruiting message sent to their university e-mail addresses. The sample was selected following a systematic random sampling procedure with a skip interval technique. These student-respondents were randomly assigned to view one of two types of informational brochures about food irradiation. Then, they were asked to complete a questionnaire regarding the material to which they were exposed.

The results of the human subjects evaluation procedure as stipulated by the university's Institutional Review Board, including the measures taken to ensure informed consent from respondents and guarantees of confidentiality of responses are presented in Appendix A.

The Experimental Treatments

Two single-page informational brochures were designed to serve as the study's experimental treatments.

The first brochure used only text and numbers to describe the processes, risk and benefits associated with food irradiation (Brochure 1, Appendix B). It contained a definition of food irradiation with an explanation of how gamma rays, electron beams, and x-rays are used to irradiate food. It also included a list of approved food items for irradiation. Additionally, four benefits from irradiation were presented. These were 1) the reduction of food-borne illnesses, 2) the extension of food shelf life, 3) reduction in the use of environmentally hazardous fumigants, and 4) the availability of more safe foods to immune-compromised individuals.

The brochure also listed and explained the four risks attendant to food irradiation. These risks are 1) the possible depletion of vitamins; 2) the possible reduction in safe sanitation practices by food producers, manufacturers and distributors; 3) the possible development of radiolyctic products, including benzene and formaldehyde, and 3) the dangers posed to workers and the general public by the use and transport of radioactive materials.

The second brochure used text and visuals, including tables, diagrams and images to illustrate the same processes, risks and benefits attributable to food irradiation (Brochure 2, Appendix B). As in Brochure 1, a definition of food irradiation was provided along with a table highlighting food items approved for irradiation, and the purpose of irradiation for each case. Again, the three processes of irradiating foods using different radiation energy were explained. A diagram that illustrates the use of gamma rays and electron beams for this process was included. A table highlighted projected reductions in illnesses, hospitalizations and deaths if only 50% of meat and poultry products available to the general public were irradiated. A photograph of a moldy bundle of strawberries that had not been irradiated was paired against a picture of another bundle of fresh strawberries that had been irradiated to demonstrate how the process extends shelf life. Both batches of strawberries had been stored for 25 days at 3 degrees Celsius. Another table emphasized the loss of nutrients due to the process, especially on chicken products when they are frozen or irradiated with gamma rays and with electrons. The brochure also showed a picture of a food inspector going about his work.

The combination of *icons* (represented by the diagrams of the irradiation facilities and the image of the strawberries approved for irradiation), *indexical signs* (signified by the image of the food inspector representing food safety) and *symbols* (embodied by the numbers in the tables and words within the paragraph text) are inherent to message making and human understanding. The interconnected mechanisms of visual and linguistic signs, also known as the *signifier*, are utilized to present a concept or message, known as the *signified* (Crow, 2003). The arrangement and blending of these mechanisms can be implemented for quality message making and reception.

Experimental Procedure

The subjects were randomly assigned to two groups. Group 1 was presented with the primarily text informational material (Brochure 1). Group 2 was presented with the brochure with text and graphics (Brochure 2). The materials and the accompanying questionnaire were sent via the university's e-mail system. The informed consent document explained to students that the study's objective is to analyze individuals' recall, attitudinal and behavioral responses to food irradiation. They were also told their participation in the study is completely voluntary, and that they can refuse to participate or leave the study at any time.

Those who agreed to participate were be given as much time as needed to review the brochure. They were then asked to complete a questionnaire intended to measure their recall, attitudes and behavioral intentions toward the innovation. Additionally, they were asked to provide an analysis of the brochure as an informational aid. The experimental protocols were such that the subjects were not allowed to return to the brochure once they had begun answering the questionnaire to ensure accurate responses to the open ended questions. Following the initial e-mail message, students were sent three weekly e-mail reminders requesting their participation in the study.

The Questionnaire

The questionnaire was five Web pages in length with each page representing a different section. The first section aimed to measure recall. Two questions were posed to gauge students' previous exposure to food irradiation information prior to viewing the brochure. Three open-ended knowledge questions were presented and students were given as much time as needed to answer these three questions. The responses were scored from 1 to 3 where 1 means "incorrect," 2 means "partially correct," and 3 means "correct."

The second section aimed to measure attitudes toward food irradiation and irradiated food items. Students were asked the extent to which they agree to seven Likert scale statements with response items that range from 1 to 5 where 1 means "strongly disagree" and five means "strongly agree."

The third section dealt with behavioral intentions. Five items were listed to gauge students' behavioral intentions toward irradiated food. Again, Likert scales were used with response items that range from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree."

The fourth section was intended to determine the subject's general evaluation of the brochure as an effective information tool. Ten items were presented to gauge perceived effectiveness of the brochure based on content, quality of writing and physical appearance. Again, Likert scales were used with response items ranging from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree."

Finally, the fifth section solicited demographic information. A copy of the complete questionnaire is presented in Appendix C.

Variables and Their Measure

The first three dependent variables in this study are recall, attitudes, and behavioral intention toward food irradiation and irradiated food products. The fourth dependent variable is the general evaluation of the brochure in terms of defining and explaining the processes, risks and benefits of food irradiation.

Recall refers to the stock of knowledge about food irradiation students develop as a consequence of their exposure to the brochure. Two questions were posed to measure their previous exposure to food irradiation information. They were as follows:

1. Have you ever heard of food irradiation prior to reading this brochure?

2. If yes, how familiar are you with the process of food irradiation?

Recall was determined by the sample's open-ended responses to the following questions:

1. Please name three food items experts have approved for irradiation.

2. Please cite one benefit of food irradiation.

3. Please cite one risk consumers may be subjected to as a result of food irradiation.

The responses to the last three items were coded from 1 to 3, where 1 means "incorrect," 2 means "partially correct," and 3 means "correct." Recall was measured by calculating the average of the subject's responses to the three questions above. A high score on this index means a higher recall level of the process, risks and benefits associated with food irradiation.

Attitude toward food irradiation refers to the cognitive and affective disposition people have toward food irradiation as a process or an issue. In this study, it refers specifically to the students' attitude toward irradiation after exposure to the brochure. Attitude was measured by averaging the students' responses to the following seven Likert-scale items:

1. Food irradiation is a safe process.

2. Food irradiation will protect me from food-borne illnesses caused by pathogens such as *E. coli* and salmonella.

3. Food irradiation will eliminate the need for environmentally hazardous fumigants often used to rid food items of harmful organisms.

4. Food irradiation poses dangers to those who work at or live near an irradiation facility.

5. Food irradiation will eliminate the need for already existing food safety practices.

6. Food irradiation depletes the nutritional value of food.

7. Food irradiation will become a widely accepted food process in the future.

The responses for these scales ranged from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree." A high score on this index means more favorable attitudes toward the innovation.

Behavioral intentions toward food irradiation refers to the extent to which people see themselves as abiding by the practice as recommended in a message. In this study, it was measured by the probability that students will perform the following actions:

1. I am willing to try foods that have been irradiated.

2. I will buy irradiated food if it is available at my local store.

3. I am willing to serve irradiated food to my friends and family.

4. I am more likely to store irradiated foods for consumption for a longer period of time than food items that are not irradiated.

5. I am willing to pay more for irradiated food.

The responses to these Likert scale items ranged from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree." Behavioral intention was measured by getting the average of the subject's responses to the five items listed above. A high score on this index means more favorable behavioral intentions toward the innovation.

Evaluation refers to the cognitive and affective assessment of the brochure as an information aid. In this study, it pertains specifically to the students' assessments of the content, quality of writing and physical appearance of the brochure. Evaluation of the brochure was measured by students' responses to ten Likert-scale items listed below:

1. The brochure was informative about the process of food irradiation.

2. The brochure was informative about the benefits of food irradiation.

3. The brochure was informative about the risks that may be engendered by food irradiation.

4. The information in the brochure was valuable to me.

5. The brochure held my interest.

6. The visuals helped me better understand food irradiation.

7. The layout of the brochure was easy to navigate.

8. The brochure was easy to read.

9. The amount of text in the brochure was overwhelming.

10. The overall appearance of the brochure was pleasing.

Question 9 was asked only of those who were exposed to the highly visual Brochure 2. The response range for these scales ranged from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree." Evaluation of the brochure was measured by getting the average of the subject's responses to the ten items listed above. A high score on this index means more favorable reactions to the brochure as an information tool.

The questionnaire also solicited information about the subjects' gender, age, academic classification and major field of study.

Hypotheses Testing

An independent samples *t*-test was conducted to evaluate if there is a significant difference in recall, attitudes, behavioral intentions, and overall evaluation of the brochure between the group that received the highly textual brochure and the group exposed to the highly visual brochure. A *t*-test was also used to analyze if the two groups differed on these four factors by gender. A Pearson correlation test was conducted to determine if age was related to recall, attitude, behavioral intentions, and evaluation of the brochure. A one-way analysis of variance test was conducted to determine whether recall, attitude, behavior and evaluation of the brochure varied by college classification.

CHAPTER4
RESULTS AND DISCUSSION

Of the 75 student-respondents, 59% were female. The age range was 19 to 65 years, with 81% reporting they were college juniors or higher in terms of academic classification. The demographic characteristics of those that compose the text only and the text + visuals group are shown in Table 2.

While 69% of the subjects had heard of food irradiation prior to reading the brochure, the sample met the expectation that few would be familiar with irradiation principles and processes. Half of the sample was unfamiliar with the innovation, 42% said they were somewhat familiar with it, and only 8% claimed to be very familiar with the subject matter.

Table 2. Demographic characteristics by group

	Group 1 (text only)	Group 2 (text and visuals)
Gender		
Female	15	14
Male	19	22
Did not respond	4	1
Age		
Youngest age	19	19
Oldest age	38	68
Academic classification		
Freshman	3	3
Sophomore	4	5
Junior	8	4
Senior	7	10
Graduate student	14	15
Did not respond	2	0
College that offers the major		
Agriculture and Life Sciences	11	7
Business	0	4
Design	3	2
Engineering	9	4
Human Sciences	3	6
Liberal Arts and Sciences	4	9
Veterinary Medicine	2	2
Did not respond	6	3

Recall

Despite low familiarity, the combined student sample provided accurate responses to three knowledge questions (M=2.53, SD=61, range=2) asked after exposure to one of the two types of brochure (Table 3). When asked to name three food items approved for irradiation, 65% of respondents answered correctly. When asked to cite one benefit of food irradiation, 81% gave correct answers. Sixty-five percent were able to provide correct answers when prompted to cite one risk associated with food irradiation.

Reponses were scored from 1 to 3, where 1 means “incorrect,” 2 means “partially correct,” and 3 means “correct.” Incorrect answers were those that made no reference to the information presented in the brochure. For example, when asked to list three food items approved for irradiation, an incorrect answer provided was, “Popcorn, noodles, and milk.” None of these food items were listed in the brochure, nor are they approved for the irradiation process. A partially correct answer is one that made reference to information within the brochure, but also included additional information that was not accurate. For example, when asked to site one benefit of food irradiation, a partially correct answer given was “Extension of shelf life without sacrificing texture.” While the extension of shelf life is in fact a benefit of food irradiation, at no point was the protection of texture referenced within the brochure, nor is it a scientifically identified benefit of irradiation. A correct answer is one that accurately repeated the information found in the brochure. For example, when asked to site a risk related to food irradiation, “loss of nutrients” was one of the correct answers given.

Table 3. Recall results

	Means	(Std. dev.)
1. Please name three food items experts have approved for irradiation.	2.49	.79
2. Please cite one benefit of food irradiation.	2.69	.68
3. Please cite one risk people may face with food irradiation.	2.39	.88
Recall index (average of the three items combined)	2.53	.61

Responses were scored from 1 to 3 where 1 means "incorrect", 2 means "partially correct", and 3 means "correct."

An independent-samples *t*-test was conducted to evaluate if there was a significant difference in recall between Group 1 (text only) and Group 2 (text+visuals) based on the students' scores on each of the three knowledge questions and their performance on the combined knowledge measure (average of the three items). The test for the combined measure produced statistically significant results [t(73)= -3.24, p=.0018]. Table 4 shows that Group 2 (M=2.75, SD=.49) had significantly higher recall levels across all three items than those in Group 1 (M=2.32, SD=.65).

Table 4. Recall results for the two groups

	Group 1 (n=38) (text only)		Group 2 (n=37) (text and visuals)		*t*-test results		
	Means	(Std. dev.)	Means	(Std. dev.)	*t* value	prob.	Df
1. Please name three food items experts have approved for irradiation.	2.24	.85	2.76	.55	-3.13	.0025	73
2. Please cite one benefit of food irradiation.	2.53	.80	2.86	.48	-2.22	.0295	73
3. Please cite one risk people may face with food irradiation.	2.18	.96	2.60	.76	-2.05	.0436	73
Recall index (average of the three items combined)	2.32	.65	2.75	.49	-3.24	.0018	73

Responses were scored from 1 to 3 where 1 means "incorrect", 2 means "partially correct", and 3 means "correct."

Specifically, Group 2 (M=2.76, SD=.55) more accurately recorded three food items approved for irradiation [t(73)= -3.13, p=.0025] than Group 1 (M=2.24, SD=.85). Group 2 was presented with a table that listed various food items approved for irradiation and the purpose of irradiation for each, while Group 1 was shown the same list of food items approved for irradiation embedded within the paragraph text. The findings suggest that the table was more effective in enhancing recall of food items approved for this food safety procedure.

When asked to cite one benefit of food irradiation, Group 2 (M=2.86, SD=.48) again recorded a higher number of correct responses [t(73)= -2.22, p=.0295] than Group 1 (M=2.53, SD=.80). Group 2 was presented with a table highlighting the projected number of reductions in illnesses, hospitalization and deaths if only 50% of meat and poultry products in the market were irradiated. Group 1 received a summarized version of this information using percentiles embedded within the narrative.

In addition to the table, Group 2 was also given a photograph intended to emphasize the effect of irradiation. An image of a moldy bundle of non-irradiated strawberries was paired with a fresh bundle of irradiated strawberries. Both batches of fruit had been stored for 25 days at 3 degrees Celsius. For Group 1, the results of the same test was explained in paragraph form. Ninety-two percent of those in Group 2 documented “the reduction of food-borne pathogens” and “the extension of shelf life” as benefits that can be derived from food irradiation. These findings suggest that information in tabular form and the use of photographs were effective memory-enhancing devices.

When asked to cite one risk attendant to food irradiation, Group 2 (M=2.60, SD=.76) again recorded a higher number of correct responses [t(73)= -2.05, p=.0436] than Group 1

(M=2.18, SD=.96). Group 2 was shown a table that expressed the numeric loss of food nutrients as a consequence of freezing, gamma ray irradiation and electron beam irradiation. Additionally, an image of a food safety worker was shown to depict food safety practices that may become lax if food irradiation becomes the norm to decontaminate food. The possible loss of nutrients and the potential reduction in food safety practices were explained textually to members of Group 1.

Based on these findings, the hypothesis that visuals when combined with text will outperform purely textual presentations in helping audience members develop an accurate understanding of the processes, risks and benefits associated with food irradiation was supported.

Evaluation of Brochure Presentations

The combined student sample generated a relatively positive evaluation of the brochures based on their responses to ten statements (M=3.76, SD=.58, range=3.18) summarized in Table 5. In this case, the negatively framed items were recoded so that a higher mean indicates a more positive evaluation of the brochure. The findings suggest respondents were pleased with the quality of the content, writing and overall appearance of the brochure they have seen as an information aid.

Table 5. Evaluations of the brochure

	Means	(Std. dev.)
1. The brochure was informative about the process of food irradiation.	4.00	.78
2. The brochure was informative about the benefits of food irradiation.	3.94	.71
3. The brochure was informative about the risks food irradiation entails.	3.72	.88
4. The information in the brochure was valuable to me.	3.89	.67
5. The brochure held my interest.	3.70	.88
6. The layout of the brochure was easy to navigate.	3.74	.85
7. The brochure was easy to read.	3.94	.70
8. The amount of text in the brochure was overwhelming.	3.28	1.00
9. The visuals in the brochure helped me a great deal in understanding food irradiation.	3.79	.89
10. The overall appearance of the brochure was pleasing.	3.68	.82
Evaluation index (average of the nine items combined)	3.76	.58

Response items ranged from 1 to 5 where 1 means “strongly disagree” and 5 means “strongly agree.” The negatively framed items were reverse-coded so that a higher mean indicates a more positive evaluation of the brochure.

An independent samples *t*-test was conducted to evaluate if there was a significant difference between Group 1 and Group 2 regarding their evaluation of the brochure as an effective information aid. This was measured based on their responses to nine statements as shown in Table 6. Again, the negatively framed items were recoded so that a higher mean indicates a more positive evaluation of the brochure.

To determine whether the nine items constitute an internally consistent evaluation index, a reliability test was conducted. The results produced a Cronbach’s alpha of .8760, which suggests acceptable internal consistency. The t-test result shows no statistically significant difference between the all-text (M=3.75, SD=.53) and the text+graphics groups (M=3.76, SD=.63) in terms of the combined measure of brochure evaluation.

Table 6. Comparative evaluations of the brochure

	Group 1 (text only)		Group 2 (text and visuals)		*t*-test results		
	Means	(Std. dev.)	Means	(Std. dev.)	*t* value	prob.	df
1. The brochure was informative about the process of food irradiation.	3.94	.68	4.03	.87	-.46	.6497	70
2. The brochure was informative about the benefits of food irradiation.	3.91	.70	3.97	.73	-.35	.7286	70
3. The brochure was informative about the risks food irradiation entails.	3.71	.89	3.72	.88	-.04	.9701	69
4. The information in the brochure was valuable to me.	3.86	.65	3.92	.69	-.37	.7096	69
5. The brochure held my interest.	3.66	.87	3.75	.91	-.44	.6616	69
6. The layout of the brochure was easy to navigate.	3.91	.74	3.57	.92	1.72	.0901	68
7. The brochure was easy to read.	4.03	.75	3.86	.65	1.03	.3088	68
8. The amount of text in the brochure was overwhelming.	3.21	.95	3.35	1.06	-.61	.5452	69
9. The overall appearance of the brochure was pleasing.	**3.49**	**.85**	**3.86**	**.75**	**-2.00**	**.0489**	**70**
Evaluation index (average of the nine items combined)	3.75	.53	3.76	.63	-.09	.9319	70

Response items ranged from 1 to 5 where 1 means “strongly disagree” and 5 means “strongly agree.” The negatively framed items were reverse coded so that a higher mean indicates a more positive evaluation of the brochure.

The descriptive statistics suggest that Group 2 found the brochure more informative about the process, benefits of and the risks entailed in food irradiation. Again, to enhance understanding and recall of the definition of food irradiation, a table listed the food items approved for irradiation. Two diagrams were used to illustrate the gamma ray and electron beam processes. Finally, a table and a photograph were employed to show two benefits of the process as well as two risk issues that concern people about food irradiation. Based on the findings, it can be surmised that visuals assisted in the cognitive processing of information regarding this fairly complicated topic.

Group 2, exposed to the visual presentation, saw the brochure as providing more valuable information and reported greater interest on the subject than those in Group 1. The use of visuals interrupted the multiple paragraphs of text, leading Group 2 to view the amount of reading matter as less overwhelming than those in Group 1. Finally, those presented with more images (M=3.86, SD=.75) assessed the brochure as significantly more visually pleasing [t(70)=-2.00, p-.0489] than those presented with the text-only format (M=3.49, SD=.85). Based on these responses, Group 2 scored higher in the overall evaluation index (average of the nine items combined) although this performance was not statistically different from that of Group 1.

Group 2 was also asked to respond to a separate question that asked members to evaluate whether the visuals helped them better understand food irradiation. The mean of the responses was 3.78 (SD=.89), indicating that the use of visuals did make for a more effective information aid.

The all-text group found its version of the brochure easier to read and easier to navigate than those presented with visuals and text. This may be because textual treatments were also applied to provide visual interest and contrast. For example, the large, bold headlines were emphasized for increased visual relevance. In order to decipher the smaller paragraph text, numbered bullet points and extended line separations between paragraphs were used. While not referencing food irradiation information, these design features considerably enhanced the legibility of text. The finding indicates that there are audience members who learn more using highly textual formats perhaps because of familiarity and constant exposure to texts as explanatory devices.

Attitudes Toward Food Irradiation

The combined student sample exhibited a fairly neutral attitudinal position based on their responses to seven statements about the irradiation procedure (M=3.51, SD=.52) listed in Table 7. The negatively framed items were recoded so that a higher mean indicates a more positive attitude toward food irradiation. Respondents agreed that irradiation is a safe process and has the ability to protect them from food-borne illnesses. They disagreed that food irradiation will eliminate the need for existing food safety practices. The responses demonstrate a strong attitudinal response to those statements directly referencing food safety issues, while the other statements elicited more neutral or undecided assessments.

Table 7. Responses to attitude items

	Means	(Std. dev.)
1. Food irradiation is a safe process.	3.75	.89
2. Food irradiation will protect me from food-borne illnesses caused by pathogens such as *E. coli* and salmonella.	4.01	.66
3. Food irradiation will eliminate the need for environmentally hazardous fumigants to get rid of harmful organisms in food items.	3.34	.86
4. Food irradiation poses dangers to those who work at or live near an irradiation facility.	2.92	1.07
5. Food irradiation will eliminate the need for existing food safety practices.	4.42	.88
6. Food irradiation depletes the nutritional value of food.	2.67	.91
3. Food irradiation will eliminate the need for environmentally hazardous fumigants to get rid of harmful organisms in food items.	3.34	.86
7. Food irradiation will become a widely accepted food process in the future.	3.49	.78
Attitude index (average of the seven items combined)	3.51	.52

Response items ranged from 1 to 5 where 1 means “strongly disagree” and 5 means “strongly agree.” The negatively framed statements were recoded in the opposite direction to represent the same trajectory of responses. That is, high numbers mean greater agreement.

An independent samples *t*-test was conducted to evaluate if there was a significant difference between Group 1 and Group 2 based on their responses to the seven attitudinal statements summarized in Table 8. Again, the negatively framed items were recoded so that a higher mean indicates a more positive attitude toward food irradiation.

To determine whether the seven items constitute an internally consistent attitude index, a reliability test was conducted. The results produced a Cronbach's alpha of .7045, which suggests acceptable internal consistency. The t-test result shows no statistically significant difference between the all-text vs. the text+graphics groups in terms of the combined measure of attitude.

Table 8. Comparative responses to attitude items between the two groups

	Group 1 (n=37) (text only)		Group 2 (n=36) (text and visuals)		*t*-test results		
	Means	(Std. dev.)	Means	(Std. dev.)	*t* value	prob.	df
1. Food irradiation is a safe process.	3.81	.91	3.69	.89	.55	.5818	71
2. Food irradiation will protect me from food-borne illnesses caused by pathogens such as *E. coli* and salmonella.	4.11	.77	3.91	.51	1.25	.2158	70
3. Food irradiation will eliminate the need for environmentally hazardous fumigants to get rid of harmful organisms in food items.	3.30	.97	3.38	.76	-.40	.6895	72
4. Food irradiation poses dangers to those who work at or live near an irradiation facility.	3.03	1.19	2.81	.94	.87	.3883	72
5. Food irradiation will eliminate the need for existing food safety practices.	4.30	.91	4.54	.84	-1.20	.2349	72
6. Food irradiation depletes the nutritional value of food.	**2.94**	**.98**	**2.41**	**.76**	**2.62**	**.0107**	**71**
7. Food irradiation will become a widely accepted food process in the future.	3.54	.73	3.43	.83	.59	.5550	72
Attitude index (average of the seven items combined)	3.58	.58	3.44	.44	1.09	.2773	72

Response items ranged from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree." The negatively framed statements were recoded in the opposite direction to represent the same trajectory of responses. That is, high numbers mean greater agreement.

Group 1 (the text group) found food irradiation safer, saw the process more as a protective measure against dangerous pathogens, judged it as posing less risk to workers and those who live next to irradiation facilities, assessed it as less likely to deplete nutritional content, and demonstrated a more positive outlook that the process will become widely accepted in the future. Of these items, however, the two groups differed significantly only in their assessment that the process depletes the nutritional value of food [t(72)=2.62, p=.0107], with Group 1 (M=2.94, SD=.98) agreeing more with the statement than Group 2 (M=2.41, SD=.76).

Group 2 agreed more that irradiation has the potential to eliminate the need for environmentally hazardous fumigants used to rid food items of harmful organisms, but disagreed more with the statement that food irradiation will eliminate the need for already existing food safety practices such as inspections from certified agencies. The differences between the two groups on these items, however, were not statistically significant.

Considering the above results, the second hypothesis was not supported.

Behavioral Intentions

The combined student sample generated relatively neutral behavioral intentions based on responses to five behavioral statements (M=3.29, SD=.82) listed in Table 9. The majority of respondents were willing to try, buy, serve and store irradiated foods. However, the majority also said they were not willing to pay more for foods that had been irradiated.

Table 9. Responses to behavioral intention items

	Means	(Std. dev.)
1. I am willing to try foods that have been irradiated.	3.82	1.03
2. I will buy irradiated food if it is available at my local store.	3.48	1.09
3. I am willing to serve irradiated food to my friends and family.	3.49	1.12
4. I am more likely to store irradiated foods for consumption for a longer period of time than food items that are not irradiated.	3.55	1.00
5. I am willing to pay more for irradiated food.	2.10	.90
Behavior index (average of the five items combined)	3.29	.82

Response items ranged from 1 to 5 where 1 means "strongly disagree" and 5 means "strongly agree."

An independent samples *t*-test was conducted to evaluate if there was a significant difference between Group 1 and Group 2 on their responses to five behavioral statements. Table 10 summarizes the subjects' responses to these five items.

To determine whether the five items constitute an internally consistent behavioral intention index, a reliability test was conducted. The results produced a Cronbach's alpha of .8469, which suggests acceptable internal consistency. The t-test result shows no statistically significant difference between the all-text and the text+graphics groups in terms of the combined measure of behavioral intentions.

Table 10. Comparative responses to behavior items between the two groups

	Group 1 (n=0) (text only)		Group 2 (n=0) (text and visuals)		*t*-test results		
	Means	(Std. dev.)	Means	(Std. dev.)	*t* value	prob.	df
1. I am willing to try foods that have been irradiated.	3.78	1.07	3.86	1.00	-.36	.7212	71
2. I will buy irradiated food if it is available at my local store.	3.53	1.00	3.43	1.19	.37	.7125	71
3. I am willing to serve irradiated food to my friends and family.	3.50	1.06	3.49	1.19	-.05	.9593	71

Table 10. (Continued)

4. I am more likely to store irradiated foods for consumption for a longer period of time than food items that are not irradiated.	**3.31**	**.98**	**3.78**	**.98**	**-2.09**	**.0403**	**71**
5. I am willing to pay more for irradiated food.	**2.17**	.97	2.03	.83	.66	.5113	71
Behavior index (average of the five items combined)	3.26	.84	**3.32**	.81	-.33	.7438	71

Response items ranged from 1 to 5 where 1 means “strongly disagree” and 5 means “strongly agree.”

Group 2 indicated greater willingness to try irradiated foods, and its members were more likely (M=3.78, SD=.98) than those in Group 1 (M=3.31, SD=.98) to store irradiated food for consumption for longer periods of time. The difference between the two groups with respect to this last aspect was statistically significant [t(71)= -2.09, p=.0403]. In particular, this statement directly relates to a visual (the photograph of a moldy bundle of non-irradiated strawberries opposite an image of a fresh bundle of irradiated ones) in the brochure, suggesting that those given visual evidence of the effect of food irradiation on storage life were more comfortable with storing and consuming such food items later in time.

Group 1 indicated greater willingness to buy and serve irradiated foods to friends and family. They were also slightly more willing to pay a higher price for irradiated food. However, the difference between the two groups with respect to these three aspects were not statistically significant.

Group 2 also scored higher than Group 1 in the overall behavioral intention index although this difference also was not statistically significant.

Given the above results, the third hypothesis was not supported.

Additional Analysis: The Impact of Demographic Variables

Do demographic characteristics have a bearing on the four dependent variables (recall, attitude, behavioral intention and evaluation of the brochure)? To answer this question, a series of tests were conducted separately for each group. For this analysis, the combined recall score and the index for each of the three other dependent variables were used.

Table 11 shows the results of a series of *t*-tests conducted to determine if males and females in Group 1, which received the text only brochure, differ in terms of recall, attitudes toward food irradiation, behavioral intentions about food irradiation, and evaluation of the brochure. The results indicate that males recorded significantly higher behavioral intentions than females [$t(32)= 2.72$, $p=.0299$]. Specifically, men were more willing to try, buy, store and serve irradiated food to friends and family than women. Males also recorded slightly higher recall scores, held a more positive attitude toward food irradiation, and viewed the brochure as a more effective information aid than females although these differences were not statistically significant.

Table 12 shows the results of a series of *t*-tests conducted to determine if males and females in Group 2, which received the text + visuals brochure, differ in terms of the four dependent variables. The tests did not produce any statistically significant findings. However, in absolute terms, females gave higher recall scores, had more positive attitudes toward irradiation, and viewed the brochure as an effective information aid than males. As in Group 1, the males in Group 2 recorded more positive behavioral intentions with regards to food irradiation. The findings for both groups suggest that men are more willing to incorporate irradiated foods into their daily food consumption patterns than their female counterparts.

Table 11. T-test results showing differences between males and females in Group 1 based on recall, attitudes, behavioral intentions, and evaluations of the brochure

Dependent variables	Males		Females		*t*-test results		
	Mean	Std. dev.	Mean	Std. dev.	*t* value	prob.	df
Recall	2.42	.72	2.33	.60	.40	.6942	32
Attitudes	3.73	.42	3.44	.68	1.47	.1505	32
Behavioral intentions	**3.61**	**.56**	**2.98**	**.96**	**2.72**	**.0299**	**32**
Evaluation	3.81	.47	3.68	.58	.67	.5059	32

Table 12. T-test results showing differences between males and females in Group 2 based on recall, attitudes, behavioral intentions, and evaluations of the brochure

Dependent variables	Males		Females		*t*-test results		
	Mean	(Std. dev.)	Mean	(Std. dev.)	*t* value	prob.	df
Recall	2.69	.52	2.77	.49	-.49	.6301	34
Attitudes	3.42	.63	3.46	.29	-.30	.7633	34
Behavioral intentions	3.44	.98	3.26	.72	.64	.5296	34
Evaluation	3.70	.78	3.82	.55	-.54	.5897	34

Based solely on mean scores, men presented with the purely textual brochure recorded more positive attitudinal responses, had higher behavioral intentions, and viewed the brochure as a more effective information aid than men presented with the highly visual brochure. However, the males in Group 2 (the text+visuals group) gave higher recall scores consistent with the findings above.

On the other hand, women presented with the visual brochure recorded higher recall scores, viewed the innovation as more positive, had higher intentions to incorporate irradiated foods into their lives, and found the brochure a more effective information tool than the women presented with the text brochure. This suggests that visuals may have a more immediate effect on recall, attitude formation, and behavioral adjustments on women more than messages presented in plain text.

A series of Pearson's correlation tests were conducted to evaluate if the four dependent variables correlate with age. Again, the analysis was done separately for each group.

Table 13 outlines the results of a series of tests conducted to determine if each of the four dependent variables correlate with age for members of Group 1. The results indicate no significant correlation between age and each of the dependent variables recall, attitude, behavioral intention and evaluation of the brochure. The weak correlations were all positive, suggesting a tendency for older individuals to score higher, be more willing to accept irradiated foods, have stronger behavioral intentions, and view the brochure as a more effective information aid than younger respondents.

Table 14 lists the results of a series of tests conducted to determine if each of the four dependent variables correlate with age for members of Group 2. The results again indicate no significant results for this group. The correlations were positive for recall, behavioral intention, and evaluation of the brochure. However, age correlated negatively with attitude, suggesting that younger respondents were more willing to accept irradiation than older individuals among those exposed to the text+visuals format. Regardless of direction, all correlations were weak.

Table 13. Pearson correlation between age and recall, attitudes, behavioral intentions, and evaluations of the brochure for Group 1

Dependent variables	Age	
	r	prob.
Recall	.0973	.5782
Attitudes	.1861	.2844
Behavioral intentions	.1764	.3108
Evaluations	.0381	.8280

Table 14. Pearson correlation results between age and recall, attitudes, behavioral intentions, and evaluations of the brochure for Group 2

Dependent variables	Age	
	r	prob.
Recall	.2194	.1920
Attitudes	-.0074	.9654
Behavioral intentions	.0096	.9549
Evaluations	.2711	.1046

A series of one-way analysis of variance tests was conducted to determine whether recall, attitude, behavior and evaluation of the brochure varied by college classification for each of the two groups. The grouping variable had five categories: freshmen, sophomores, juniors, seniors and graduate students.

Table 15 outlines the results for Group 1. The findings indicate that freshmen registered the highest recall scores. They also had more positive behavioral intentions, and viewed the brochure as more effective than the other class categories. Graduate students had the most positive attitudinal response to food irradiation. These differences among groups, however, were not statistically significant.

Table 16 shows the results for Group 2, suggesting that sophomores in this group gave the highest recall scores. They, together with graduate students, also had more positive behavioral intentions and viewed the brochure as more effective. Juniors had the most positive attitudinal response. However, these differences were not statistically significant.

Table 15. Results of a series of one-way analysis of variance tests to determine difference among class categories in terms of recall, attitudes, behavioral intentions, and evaluations of brochure for Group 1

	Freshmen		Sophomores		Juniors		Seniors		Grad students		ANOVA test results		
	Mean	(Std. dev.)	Mean	(Std. dev.)	Mean	(Std. dev.)	Mean	(Std. dev.)	Mean	(Std. dev.)	F	prob.	df
Comp.	2.67	.47	1.92	.83	2.46	.71	2.29	.76	2.45	.50	.72	.5858	34
Attit.	3.64	.10	3.54	.59	3.45	.42	3.29	.94	3.78	.45	.94	.4558	34
Behav.	3.70	.14	2.60	1.05	3.28	.84	2.97	1.15	3.55	.58	1.40	.2586	34
Effect.	4.05	.23	3.39	.60	3.70	.71	3.81	.51	3.82	.42	.71	.5916	34

Table 16. Results of a series of one-way analysis of variance tests to determine difference among class categories in terms of recall, attitudes, behavioral intentions, and evaluations of brochure for Group 2

	Freshmen		Sophomores		Juniors		Seniors		Grad students		ANOVA test results		
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	F	prob.	df
Comp.	2.22	.84	3.00	0	2.75	.5	2.8	.36	2.73	.54	1.29	.2963	36
Attit.	2.95	1.08	3.49	.44	3.53	.27	3.43	.35	3.52	.34	1.13	.3590	36
Behav.	2.73	.61	3.44	.46	3.25	.68	3.28	.72	3.44	1.03	.49	.7465	36
Effect.	3.41	.63	4.08	.42	3.39	1.00	3.56	.37	3.97	.67	1.68	.1794	36

CHAPTER 5
CONCLUSIONS

This study sought to compare two modes of presenting information about food irradiation on audience's knowledge of as well as attitude and behavioral intentions toward a food safety innovation. The manipulation of brochure presentation served as the study's experimental treatment. Half of the study's respondents were presented with a brochure that used only text to describe the processes, risks and benefits associated with food irradiation. The other version of the brochure, which includes the extensive use of visuals, was presented to the other half of the study's respondents. The respondents were randomly assigned to the two treatments.

Several conclusions can be drawn from the results. First, there was clear indication that prior exposure to food irradiation was relatively low, which supports the findings of Bord & O'Connor (1990). This suggests that future campaign efforts must expand reach and frequency of message dissemination. Informational materials should promote the personal relevance of food irradiation among audiences that are likely to have heard very little about this innovation. With higher awareness and understanding, additional incoming information items are likely to be processed using a more informed schema.

Claims made against new technologies such as food irradiation can significantly influence consumer perceptions, creating negative schemata even without trial and first-hand evaluation. If new technologies are generally regarded to be in the public's best interest, as is the case with food irradiation, efforts to counter the anti-technology message can enhance public health and welfare (Fox, Hayes, & Shogren, 2002). It is therefore important for risk communicators to disseminate accurate and thorough information about food irradiation so that the resulting positive schemata can generate positive attitudinal and behavioral intentions.

"It has been argued that increased scientific literacy among the members of the general public will help decrease perceived risks associated with science and technology, and, by implication, the products of those technologies. Against this, the level of scientific literacy required is so high that it is difficult to attain and difficult to motivate the public to attain it" (Frewer et al., 1999). This study found that text combined with visuals outperformed the purely textual presentation in helping audience members accurately recall informational items regarding a fairly complex topic. These results suggest that risk communicators should endeavor to present materials in more visual terms, and thus the need to invest in producing and testing visuals, especially information graphics, that can be used in a variety of materials to explain processes and risks.

If risk is indeed an objective property of events, measured as the probability of occurrence of adverse effects, then the implications of the findings of this study to risk communication are obvious. Grounded on economic theories of rational citizens, the technical/rational approach to risk communication holds that people make risk decisions based on a personal cost-benefit analysis informed by scientific and technical data. From this perspective, opposition to a technology that experts define as "safe" results from not understanding or not knowing the actual "objective" risks. Public opposition is often defined as a problem in effective risk communication. Effective, in this context, usually means improved methods of presenting technical risk information. The findings of this study clearly point to greater recall of objective facts when readers are presented risk information using a combination of text and visuals. With greater recall, audiences are better positioned to make informed decisions about how to mitigate risks.

Such findings are also in line with the principles of visual perception, which postulate, among others, that visuals have a tremendous capacity to increase comprehension abilities, memory processing capabilities and the sense of immediacy. They also have the ability to grab and hold viewers' attention more than plain text (Lodding, 1983; Tufte, 1973). As a decision support tool, visuals can help present risk in more understandable terms, leading to a more accurate public perception of risks attendant to technological innovations and natural events.

This study also hypothesized that greater understanding leads to more positive evaluations and perceptions of food irradiation. However, the study's respondents demonstrated close to neutral attitudinal dispositions toward items related to this subject, with no significant difference between Group 1 (text only) and Group 2 (text+brochure). In a nutshell, the results suggest a lack of attitude commitment that risk communicators can exploit. Studies (e.g., Bord & O'Connor, 1990) have shown that such attitudes are more transient and are easier to adjust or secure. This indicates that a heightened visual campaign is more likely to produce more positive attitudinal assessments.

A more detailed analysis indicates that members of Group 1 (text only) found irradiation to be safer, viewed it as a more potent technology to reduce pathogens, and thought it to be less dangerous to workers and those who live near irradiation facilities. They also expressed more optimism that irradiation will become widely accepted in the future. Such findings suggest that audiences are familiar and comfortable with textual explanations so that narratives that explain a relatively unknown procedure in clear and succinct ways still have the ability to elicit favorable attitudes.

In comparison, Group 2 (text+visuals) members agreed more that irradiation has the potential to eliminate the need for environmentally hazardous fumigants to keep the food supply safe, and disagreed more with the statement that food irradiation will eliminate the need for already existing food safety practices. Additionally, Group 2 related more to the notion that irradiation reduces the nutritional value of food than Group 1. The visual brochure incorporated a table, which emphasized incremental decreases in vitamins when chicken was irradiated. It can be surmised that Group 2 had higher recall of this risk based on the visual representation, causing them to view the process more negatively than those who were explained the same nutritional reduction in textual form.

The current study also hypothesized that visuals have the capacity to provoke people to follow a recommended practice or behavior, such as purchasing and consuming irradiated foods. In this study, the responses regarding this aspect were fairly neutral, with no significant difference between Group 1 (text only) and Group 2 (text+visuals). With a relatively weak attitudinal commitment, it should come as no surprise that respondents were undecided about incorporating irradiated food in their diets.

On closer inspection, Group 2 (text+visuals) indicated greater willingness to try irradiated foods. When presented with photographs of fresh-looking irradiated strawberries in contrast with moldy non-irradiated fruits, respondents indicated significantly greater willingness to store irradiated foods for longer periods of time than those presented with the text brochure. However, Group 1 (text only) indicated greater willingness to buy and serve irradiated foods to friends and family.

Respondents in both groups were not willing to pay higher prices for irradiated food. This finding, however, may be an artifact of a pure student sample, a demographic group with a generally limited income.

Finally, it was hypothesized that visuals combine with text will outperform purely textual presentations in producing a more effective informational aid. Overall evaluative responses regarding the brochure were positive, but no significant differences between Group 1 (text only) and Group 2 (text+visuals) were detected.

A more detailed assessment revealed that Group 2 (text+visuals) viewed the brochure to be more informative about the processes, risks and benefits of food irradiation. This group also found the information to be more valuable and, in turn, were more interested in the content being showcased. With visual breaks between lines of text, Group 2 was less likely to find the text overwhelming, and reported a significantly higher approval rating of the brochure's overall appearance. However, those presented with the purely textual brochure found it easier to read and easier to navigate. Such findings suggest that respondents generally prefer the combined used of visuals and text, but text treated to highlight relevant data, enhance contrast, and increase legibility allowed for more immediate and salient message understanding and recall.

Demographic characteristics also asserted some influence on the four dependent variables. In the text-only group, males were significantly more willing to try, buy, serve, and store irradiated foods than females. They also gave higher recall scores, held more positive attitudes toward food irradiation, and viewed the brochure as a more effective information aid. The males in Group 2 (text only) also had more positive behavioral intentions than their female counterparts. However, women scored higher in terms of recall, held more positive attitudes toward irradiation, and found the brochure to be a more effective information aid than men. Such findings suggest that men are more willing to integrate irradiated foods into their every day lives.

The men in Group 1 (text only) were more positively disposed to the innovation, demonstrated stronger behavioral intentions, and viewed the brochure as more effective than the men in Group 2 (text+visuals). However, the males in Group 2 had higher recall scores.

The women of Group 2 (text+visuals) generated more positive findings across all four dependent variables than the women in Group 1 (text+visuals), suggesting that visuals are effective tools to enhance information intake, develop stronger attitudes and behavioral influence.

In both groups, age did not correlate with any of the four dependent variables. A closer examination shows positive correlations between age and each of the four dependent variables, but these were not statistically significant. The only exception was a negative correlation between age and attitudes for those in Group 2.

There were also no significant findings suggesting that recall, attitude, behavior and evaluation of the brochure varied by college classification for each of the two groups. In Group 1 (text only), freshmen had the highest recall scores, held more positive behavioral intentions toward food irradiation, and viewed the brochure as more effective than the other classes. Graduate students demonstrated the most positive attitudinal response. These differences, however, were not statistically significant.

In Group 2 (text+visuals), sophomores recorded the highest recall scores, had more positive behavioral intentions toward food irradiation along with graduate students, and viewed the brochure as more effective than the other classes. In this group, juniors had the most positive attitudinal response. As in the case of Group 1, however, these differences were not statistically significant.

The findings of this study suggest that an expansive communication campaign which incorporates both text and information graphics is necessary not only to expose individuals to the technology, but also to enhance the acquisition of correct information. A communication campaign of this nature has the ability to attract a wide audience base with varying knowledge levels, and dispel misconceptions associated with the innovation. When individuals are educated about the technical aspects of this technology, they are less likely to overestimate risks, a boon to society because food irradiation offers tremendous potential to reduce public health threats from food-borne illnesses while simultaneously reducing medical expenses and lost productivity.

The results on attitude formation toward a relatively unknown innovation indicate that a more accessible way of presenting complicated scientific information can reduce outrage factors commonly provoked by technological risks that are misunderstood. Such factors include controllability, familiarity, uncertainty and dread (Slovic, 1987). The findings of the current study suggest that messages presented in visual and textual terms show great potential to demonstrate how complex processes and principles work to enhance the lay public's understanding of such principles and processes. For example, studies (i.e., Slovic, 1986 and 1987; Kasperson et al., 1988; Covello et al., 2001) have generally indicated that the perceived lack of control over complex technological innovations leads to high public notions of dread. Studies of consumer perceptions of food irradiation have shown that people fear that foods subjected to irradiation treatments can turn radioactive. Such a perception can be reduced when an individual learns of the protective measures put in place in irradiation facilities. Additionally, the visual representation of such processes allows audience members to better understand their effect on the food items they consume.

The results of the present study indicate that using visuals to explain medical, technological, and natural hazards has great influence on knowledge acquisition. A more enlightened citizenry has the wherewithal to make more informed judgments about how to mitigate risks related to the foods they eat. Therefore, developing messages in ways that cater to the needs of different learners (i.e., those who respond more to text and those who respond more to visuals) is a worthy objective for public investments.

Limitations of the Study and Suggestions for Future Research

The present study involved a relatively small sample of college students from a premier land grant university. Thus, the results cannot be generalized to the entire population of American consumers. Also, a larger sample size could have provided greater statistical power to detect between-group differences.

The study also employed a limited number of visual aids in the experimental treatment. Future studies should evaluate the impact of risk ladders, graphs and charts on recall, attitudes and behavioral intentions. According to Lipkus & Hollands (1999), it is important to test which graphical displays are best suited to varying risk communication objectives.

Considering that the visual representation of risk is still a nascent field of study, an interdisciplinary approach is necessary to develop an overarching framework that encompasses the psychological processes individuals go through when presented with visual stimuli. Visual risk communication demonstrates an innate ability to increase recall and exhibits capabilities to influence attitudes and behavioral intention towards food irradiation. The findings of cross-disciplinary research should begin to bridge the gap between scientific experts and the general public when it comes to risk assessment pertaining to the safety and quality of foods through radiation processes.

REFERENCES

Bogardus, S.T., Holmboe, E., & Jekel, J.F. (1999). Perils, pitfalls, and possibilities in talking about medical risk. *JAMA, 281*(11), 1037-1041.

Bord, R.J., & O'Connor, R.E. (1990). Risk communication, knowledge, and attitudes: Explaining reactions to a technology perceived as risky. *Risk Analysis, 10*(4), 499-506.

Bruhn, C.M. (1994). Consumer attitude and market response to irradiated foods. *Journal of Food Protection, 58*(2), 175-181.

Burkell, J. (2004). What are the chances? Evaluating risk and benefit information in consumer health materials. *J Med Libr Assoc, 92*(2), 200-208.

Centers for Disease Control and Prevention. (2005). Food irradiation. Retrieved October 20, 2008, from http://www.cdc.gov/ncidod/DBMD/diseaseinfo/foodirradiation.htm.

Cleveland, W.S., & McGill, R. (1985). Graphical perception and graphical methods for analyzing scientific data. *Science, 229*(4716), 828-833.

Cohen, B.C. (1969). *The press and foreign policy.* Princeton, NJ: Princeton University Press.

Covello, V.T., Peters, R.G., Woktecki, J.G., & Hyde, R.C. (2001). Risk communication, the West Nile virus epidemic, and bioterrorism: Responding to the communication challenges posed by the intentional or unintentional release of a pathogen in an urban setting. *Journal of Urban Health*, *78*(2), 382-391.

Crow, D. (2003). *Visible signs: An introduction to semiotics.* Switzerland: Ava Publishing SA.

Dickenson, G.W., DeSanctis, G., & McBride, D.J. (1986). Understanding the effectiveness of computer graphics for decision support: A cumulative experimental approach. *Communication of the ACM*, *29*(1), 40-47.

Dondis, D.A. (1973). *A primer on visual literacy.* Cambridge, MA: MIT Press.

Eagly, A.H., & Chaiken, S. (1993). *The psychology of attitudes.* Fort Worth, TX: Harcourt Brace College Publishers.

Environment Protection Agency. (2008). Food irradiation. Retrieved October 20, 2008, from http://www.epa.gov/rpdweb00/sources/food_irrad.html.

Farkas, J. (1998). Irradiation as a method for decontaminating food. *International Journal of Food Microbiology, 44*, 189-204.

Few, S. (2004). *Show me the numbers: Designing tables and graphs to enlighten.* Oakland, CA: Analytics Press.

Food Marketing Institute. (2000). *Food irradiation backgrounder.* Washington, DC: Food Marketing Institute

Fortin, J.M., Hirota, L.K., Bond, B.E., O'Connor, A.M., & Col, N.F. (2001). Identifying patient preferences for communicating risk estimates: A descriptive pilot study. *BMC Medical Informatics and Decision Making, 1*(2), 1-11.

Fox, J.A., Hayes, D.J., & Shogren, J.D. (2002) Consumer preferences for food irradiation: How favorable and unfavorable descriptions affect preferences for irradiated pork in experimental auctions. *The Journal of Risk and Uncertainty*, 24(1), 75-95.

Frewer, L.J., Howard, C., Hedderly, D., & Shepherd, R. (1998). Methodological approaches to assessing risk perceptions associated with food-related hazards. *Risk Analysis, 18*(1), 95-102.

Gamson, W.A., & Modigliani, A. (1989). Media discourse and public opinion on nuclear power: A constructionist approach. *The American Journal of Sociology, 95*(1), 1-37.

Glenburg, A.M., & Langston, W.E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language, 31*(2), 129-151.

Graber, D.A. (1984). *Processing the news: How people tame the information tide.* New York: Longman Press.

Graber, D.A. (1996). Say it with pictures. *Annals of the American Academy of Political and Social Science, 546,* 85-96.

Iowa State University Extension. (2006). Food irradiation – What is it? Retrieved October 20, 2008, from http://www.extension.iastate.edu/foodsafety/irradiation/index.cfm?parent=3 .

Kasperson, R.E, Renn, O., Slovic, P., Brown, H.S., Emel, J., Goble, R., Kasperson, J.X., & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis, 8*(2), 177-187.

Lipkus, I.M., & Hollands, J.G. (1999). The visual communication of risk. *Journal of the National Cancer Institute Monographs, 25,* 149-163.

Loaharanu, P., & Thomas, P. (2001). Irradiation for food safety and quality: Proceedings of the FAO/IAEA/WHO international conference on ensuring the safety and quality of foods through radiation processing. Boca Raton, FL: CRC Press.

Lodding, K.N. (1983). Iconic interfacing. *IEEE Computer Graphics and Applications, 3*(2), 11-20.

McCombs, M., & Shaw, D. (1972). The agenda-setting function of mass media. *Public Opinion Quarterly, 36*(2), 176-187.

Mead, P.S., Slutsker, L., Dietz, V., McCaig, L.F., Bresee, J.S., Shapiro, C., Griffin, P.M., & Tauxe, R.V. (1999). Food-related illness and death in the United States. *Emerging Infectious Diseases Journal*, *5*(5), 607-625.

Mehta, M.D. (2002). Public perceptions of food safety: Assessing the risks posed by genetic modification, irradiation, pesticides, microbiological contamination and high fat/high calorie foods. *Pierce Law Review, 69,* 69-84.

National Research Council. (1989). *Improving risk communication.* Washington D.C.: National Academy Press

National Work Group on Literacy and Health. (1998). Communicating with patients who have limited literacy skills. *The Journal of Family Practice, 46,* 168-176.

Nisbett, R.E., & Ross, L., (1980). *Human inference: Strategies and shortcomings of social judgment.* Englewood Cliffs, NJ: Prentice-Hall.

Organization for Economic Cooperation and Development. (2000). *Literacy in the information age: Final report of the international adult literacy survey.* Paris, France: OECD.

Rodriguez, L. (2007). The impact of risk communication on the acceptance of irradiated food. *Science Communication, 28,* 476-500.

Rothman, A.J., & Kiviniemi, M.T. (1999). Treating people with information: An analysis and review of approaches to communicating health risk information. *J. Natl Cancer Inst Monogr, 25,* 44-51.

Sandman, P.M. (1989). Hazard versus outrage in the public perception of risk. In V.T. Covello, D.B. McCallum, & M.T. Pavlova (Eds). *Effective risk communication: The role and responsibility of government and non-government organizations* (pp. 45-49). New York: Plenum Press.

Slovic, P. (1986). Informing and educating the public about risk. *Risk Analysis, 6*(4), 403-415.

Slovic, P. (1987). Perception of risk. *Science, 236*(4799), 280-285.

Stone, R. (2006). Inside Chernobyl. Retrieved November 20, 2008, from http://ngm.nationalgeographic.com/2006/04/inside-chernobyl/stone-text/1.

Tauxe, R.V. (2001). Food safety and irradiation: Protecting the public from food-borne infections. *Emerging Infectious Disease, 7*(3), 516-521.

Tufte, E.R. (1983). *The visual display of quantitative information.* Cheshire, CT: Graphic Press.

U.S. Department of Agriculture. (2000). *Consumer acceptance of irradiated meat and poultry products* (Agriculture Information Bulletin No. 757). Washington, DC: U.S. Government Printing Office.

U.S. Strategic Bombing Survey (1946). The effects of the atomic bombings of Hiroshima and Nagasaki. Retrieved November 20, 2008 from http://www.trumanlibrary.org/whistlestop/study_collections/bomb/large/documents/index.php?pagenumber=1&documentdate=1946-0619&documentid=65&studycollectionid=abomb.

U.S. Food and Drug Administration. (2009). Foods permitted to be irradiated under FDA regulations. Retrieved November 21, 2009, from http://www.fda.gov/Food/FoodIngredientsPackaging/IrradiatedFoodPackaging/ucm074734.htm.

APPENDIX A.
IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

DATE: September 18, 2009

TO: Elizabeth Wilson
112 10th Street, Apt. 309
Des Moines, IA 50309

CC: Dr. Lulu Rodriguez
214 Hamilton Hall

FROM: Roxanne Bappe, IRB Coordinator
Office for Responsible Research

TITLE: **The effect of visuals on risk knowledge, attitude and behavioral intention toward irradiated foods**

IRB ID: **09-430** **Study Review Date:** 17 September 2009

The Institutional Review Board (IRB) Chair has reviewed this project and has declared the study exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b). The IRB determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**
- **You must carry out the research as proposed in the IRB application**, including obtaining and documenting (signed) informed consent if you have stated in your application that you will do so or if required by the IRB.
- **Any modification of this research should be submitted to the IRB on a Continuing Review and/or Modification form, prior to making any changes**, to determine if the project still meets the Federal criteria for exemption. If it is determined that exemption is no longer warranted, then an IRB proposal will need to be submitted and approved before proceeding with data collection.

Please be sure to **use the documents with the IRB approval stamp** in your research.

Please note that you must submit all research involving human participants for review by the IRB. **Only the IRB may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

APPENDIX B
BROCHURES

Brochure 1

What is Food Irradiation?

What is food irradiation?

Food irradiation is a process in which radiation is passed through foods in order to destroy bacteria, mold, parasites and other organisms that cause spoilage and food borne illnesses such as *E. coli* and Salmonella. Since 1963, a multitude of foods have been approved for irradiation by the United States Food and Drug Administration (FDA) and the US Department of Agriculture (USDA). These foods include wheat flour, white potatoes, fresh fruits and vegetables, herbs and spices, uncooked poultry, pork, beef, spinach and lettuce. While these foods are approved for irradiation, little irradiated food is actually available to the general public (CDC, 2005; Tauxe, 2001).

How is food irradiated?

(1) The first and most common method of irradiating food uses radioactive substances such as Cobalt 60 and Cesium 137. These materials emit gamma rays, which have the ability to penetrate food at several feet, even after packaging. Given their radioactive nature, the materials are stored in pools of water surrounded by a secure concrete chamber. In this method, the food is brought into the secure chamber and the radioactive substances are pulled up from the water and exposed to the food for a specific period of time. Gamma rays do not produce neutrons, meaning at no point in the irradiation process does the food become radioactive (CDC, 2005).

(2) The second method of irradiation uses an electron beam to propel a stream of high-energy electrons through food. Different from gamma rays, electrons can only penetrate food items that are a little more than an inch thick. Thus, foods treated with this method must be thin enough to be fully irradiated. A simple on and off button controls the stream and no radioactivity is involved in the process (CDC, 2005).

(3) The third method of irradiation uses X-rays. X-ray irradiating machines used for food are similar to those used in the medical profession, but are much more powerful. To produce x-rays, a beam of electrons is sent through a thin plate of gold or other metal, producing a stream of x-rays out the other side. Like gamma rays, this method can pass through thick foods and requires heavy shielding. However, like the electron beam, it can be switched on and off, and no radioactive substances are involved (CDC, 2005).

Benefits of food irradiation

(1) Irradiation destroys most bacteria, molds, parasites and microorganisms that cause food borne diseases including *E. coli* O157, *Salmonella, Campylobactor, Listeria, and Toxoplasma*. It has been estimated that if 50% of all poultry, ground beef, pork and processed meats were irradiated there would be a 25% reduction in the morbidity and mortality rate cause by these infections (Loaharanu & Thomas, 2001; Tauxe, 2001; Thayer, 1990).

(2) Irradiation can extend the shelf life of food by reducing spoilage, ripening and sprouting. The resulting products are closer to the fresh state in texture, flavor and color for a longer period of time. Irradiated strawberries for example, last at least a week longer in the refrigerator than untreated strawberries. (FMI, 2000; Thayer, 1990).

(3) Irradiation provides an alternative to using hazardous pesticides, fumigants and preservatives currently used to protect foods from insects and diseases. Irradiation also eliminates the unwanted residue left on foods that have been treated with insect sprays and fumigants (FMI, 2000).

(4) Irradiation at low doses improves the safety of foods for immune-compromised people such as those with diabetes, transplant patients, people on cancer therapies and HIV/AIDS patients. Irradiation at high doses is currently used to sterilize more than half of all medical supplies, along with cotton swabs, contact lenses, saline solutions, tampons, teething rings and cosmetics (FMI, 2000; Tauxe, 2001).

Risks of food irradiation

(1) Much like canning, pasteurization and cooking, irradiation can reduce the levels of vitamins found in food including vitamins E, C, A, K and thiamin. While the reduction of vitamins is relatively low, individuals whose diets consisted largely of irradiated foods could lose the necessary vitamins needed (FMI, 2000; Thayer, 1990).

(2) Widespread use of irradiation could prompt producers, distributors and consumers to be less aggressive in practicing necessary sanitation measures. Irradiation should not be viewed as a substitute for safe sanitation practices because foods can still be re-contaminated if they come in contact with unclean surfaces or raw foods, or if they are otherwise improperly stored, handled or prepared (FMI, 2000).

(3) Some gamma rays used in irradiation can break chemical bonds to form "radiolytic products," which may cause adverse health effects. For example, irradiating meat can produces benzene and irradiating carbohydrate-rich foods can yield formaldehyde. However, this effect is not limited to irradiation: cooking, canning and pasteurization also produces radiolytic products. Additionally, irradiation produces small amounts of such compounds – in some cases much smaller than occur naturally in foods. (FMI, 2000).

(4) The transportation and use of radioactive materials could pose unnecessary risks to the public and workers handling these materials. Because the gamma ray method of irradiation involves hazardous radioactive materials, severe regulations are enforced for their handling and transportation by the Nuclear Regulatory Commission and the Department of Transportation (FMI, 2000).

—Center for Disease Control and Prevention. (2005). Food irradiation. Retrieved October 20, 2008, from http://www.cdc.gov/ncidod/DBMD/diseaseinfo/foodirradiation.htm.
—Food Marketing Institute. (2000). *Food irradiation backgrounder*. Washington, DC: Food Marketing Institute.
—Loaharanu, P., & Thomas, P. (2001). Irradiation for food safety and quality: Proceedings of FAO/IAEA, WHO international conference on ensuring the safety and quality of foods through radiation processing. Boca Raton, Florida: CRC Press.
—Tauxe, R.V. (2001). Food safety and irradiation: Protecting the public from food borne infections. *Emerging Infectious Disease*, 7(3), 516-521.
—Thayer, D.W. (1990). Food Irradiation: Benefits and Concerns. *Journal of Food Quality*, 13, 147-169.

Brochure 2

What is Food Irradiation?

What is food irradiation?

Food irradiation is a process in which radiation is passed through foods in order to destroy bacteria, mold, parasites and other organisms that cause spoilage and food borne illnesses such as *E. coli* and Salmonella. Since 1963, a multitude of foods have been approved for irradiation by the United States Food and Drug Administration (FDA) and the US Department of Agriculture (USDA). These foods include wheat flour, white potatoes, fresh fruits and vegetables, herbs and spices, uncooked poultry, pork, beef, spinach and lettuce. While these foods are approved for irradiation, little irradiated food is actually available to the general public (CDC, 2005; Tauxe, 2001).

Irradiation Approved Foods in the United States

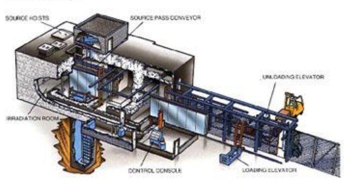
Purpose	Food
Control Mold	Wheat flour
Inhibit sprouting	Potatoes, Onions, Garlic, Ginger Root Chestnut, Carrots
Insect disinfestation	Fresh & Dried Fruits, Vegetables, Dried Meat & Fish, Cereals & Legumes
Extend shelf life	Fresh Fruits, Fresh Vegetables, Raw Fish & Seafood
Reduce bacterial pathogens and spoilage	Raw & Frozen Poulty, Meat, & Seafood, Spices, Dried Vegetable Seasonings, Tea Lettuce, Spinach

(CDC, 2005; Tauxe, 2001)

How is food irradiated?

(1) The first and most common method of irradiating food uses radioactive substances such as Cobalt 60 and Cesium 137. These materials emit gamma rays, which have the ability to penetrate food at several feet, even after packaging. Given their radioactive nature, the materials are stored in pools of water surrounded by a secure concrete chamber. In this method, the food is brought into the secure chamber and the radioactive substances are pulled up from the water and exposed to the food for a specific period of time. Gamma rays do not produce neutrons, meaning at no point in the irradiation process does the food become radioactive (CDC, 2005).

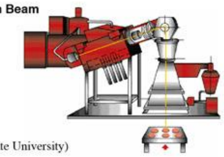
Gamma Ray



(University of Wisconsin Food Irradiation Group)

(2) The second method of irradiation uses an electron beam to propel a stream of high-energy electrons through food. Different from gamma rays, electrons can only penetrate food items that are a little more than an inch thick. Thus, foods treated with this method must be thin enough to be fully irradiated. A simple on and off button controls the stream and no radioactivity is involved in the process (CDC, 2005).

Electron Beam



(Iowa State University)

(3) The third method of irradiation uses X-rays. X-ray irradiating machines used for food are similar to those used in the medical profession, but are much more powerful. To produce x-rays, a beam of electrons is sent through a thin plate of gold or other metal, producing a stream of x-rays out the other side. Like gamma rays, this method can pass through thick foods and requires heavy shielding. However, like the electron beam, it can be switched on and off, and no radioactive substances are involved (CDC, 2005).

Benefits of food irradiation

(1) Irradiation destroys most bacteria, molds, parasites and microorganisms that cause food borne diseases including *E. coli* O157, *Salmonella, Campylobacter, Listeria, and Toxoplasma*. It has been estimated that if 50% of all poultry, ground beef, pork and processed meats were irradiated there would be a 25% reduction in the morbidity and mortality rate cause by these infections (Loaharanu & Thomas, 2001; Tauxe, 2001; Thayer, 1990).

Potential number of health problems prevented annually if 50% of meat and poultry were irradiated.

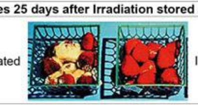
Pathogen	Cases Prevented	Hospitalizations Prevented	Deaths Prevented
E. coli O157:H7	23,000	700	20
Campylabacter	500,000	2600	25
Salmonella	330,000	4,000	140
Listeria	625	575	125
Toxoplasma	28,000	625	94
Total	**881,625**	**8,500**	**352**

(Tauxe, 2001)

(2) Irradiation can extend the shelf life of food by reducing spoilage, ripening and sprouting. The resulting products are closer to the fresh state in texture, flavor and color for a longer period of time. Irradiated strawberries for example, last at least a week longer in the refrigerator than untreated strawberries. (FMI, 2000; Thayer, 1990).

Strawberries 25 days after Irradiation stored at 3ºC

Not Irradiated



Irradiated

http://www.foodirradiationinfo.org/img/irradiatedstrawberries.jpg

(3) Irradiation provides an alternative to using hazardous pesticides, fumigants and preservatives currently used to protect foods from insects and diseases. Irradiation also eliminates the unwanted residue left on foods that have been treated with insect sprays and fumigants (FMI, 2000).

(4) Irradiation at low doses improves the safety of foods for immune-compromised people such as those with diabetes, transplant patients, people on cancer therapies and HIV/AIDS patients. Irradiation at high doses is currently used to sterilize more than half of all medical supplies, along with cotton swabs, contact lenses, saline solutions, tampons, teething rings and cosmetics (FMI, 2000; Tauxe, 2001).

Risks of food irradiation

(1) Much like canning, pasteurization and cooking, irradiation can reduce the levels of vitamins found in food including vitamins E, C, A, K and thiamin. While the reduction of vitamins is relatively low, individuals whose diets consisted largely of irradiated foods could lose the necessary vitamins needed (FMI, 2000; Thayer, 1990).

Vitamin Contents of Frozen, Gamma Ray-Irradiated and Electron-Irradiated Chicken

Vitamin	Frozen	Gamma Ray	Electron
Folic Acid, ppm	.83	1.26	1.47
Niacin, Chemical, ppm	218.6	209.8	212.1
Niacin, Bound, ppm	212.9	197.9	208.2
Pyridoxine, ppm	7.26	5.32	6.70
Thiamine-HCl, ppm	2.31	1.57	1.98
Vitamin A, IU/kg	2716	2270	2270
Vitamin D, IU/kg	375.1	354.0	466.1
Vitamin K, ppm	1.29	.81	.85
Vitmain B12, ppm	.0083	.0137	.0088

Vitamin concentratious are reported on a dry weight basis (Thayer, 1990)

(2) Widespread use of irradiation could prompt producers, distributors and consumers to be less aggressive in practicing necessary sanitation measures. Irradiation should not be viewed as a substitute for safe sanitation practices because foods can still be re-contaminated if they come in contact with unclean surfaces or raw foods, or if they are otherwise improperly stored, handled or prepared (FMI, 2000).

http://www.redbridge.gov.uk/cms/images/food_inspector_webbed.jpg

(3) Some gamma rays used in irradiation can break chemical bonds to form "radiolytic products," which may cause adverse health effects. For example, irradiating meat can produces benzene and irradiating carbohydrate-rich foods can yield formaldehyde. However, this effect is not limited to irradiation: cooking, canning and pasteurization also produces radiolytic products. Additionally, irradiation produces small amounts of such compounds – in some cases much smaller than occur naturally in foods. (FMI, 2000).

(4) The transportation and use of radioactive materials could pose unnecessary risks to the public and workers handling these materials. Because the gamma ray method of irradiation involves hazardous radioactive materials, severe regulations are enforced for their handling and transportation by the Nuclear Regulatory Commission and the Department of Transportation (FMI, 2000).

—Center for Disease Control and Prevention. (2005). Food irradiation. Retrieved October 20, 2008, from http://www.cdc.gov/ncidod/DBMD/diseaseinfo/foodirradiation.htm.
—Food Marketing Institute. (2000). *Food irradiation backgrounder*. Washington, DC: Food Marketing Institute.
—Loaharanu, P., & Thomas, P. (2001). Irradiation for food safety and quality: Proceedings of FAO/IAEA, WHO international conference on ensuring the safety and quality of foods through radiation processing. Boca Raton, Florida: CRC Press.
—Tauxe, R.V. (2001). Food safety and irradiation: Protecting the public from food borne infections. *Emerging Infectious Disease*, 7(3), 516-521.
—Thayer, D.W. (1990). Food Irradiation: Benefits and Concerns. *Journal of Food Quality*, 13, 147-169.

APPENDIX C.
QUESTIONNAIRE AFTER READING THE BROCHURE

The Process, Risks and Benefits of Food Irradiation

(Please choose only one answer for each question.)

Comprehension

The following section aims to gauge your comprehension of the food irradiation brochure you have just reviewed. If you do not know the answer to a question, you may leave it blank.

1. Have you ever heard of the process of food irradiation prior to reading this brochure?

   YES
   NO

2. If yes, how familiar are you with the process of food irradiation?

   Very familiar
   Somewhat familiar
   Unfamiliar

3. Please name three food items experts have approved for irradiation.

4. Please cite one ***benefit*** of food irradiation.

5. Please cite one ***risk*** consumers may be subjected to due to food irradiation.

Attitudes

The following section aims to gauge your attitude toward food irradiation.

6. Food irradiation is a safe process.

   Strongly disagree
   Disagree
   Undecided
   Agree
   Strongly agree

7. Food irradiation will protect me from food-borne illnesses caused by pathogens such as *E. coli* and salmonella.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

8. Food irradiation will eliminate the need for environmentally hazardous fumigants often used to get rid of harmful organisms in food items.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

9. Food irradiation poses dangers to those who work at or live near an irradiation facility.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

10. Food irradiation will eliminate the need for already existing food safety practices.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

11. Food irradiation depletes the nutritional value of food.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

12. Food irradiation will become a widely accepted process in the future.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

Behavior

The following section aims to gauge your behavioral intention towards food irradiation.

13. I am willing to try foods that have been irradiated.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

14. I will buy irradiated food if it is available at my local store.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

15. I am willing to serve irradiated food to my friends and family.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

16. I am more likely to store irradiated foods for consumption for a longer period of time than food items that are not irradiated.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

17. I am willing to pay more for irradiated food.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

Evaluation

The following section aims to gauge your response to the food irradiation brochure.

18. The brochure was informative about the process of food irradiation.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

19. The brochure was informative about the benefits that can be derived from food irradiation.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

20. The brochure was informative about the risks entailed in food irradiation.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

21. The information I read in the brochure was valuable to me.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

22. The brochure held my interest.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

*23. The visuals in the brochure helped me a great deal in understanding food irradiation.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

24. The layout of the brochure was easy to navigate.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

25. The brochure was easy to read.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

26. The amount of text in the brochure was overwhelming.

Strongly disagree
Disagree
Undecided
Agree
Strongly agree

27. The overall appearance of the brochure was pleasing.

Strongly disagree
Disagree
Undecided
Agree

Strongly agree

Demographics

28. Gender

Female
Male

29. Age

30. Academic Classification

Freshman
Sophomore
Junior
Senior
Graduate student

31. Major field of study

* Question 23 was asked only of those who reviewed Brochure 2.

ACKNOWLEDGMENTS

First and foremost, I would like to thank my major professor, Dr. Lulu Rodriguez, for her continued support throughout the conduct of this study. Her combined knowledge of visual and risk communication provided a unique perspective and proved immensely helpful in the development and execution of this research project. I would also like to thank my committee members, Dr. Sela Sar and Dr. Robyn Cooper for bringing their expertise to bear on this research project.

In addition, I want to thank Riley for his patience and support throughout this process. His pep talks during late night writing sessions kept me going when procrastination would have gotten the better of me.

Finally, I would like to thank my family for their continued support of my educational and career goals. Their consistent encouragement has helped me follow this path into the journalism field.

The friendships and experiences I have made at Iowa State University's Greenlee School of Journalism and Mass Communication are immeasurable, and I thank the faculty, staff, and fellow graduate students for creating a supportive and enthusiastic learning environment.