Iowa dietitians' attitudes toward and knowledge of new food technologies: Genetically engineered and irradiated foods

by

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GENERAL INTRODUCTION

New technologies have assumed an increasingly important role in the food industry as demographics and lifestyles of consumers have changed, and public health policies have supported consumption of reduced fat foods. As a result of these changes, an aggressive posture has been taken by the food industry toward use of innovative technologies to satisfy consumers' needs and desires (Smith, 1993).

Many studies have reported the potential of genetic engineering in enhancing the quality, nutritional value, and variety of food available for human consumption, and the potential to increase the efficiency of food production and processing, particularly for countries with inadequate food supplies (Hoppes, 1993; Kunkel, 1993; American Dietetic Association [ADA], 1995; Welser, 1991). Genetic engineering is a method of changing the inherited characteristics of an organism in a predetermined way by altering its genetic material (Clarke, 1994). Genetic engineering techniques use restriction enzymes to cleave DNA strands at specific sequences. A DNA fragment (specific characteristic) is cut by restriction enzymes and then inserted into a host cell where it either integrates into the DNA of that cell or replicates independently. The inserted DNA does not migrate within the host genome; therefore, only a remote chance exists that pathogenic mutations will form or genetic occurrence be rearranged (American Medical Association [AMA], 1991).

Irradiation is a food processing technique, as is canning or freezing. Food irradiation uses ionizing energy from radioactive sources to penetrate the food and kill insects, fungi, and bacteria that cause food spoilage and foodborne illnesses. The majority of the energy passes through the food in much the way as microwaves do in cooking (World Health Organization [WHO], 1988). Irradiation offers advantages to producers and consumers such as improved safety and extended shelf life of foods (Bruhn, Schutz, & Sommer, 1986a; Bruhn & Wood, 1996; WHO, 1988).

The first genetically engineered whole food product, a slow-softening tomato (*Flavr Savr*) that remains longer on the vine to develop its full flavor, was made available to the American public at retail stores in the fall of 1994 (Nelson & Poorani, 1996; Schuch, 1994). Irradiated chicken has been a fast-selling item at one specialized retail outlet, primarily because of consumer concerns of bacteria that cause foodborne illnesses (Diehl, 1993).

However, in spite of the potential benefits of genetically engineered and irradiated foods, both of these technologies have been the center of controversy (Busch, 1991; Crawford & Clarke, 1990; Sapp, 1995; Zimmerman, Kendall, Stone, & Hoban, 1994). One controversial issue of genetically engineered foods is the creation of new life forms (Nelson & Poorani, 1996). Another concern is the potential to violate consumers' dietary restrictions and/or religious beliefs (Bernstein, 1992). Organizations opposed to food irradiation cite concerns about long-term health effects, nutrient losses, and worker safety at irradiation facilities (Webb, Lang, & Tucker, 1987) as well as questioning whether bacterial toxins and mycotoxins present in food are destroyed by radiation treatment (Diehl, 1993).

Whether the benefits of genetic engineering and irradiation of foods will be fully realized depends upon how well-informed consumers can become about the benefits and safety of these products. A Registered Dietitian (RD) has been described as "a food and nutrition expert who can separate facts from fads, and translate the latest scientific breakthroughs into practical food choices" (National Center for Nutrition and Dietetics, 1995). Dietetics professionals are perceived by consumers as reliable providers of food and nutrition information and services (Kunkel, 1993). One purpose of the American Dietetic Association (ADA) is to educate consumers about food and nutrition issues, including new technologies such as genetic engineering or irradiation (Bruhn & Wood, 1996; Kunkel, 1993).

Zimmerman et al. (1994) reported consumers were skeptical of information received from the mass media about food, although these were sources indicated as most frequently used. In the same study, the most trusted sources of information about genetic engineering were identified as dietitians, other health professionals, and university scientists. As key communicators on nutrition issues, RDs have an important role to play in informing the public about the potential of technological advances to add value and benefits to the food supply ("ADA participates," 1994).

Previous research has studied attitudes toward and/or knowledge of genetically engineered or irradiated food held by subgroups identified on the basis of demographic variables, such as gender, education, age, employment sector, and geographic location. No research has been published about attitudes toward and knowledge of genetically engineered or irradiated foods held by RDs.

The specific objectives of this study were to:

1. Determine attitudes of Iowa RDs toward genetically engineered and irradiated foods.
2. Determine knowledge levels of Iowa RDs of genetically engineered and irradiated foods.

3. Compare attitudes among respondents grouped by age, educational level, employment sector, and number of years as a RD toward genetically engineered and irradiated foods.
4. Compare knowledge level of respondents grouped by age, level of education, employment sector, and number of years as a RD toward genetically engineered and irradiated foods.

Thesis Organization

This thesis has been organized so that a general introduction and literature review precede the manuscript with a general conclusions section following. The general conclusions section summarizes the results and discussion, and provides suggestions for further research.

The manuscript has been written according to specifications for submission to the Journal of the American Dietetic Association, a referred scholarly journal, which follows the manual style of the American Medical Association (1989). The manuscript is entitled "Iowa dietitians' attitudes toward and knowledge of new food technologies: Genetically engineered and irradiated foods." Authorship of the manuscript is shared with Catherine H. Strohbehn, Ph.D., RD, Adjunct Assistant Professor and Cathy H. C. Hsu, Ph.D., Assistant Professor in the Department of Hotel, Restaurant, and Institution Management at Iowa State University (ISU).

The definitions of items used in this thesis are in Appendix A. Approval for the study was granted by the Human Subjects Review Committee of Iowa State University. A copy of the review committee's approval form is in Appendix B. A copy of the data collection instrument is in Appendix C. Appendix D consists of additional tables that present data not included in the manuscript.

LITERATURE REVIEW

The review of literature includes three major sections. The first two sections review literature related to new food technologies of genetically engineered and irradiated foods, respectively. The third section reviews published literature pertaining to consumers' attitudes and knowledge about these new food technologies.

Genetically Engineered Foods

Information about the process of genetic engineering of foods, applications of this technology, and foods currently produced are reviewed in this section. An overview of government regulations and labeling requirements for genetically engineered foods, and controversial issues about genetic engineering of foods are also presented.

Process

The terms "biotechnology" and "genetic engineering" are frequently used interchangeably. In 1919, K. Eriky (Engel, Takeoka, & Teranishi, 1995), an Hungarian agricultural economist, coined the term "biotechnology" to define the interaction of biology with technology. In 1979, E. F. Hutton obtained a trademark on this term to market a magazine dealing with genetic engineering. Thus, the word became associated with genetic engineering rather than the more general description. Proceedings from the 1995 symposium of the American Chemical Society used the phrase "genetic engineering" to refer to alteration of the genetic makeup of organisms, rather than the term "biotechnology" (Engel et al., 1995). In this thesis, the phrases "genetic engineering" and "genetically engineered foods" are used to describe technology including manipulation of genetic structure of food items to enhance nutritional status or quality.

Hybridization is a classic breeding technique that is time-consuming, and which can result in complications. Hybridization combines all genes of the parent plants, so both desirable and undesirable traits may be expressed in the plant offspring ("Plant Breeding," 1994).

The modern era of biotechnology began in 1973 when scientists cut a gene out of one cell and "spliced" it into the cell of a tiny bacterial chromosome. The ability to specifically isolate and recombine genes led to the development of recombinant DNA technology or genetic engineering (Hoppes, 1993). Developments in genetic engineering have created new dimensions in classical biotechnology. By using recombinant DNA (rDNA) techniques, it has become possible to direct movements of specific and useful segments of genetic material between unrelated organisms, thereby crossing barriers between plants, animals, and microorganisms (Engel et al., 1995). Genetic engineering techniques increase the likelihood that the desired attribute will appear and thus reduce genetic variability (Koshland, 1989).

Genetic engineering techniques use restriction enzymes to cleave DNA strands at specific sequences. A DNA fragment cut by restriction enzymes is inserted into a host cell where it will either integrate into the DNA of that cell or replicate independently. The inserted DNA does not migrate within the host genome; therefore, only a remote chance exists pathogenic mutations will form or the genetic structure be rearranged (AMA, 1991).

Applications

Genetic engineering holds great promise in fields of medicine, environmental protection, food ingredients, and agriculture (ADA, 1995; Engel et al., 1995; Kunkel, 1993). Several applications of this technology are currently available commercially, while use in some fields is still in the experimental stages.

Medicine

The first genetically engineered product to be produced commercially was human insulin, approved for use in 1982 (Harlander, 1989). Other products developed by genetic engineering include human growth hormone, alpha interferon, and tissue plasminogen activator (Harlander, 1989).

Environmental protection

Research experiments to determine feasibility of genetic engineering for protection of the environment are in progress. Genetically modified bacteria can be used to convert organic wastes from municipalities into useful products, such as alcohol or methane which may serve as alternative fuel sources. New technologies for the clean up of oil spills and the treatment of toxic waste also may be possible through genetic engineering (ADA, 1995).

Food processing ingredients

Genetic engineering, fermentation, and biotransformation processes have been experimentally used for production of food ingredients, such as sugar substitutes, fat substitutes, colors, and flavors. Currently these ingredients are obtained from plants or animals, or manufactured synthetically (Harlander, 1989). Use of genetic engineering has the potential to pacify consumers' concerns over use of artificial additives (Kunkel, 1993).

Agriculture

Genetically modified plant seed varieties have produced crops resistant to specific weeds and pests, with the result of the need to apply fewer pesticides and herbicides (Hoppes, 1993; Kessler, Taylor, Maryanski, Flamm, & Kahl, 1992). A number of transgenic plants (change of one plant to another) resistant to insects and diseases has been developed. Transgenic plants have also been produced for human pharmaceutial products, and for the purpose of reducing processing costs of plants with allergenic or off-flavor components (Hoppes, 1993; Welser, 1991).

Animal genetic engineering research has focused on production of livestock that will utilize feed more efficiently, grow to desired slaughter weights at an earlier age with improved efficiencies, and result in higher quality products (Crawford & Clarke, 1990). Genetically manipulated animals differ from traditionally bred animals only in the expression of desired genetic traits, such as increased growth. This allows for a potential economic advantage to producers (Norcross, Berkowitz, Damare, & Brown, 1990).

Food products

In spring of 1994 the Food and Drug Administration (FDA) approved Calgene's genetically altered "*Flavr Savr*" tomato, a vine-ripened or slow-softening tomato for sale (ADA, 1995; Kahl, 1994; Nelson & Poorani, 1996). The *Flavr Savr* was the first genetically engineered whole food sold at the retail level. The gene which affected texture of the tomato was manipulated so the tomato remained longer on the vine and developed to maximum flavor without softening as part of the ripening process. This alteration allowed the product to be shipped to distant markets without quality deterioration ("ADA participates," 1994; Nelson & Poorani, 1996; Schuch, 1994).

Two genetically engineered animal products are bovine somatotropin (bST) and porcine somatotropin (pST) (Hoppes, 1993). Bovine somatotropin (bST) is a protein hormone associated with milk production and naturally present in all dairy cattle. When additional doses of bST were administered to dairy cows, milk production increased up to 20% (Becker & Taylor, 1986; Hoppes, 1993; Connaughton, 1989). The FDA also approved use of bST and ruled supplementation of dairy cows with bST pose no human health concerns (Juskevich & Guyer, 1990). FDA rulings were based on findings that (a) bST was species-specific for cows, (b) bST was a protein and is digested in the intestinal tract, (c) milk contained bST naturally and supplementation of dairy cows did not increase amount of bST in milk to levels outside the normal range, and (d) bST supplementation did not change the composition of milk.

Porcine somatotropin (pST) has the ability to dramatically alter carcass composition of hogs, significantly decreasing the amount of fat while increasing the amount of protein (Harlander, 1989). When pST was administered to growing pigs in research studies, growth rates increased up to 20%, and carcass fat content was reduced as much as 70%. Changes in growth rate were accompanied by an increase of 50% muscle growth and production efficiency with body weight gains per feed input increased 35% (as cited in Hoppes, 1993).

Government regulations

Regulatory oversight of genetically engineered foods is the responsibility of the United States (U.S.) Food and Drug Administration (FDA), the U.S. Department of

Agriculture (USDA), and the U.S. Environmental Protection Agency (EPA) (Barefoot, Beachy, & Lilburn, 1994; Hoppes, 1993; Middlekauff, 1990). Each agency has specific assignments.

The FDA is the primary agency responsible for ensuring the safety of the food supply (Barefoot et al., 1994; Kessler et al., 1992). The FDA has authority under the Federal Food, Drug, and Cosmetic Act (FDCA) to ensure the safety and wholesomeness of foods, with the exception of meat and poultry. Foods developed through genetic engineering are included in FDA's charge (Maryanski, 1995).

In a 1992 published policy statement in the Federal Register, the FDA explained how food developed by conventional and genetic engineering methods were regulated under the FDCA (as cited in ADA, 1995; as cited in Maryanski, 1995). This document stated characteristics of the food, not the method used to produce the food, formed the basis in ensuring safety of foods from new plant varieties. FDA's role in regulation of food is driven by the food product, not the process by which it is produced (ADA, 1995).

Three USDA agencies have regulatory authority over aspects of genetic engineering: Animal and Plant Health Inspection Service (APHIS), Agricultural Marketing Service (AMS), and the Food Safety and Inspection Service (FSIS). A fourth USDA agency, Economic Research Service, evaluates socioeconomic impacts of new technologies (Norcross et al., 1990).

The APHIS ensures new plant varieties pose no threat to production agriculture or to the environment during cultivation, and regulates research development by requiring permits for the field testing, shipping and delivery of any seed or plants modified through genetic engineering (ADA, 1995; Barefoot et al., 1994). The FSIS, which is responsible for ensuring wholesomeness of meat and poultry, has also established regulations governing the food use of genetically manipulated animals (Norcross et al., 1990).

The Environmental Protection Agency (EPA) regulates pesticides that may be present in foods, and sets tolerance levels to provide a margin of safety for consumers (ADA, 1995; Barefoot et al., 1994). The EPA oversees development of new plant varieties with protective abilities against insects or disease, including those developed through genetic engineering (ADA, 1995).

Labeling

The FDCA of 1938 did not require disclosure in labeling of information solely on the basis of a consumer's desire to know. "The Act required that a food be given a common or usual name, and that the label disclose information that is material to representations made or suggested about the product and consequences that may arise from the use of the product" (as cited in Maryanski, 1995, p. 20).

FDA's 1992 policy statement addressed labeling of foods derived from new plant varieties, including plants developed with genetic engineering technology (ADA, 1995; FDA, 1992; Maryanski, 1995). The FDA stated the method of plant breeding is not required to be disclosed in labeling. Special labeling is required if the composition of a food developed through genetic engineering differs significantly from the conventional counterpart. Significant changes might include alteration in composition or nutrient content, or a change in the identity of the product (ADA, 1995; Maryanski, 1995).

Application of these policies resulted in no special labeling requirement for the *Flavr Savr* tomato. The FDA concluded the common name for the *Flavr Savr* tomato was "tomato," there were no significant differences in composition of the product, or changes in nutrient content. However, the producer of the tomato voluntarily provided special labeling, including point-of-sale information (Kahl, 1994).

The original plan of dairy processing plants was not to label milk from dairy cattle treated with bST. After considerable controversy at the retail level, voluntary labeling was introduced. FDA policies allowed labels for milk, ice cream, and other dairy products to state "from cows not treated with bST," but labels also must have the statement, "No significant difference has been shown between milk derived from bST-treated and non-bST-treated cows" ("Labels can say," 1994).

Controversial issues

In spite of the potential benefits of genetically engineered foods, consumer groups and culinary experts (e.g., Chefs Collaborative: 2000) have organized to protest the use of these products (Hoppes, 1993; Nelson & Poorani, 1996). One controversial issue of genetically engineered foods is the creation of new life forms (Nelson & Poorani, 1996). Another concern about genetically engineered foods is the potential to violate consumers' dietary restrictions and/or religious beliefs (Bernstein, 1992). Animal genes spliced into vegetables, or nonkosher genes (e.g., from shellfish) inadvertently mixed with kosher foods are two examples. A third concern is that transplanted genes could cause allergic reactions to uninformed consumers (Bernstein, 1992).

The majority of the scientific community agrees benefits of genetic engineering of foods outweigh any concerns. The ADA paper stated "It is the position of The American Dietetic Association that the techniques of biotechnology are useful in enhancing the quality, nutritional value, and variety of food available for human consumption and in increasing the efficiency of food production, processing, distribution, and waste management" (Kunkel, 1993, p. 189).

From a scientific viewpoint, the emergence and application of genetic engineering to foods is efficacious and safe. Proponents believe conditions are now favorable for rapid advancements in genetically engineered foods. Nonetheless, it is the attitudes and beliefs of the consumers that will determine whether these technologies will benefit society (Hoppes, 1993; Zimmerman et al., 1994).

Irradiated Foods

In this section of the review of literature, information about the process and application of food irradiation are reviewed. Approved products, a description of government regulations, and labeling requirements for irradiated foods follow. Controversial issues about food irradiation are also presented.

Process

Current problems facing the food industry include outbreaks of microbial contamination, presence of excess chemical residues, and the need for insect control in regional and international markets. Irradiation is considered by scientists as a known and technically desirable alternative solution to these problems (Moy, 1985; Urbain, 1986).

Irradiation is the use of ionizing energy from radioactive isotopes of cobalt or cesium, machine generated X-rays, or accelerated electrons exposed to food. Food irradiation is a processing technique, as is canning or freezing. These processing methods can kill insects, fungi, and bacteria that cause food spoilage and foodborne illnesses (WHO, 1988). Food irradiation has been investigated since 1904, with active research begun in the 1950's (Bruhn, 1995; Diehl, 1993; Redlinger & Nelson, 1991).

Gamma rays from radiant energy penetrate the food and packaging, and the majority of energy passes through the food. This process is similar to the way microwaves pass through food, leaving no residue. Density of food, amount of energy emitted by the irradiator, and length of exposure to gamma energy determine the amount or dose of irradiation to which the food is exposed (AMA, 1993; Diehl, 1995). Regulated doses are set at minimum levels necessary to achieve special purposes or benefits for which approval has been granted (AMA, 1993).

Irradiation is not usable for all foods. Research has shown undesirable flavor changes resulted when dairy products were irradiated and that tissue softening in fruits, such as peaches, nectarines, and strawberries occurred (as cited in Diehl, 1993; as cited in Redlinger & Nelson, 1991; Yu, Reitmeier, Gleason, Nonnecke, Olson, & Gladon, 1995).

Food irradiation does not replace proper handling and storage. Lower doses of radiation permit some microorganisms to survive (Diehl, 1995). Therefore, safety standards for foods processed by radiation should still be maintained. Food irradiation cannot improve quality of food that is not fresh, or prevent contamination from occurring after irradiation (Bruhn & Wood, 1996).

An identical process, called radiation sterilization, is used commercially throughout the world. In the U.S., approximately 40 large-scale radiation facilities operate in the radiation industry treating medical/surgical devices, personal-hygiene products, and packaging materials (Bruhn & Wood, 1996; Lagunas-Solar, 1995; Olson, 1995); but 16 also irradiate spices for wholesale use, and several others treat foods (Bruhn & Wood, 1996). Because of the complexity in establishing distribution systems, irradiated foods are not widely available at the retail level.

Applications

Elimination of insects

The FDA has approved irradiation for purposes of insect elimination from wheat, potatoes, flour, spices, tea, fruits, and vegetables (Redlinger & Nelson, 1991). Irradiation has the advantage over chemical fumigation of insects and microorganisms because it can be applied to the packaged product, thus avoiding reinfection after treatment (Diehl, 1993).

Extension of shelf life

Irradiation is an energy-efficient food preservation method. Advantages over traditional canning include no additional liquid or heat, so little change in flavor and texture of the product occurs. Irradiation can also control sprouting and ripening. In this role, it offers an alternative to chemical preservatives for use with potatoes, fruits, grains, spices, and seasonings (Redlinger & Nelson, 1991).

Food safety

Irradiation can be also used to sterilize food. Irradiation has been identified as one tool to enhance food safety through the reduction of potential pathogens, and has been recommended as part of a comprehensive program to enhance food safety (Loaharanu, 1994; WHO, 1988). This is useful in hospitals for patients with severely impaired immune systems, such as patients with cancer or AIDS (Redlinger & Nelson, 1991).

Approved food products

The first products approved by the FDA for treatment with irradiation were wheat and white potatoes in the 1960s. During the 1980s, FDA approved irradiation of spices and seasonings, pork, fresh fruits, and dehydrated substances. Strawberries were first marketed in the U.S. in January 1992 (Marcotte, 1992). In 1990, poultry products received approval at a dosage of 3.0 kGy, considered effective in controlling foodborne bacteria and without posing a safety hazard to consumers (FDA, 1990). In September 1992, the USDA's FSIS approved guidelines for irradiation of raw packaged poultry (USDA, 1992). Currently, petitions from USDA for ground beef and fresh shell eggs are pending approval as well as a petition from FDA for seafood (Bruhn & Wood, 1996).

Government regulations

Congress defined the source of ionizing energy as a food additive, based on the Food Additives Amendment to the FDCA of 1938, and delegated regulatory authority to the FDA (Pauli, 1991). Items regulated as "food additives" required extensive animal-feeding and chemistry studies (Lagunas-Solar, 1995; Pauli, 1991).

Two agencies within the USDA also have regulatory authority for irradiated foods. The FSIS develops standards for the safe use of irradiation on meat and poultry products, and the APHIS monitors programs designed to enhance animal and plant health, e.g., using irradiation as an insect quarantine treatment in fresh produce (Pauli, 1991). Commercial application of food irradiation must also conform to regulations set by the Nuclear Regulatory Commission (NRC) when using radioactive source materials, the Department of Transportation (DOT) if transporting hazardous materials, and the Occupational Safety and Health Administration (OSHA) for worker safety (Sapp, 1995).

Labeling

Current labeling requirements in the U.S. mandate any irradiated whole food sold at the retail level bear the "radura" symbol, a flower-like logo, and phrases of "treated by irradiation" or "treated with radiation" (Bruhn & Wood, 1996; USDA, 1992). Processors may add information to explain why irradiation was used; for example, "treated by irradiation to inhibit spoilage" or "treated with radiation instead of chemicals to control insect infestation." Irradiated ingredients sold to food processors at the wholesale level must also be labeled with the statement, "do not irradiate again" (as cited in Redlinger & Nelson, 1991).

FDA requires that both the logo and statement appear on packaged foods, bulk containers of unpackaged foods, on placards at point of purchase for fresh produce, and on invoices for irradiated ingredients and products sold to food processors (as cited in Redlinger & Nelson, 1991). However, foods prepared with irradiated ingredients served in restaurants and other foodservices do not need to be labeled (Rubin, 1993), nor do small amounts of irradiated food ingredients used in processed foods sold at the retail level, such as spices in a packaged entree.

Controversial issues

The term "irradiation" can evoke fears of nuclear radioactivity and cancer among consumers (Redlinger & Nelson, 1991; Sapp, 1995). Diehl (1993) stated "Clearly the greatest disadvantage of food irradiation is its name" (p. 145). "It is the position of The American Dietetic Association that food irradiation is one way to enhance the safety and quality of the food supply. The ADA encourages the government, food manufacturers, food commodity groups, and qualified dietetics professionals to continue working together in educating consumers about this technology" (Bruhn & Wood, 1996, p. 69).

Despite repeated endorsements from scientific organizations and government regulatory approval, irradiated foods are not widely available or accepted in the U.S. Consequently, questions and concerns exist, particularly about safety or wholesomeness of irradiated foods. Bruhn (1995) reported irradiation is not widely used because of uncertainty regarding consumer acceptance.

More than 40 years of multi-species, multi-generational scientific animal studies have shown no toxic effects from eating irradiated foods (Thayer, 1994). A recent report concluded human volunteers with diets of up to 100% irradiated foods showed no ill effects (Diehl, 1995).

However, opponents still raise concerns about long-term health effects, nutrient losses, and worker safety at irradiation facilities (Webb et al., 1987). In addition, opponents of food irradiation cite bacterial toxins and mycotoxins present in food are not destroyed by radiation treatment (Diehl, 1993).

Organizations opposed to food irradiation, such as *Food & Water, Inc.* which assumed activities of the former *National Coalition to Stop Food Irradiation* and *The Center for Science in the Public Interest*, have influenced legislators in nine states (Alaska, Hawaii, Illinois, Maine, Massachusetts, New Jersey, New York, Oregon, and Pennsylvania) to consider banning the sale of irradiated products. Three states (Maine, New Jersey, and New York) have either banned or issued moratoriums on the sale of irradiated foods with the exception of prepared food products containing irradiated ingredients, such as spices (Sapp, 1995).

Opposition groups argue irradiation is not needed because other preservation methods are available, and because proper handling and cooking of foods can prevent bacterial growth to harmful levels (Webb et al., 1987). Scientists, on the other hand, point out that in 1992, the bacteria *Salmonella* and *Campylobacter jejuni* together accounted for an estimated 4 million cases of food poisoning and approximately 1,000 - 2,000 deaths in the U.S. (Pszczola, 1993).

Opposition groups also argue that irradiated foods are not as wholesome because the process depletes vitamins. Studies confirmed that up to 56% of ascorbic acid (vitamin C) is lost in the irradiation process. However, scientific researchers said this loss is comparable to losses from conventional processing, such as canning, because vitamin C is water soluble. Studies have shown that other vitamins (niacin, thiamin, riboflavin) and beta (β)-carotene remained relatively stable after irradiation (Lagunas-Solar, 1995; Sapp, 1995).

Consumers have also cited environmental concerns as a drawback to use of irradiation. Facilities needed to handle irradiation treatment of large volumes of food could result in mismanagement, or the potential for accidents in the transport of radioactive materials. Scientists note that facilities have been irradiating medical supplies safely for over 20 years. Strict regulations govern transportation and handling of radioactive material and irradiation facilities are constructed to withstand earthquakes and other natural disasters (Sapp, 1995).

Consumers' Attitudes and Knowledge

Studies pertaining to consumers' attitudes toward or knowledge of genetically engineered and irradiated foods are reviewed. This section of the literature review covers references for genetically engineered foods from 1986 to 1994 and for irradiated foods from 1985 to 1996.

Genetically engineered foods

Two national surveys explored public opinion about genetic engineering. In late 1986, the Office of Technology Assessment (OTA) of the U.S. Congress conducted telephone interviews with 1,273 randomly selected adults (OTA, 1987). Also in 1986, 1,000 respondents were interviewed by Novo Industri (Novo Industri, 1987).

Both studies reported low levels of public awareness and knowledge about genetic engineering. The OTA study found one-third of its sample had heard or read about genetic engineering and only one in five had heard of any potential dangers from genetically engineered products (OTA, 1987). In the Novo Industri study, less than two-thirds of the respondents had heard of genetic engineering and reported that they did not understand important issues associated with the technology (Novo industri, 1987).

Hoban and Kendall (1992) conducted a national telephone survey of 1,228 randomly selected consumers across the U.S. Over half of the respondents had read or heard nothing or only a little about genetic engineering, or specific applications of the technology. However, about two-thirds of respondents expressed interest in learning more about genetic engineering.

Two-thirds of respondents in this study disagreed with a statement that "only the companies that make genetic engineered products will benefit," while almost three-quarters believed "genetic engineering will have a positive effect on food quality and nutrition." Two-thirds of respondents also supported the use of biotechnology in agriculture and food production.

Results of the Hoban and Kendall study showed respondents who expressed less confidence in government agencies to effectively regulate genetic engineering had less positive attitudes about and less willingness to accept genetically engineered products. Results from this survey indicated consumers had relatively little trust in information supplied by government and industry. Respondents were most likely to trust information from health professionals, such as dietitians; university scientists; farmers; and environmental groups (Hoban & Kendall, 1992).

Zimmerman et al. (1994) conducted six focus group discussions, two in Colorado and one each in Nebraska, New York, Ohio, and Pennsylvania, and administrated surveys (N = 67) about consumer knowledge and concerns about genetic engineering in five states. This study reported most participants had only a little (45%) or some (37%) knowledge of genetic engineering. Also, participants indicated they knew little or nothing about application of the technology in food production or processing. Findings from these participants showed respondents agreed "government funding for biotechnology should be increased" (56%) and that "average citizens need more information about the use of biotechnology" (93%) (Zimmerman et al., 1994).

Newspaper, magazines, and television were identified as primary sources of information about foods; yet these sources also were mentioned as the least trusted. Participants indicated greatest trust in statements about genetically engineered foods made by dietitians, other health professionals, and scientists; moderate trust in statements made by government agencies and special interest groups; and the least trust in statements made by companies. Results were consistent with those of Hoban and Kendall's (1992) study.

Irradiated foods

Harris (1985) suggested that information about irradiation would improve consumers' acceptance. A series of studies to determine the effect of education on concern and willingness to buy irradiated foods was conducted. Results of these studies showed most groups of consumers initially expressed minor concerns over irradiated foods, with levels of concern remaining the same or decreasing slightly after information about irradiation was received (Bruhn et al, 1986a; Bruhn, Sommer, & Schutz, 1986b).

Waterfield (1987) reported 54% of consumers said they would not buy an irradiated item without more knowledge about the process. Terry and Tabor (1988) found approximately 50% of consumers would buy irradiated produce if the prices were competitive and information to explain the purpose for irradiation was provided.

Bruhn and Schutz (1989) concluded both attitudes and demographic characteristics were related to acceptance of irradiation. Concern about irradiation was highest for females with self-reported high values for "an ecologically balanced world," great concerns about chemical additives used on food, or higher levels of formal education. Bord and O'Connor (1989) reported that age was negatively associated with acceptance and that higher educated persons were most likely to support a ban on irradiated products. One study in 1984 reported only 23% of consumers were aware of the food irradiation process while another study 11 years later showed awareness had risen to 72% (Schutz, Bruhn, & Diaz-Knauf, 1989).

Many studies about consumers' attitudes or acceptance of irradiated foods have been published (Hashim, Resurreccion, & McWatters, 1996; Sapp, Harrod, & Zhao, 1995; Resurreccion, Galvez, Fletcher, & Misra, 1995). Sapp et al. (1995) reported trust in government and industry are the key determinants of consumer acceptance, and age, income, and food safety concern did not have significant partial effects on the dependent variables, which are opinion, perceived health risk, activism, and taste.

Another survey (Resurreccion et al., 1995) about attitudes toward irradiated foods indicated consumers were less concerned about irradiation than they were about food additives, pesticide residues, animal drug residues, growth hormones, and bacteria. The risk to workers and environmental issues were among the top concern about irradiation. Resurreccion et al. (1995) forecasted "a more favorable response would be observed when irradiated poultry, meats, and seafood hit the marketplace compared to responses to irradiated produce" (p. 196). Recent focus group research (Hashim et al., 1996) concluded "education, informative labels and posters, and in-store sampling are effective ways to convince consumers to purchase irradiated poultry" (p. 77).

The reviewed literature showed previous studies had focused on consumers' intentions to purchase irradiated foods at the retail level. Strohbehn and Hsu (1994) reported results from a study of one sector of the foodservice industry. A survey that assessed attitudes held by college and university food service directors toward the purchase and use of irradiated food items in their operations found that this group was knowledgeable about the irradiation process, with higher levels of concern expressed for the likelihood of experiencing harmful effects from food production and processing than from irradiation. Respondents seemed to be acceptive of food irradiation, although they strongly believed foods served with irradiated ingredients should be labeled to inform consumers. Strohbehn and Hsu suggested knowledgeable food service professionals could serve as information sources for the general public on irradiation.

Another survey (Hsu & Strohbehn, 1995) identified attitudes held by private club managers toward irradiated foods. Club managers appeared knowledgeable about the process of food irradiation, although the statement "current labeling requirements state that food services do not need to indicate if irradiated foods are served" was correctly answered by only one-third of respondents.

Another survey about school foodservice officials' knowledge of and attitudes toward irradiated foods was conducted by Nam (1996). Results indicated a majority of respondents was knowledgeable about benefits of food irradiation, yet not aware of labeling requirements, the irradiation process, and availability of irradiated foods at retail markets. Findings from this survey (Nam, 1996) showed respondents had the highest expectation for the government among relevant agencies responsible for ensuring the safety of irradiated foods, however school foodservice officials indicated lower levels of trust in the government than they had expectations of the government. Respondents provided the highest credit to food scientists in establishing standards for food safety.

IOWA DIETITIANS' ATTITUDES TOWARD AND KNOWLEDGE OF NEW FOOD TECHNOLOGIES: GENETICALLY ENGINEERED AND IRRADIATED FOODS

A paper to be submitted to the *Journal of the American Dietetic Association*

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Article Summary

A study to assess knowledge levels and attitudes held by Registered Dietitians (RDs) in Iowa (N = 767) toward genetically engineered and irradiated foods was conducted through a mail survey. Responses (35%) from 269 RDs were analyzed.

The questionnaire consisted of three sections: attitudes (51 items), knowledge (30 items), and demographic information. A five-point Likert-type scale (5 = Strongly Agree) was used by respondents to rate agreement with 32 & 19 positively and negatively phrased attitude statements related to genetically engineered and irradiated foods. Response options of "True," "False," and "Unsure" were presented to participants in the knowledge section. Demographic information was collected using open-ended and categorical questions.

Iowa RDs' attitudes toward genetically engineered foods were indicated with mean ratings of agreement to 32 statements ranging from 2.35 for "The use of genetic modification to change animals should be strictly regulated" to 4.28 for the statement "I want to know more about genetically engineered foods." Iowa RDs also indicated an interest in learning more about irradiated foods, with a mean rating of 4.20. Respondents rated "More research

needs to be done on irradiation before it is used commercially by food processors" lowest of the 19 attitude statements, with a 3.03.

Of the 15 knowledge statements about genetically engineered foods (M = 8.90), three-fourths of dietitians selected the correct response to only 4 of the 15 statements, although over 50% of respondents answered 11 of the knowledge statements correctly. The statement correctly answered most frequently dealt with practical applications of genetic modification (90.3%), while the statement correctly answered least frequently was about labeling of genetically engineered foods (17.1%). Of the 15 knowledge statements about irradiated foods (M = 7.30), three statements which dealt with outcomes of food irradiation were answered correctly by over 70% of respondents. Only 15.6% of RDs were aware that "Irradiation is classified as a food additive by the FDA." This statement had the fewest number of RDs correctly responding and the highest percentage (69.1%) selecting the "Unsure" option.

Introduction

Many studies have reported the potential of genetic engineering in enhancing the quality, nutritional value, and variety of food available for human consumption, and the potential to increase the efficiency of food production and processing, particularly for countries with inadequate food supplies (1, 2, 3, 4). Genetic engineering techniques use restriction enzymes to cleave DNA strands at specific sequences (5), thereby isolating desirable characteristics.

Irradiation is a food processing technique, as is canning or freezing. Food irradiation uses ionizing energy from radioactive sources to penetrate the food and kill insects, fungi, and bacteria that cause food spoilage and foodborne illnesses. The majority of the energy passes through the food in much the way as microwaves do in cooking (6). Therefore, irradiation offers advantages, such as improved safety and extended shelf life of foods, to producers and consumers (6, 7, 8).

However, in spite of the potential benefits of genetically engineered and irradiated foods, both of these technologies have been at the center of controversy (9, 10, 11, 12). One controversial issue of genetically engineered foods is the creation of new life forms (13). Another concern is the potential to violate consumers' dietary restrictions and/or religious beliefs (14). Organizations opposed to food irradiation cite concerns about long-term health effects, nutrient losses, and worker safety at irradiation facilities (15) as well as questioning whether bacterial toxins and mycotoxins present in food are destroyed by radiation treatment (16).

Whether the benefits of genetic engineering and irradiation of foods will be fully realized depends upon how well-informed consumers can become about the benefits and safety of these products. A Registered Dietitian (RD) has been described as "a food and nutrition expert who can separate facts from fads, and translate the latest scientific breakthroughs into practical food choices" (17). Dietetics professionals are perceived by consumers as reliable providers of food and nutrition information and services (3). One purpose of the American Dietetic Association (ADA) is to educate consumers about food and nutrition issues, including new technology such as genetic engineering or irradiation (3, 8).

As key communicators on nutrition issues, RDs have an important role to play in informing the public about the potential of technological advances to add value and benefit to the food supply (18).

Previous research has studied attitudes toward and/or knowledge of genetically engineered or irradiated food held by subgroups identified on the basis of demographic variables, such as gender, education, age, employment sector, and geographic location. The purpose of this study was to assess the attitudes and knowledge level held by Iowa RDs toward genetically engineered and irradiated foods.

Methodology

Sample

Dietitians registered with the American Dietetic Association (ADA) in the state of Iowa were sent a mail survey to assess attitudes toward and knowledge of new food technologies. A list of Registered Dietitians (RDs) in Iowa was obtained from the ADA. All RDs in Iowa (N = 771) were included in the population.

Instrument

A questionnaire was developed for collection of data. The questionnaire was divided into three parts: attitudes toward genetically engineered and irradiated foods, knowledge of genetically engineered and irradiated foods, and demographic information.

Part I of the questionnaire contained 51 attitude statements about genetically engineered (32 items) and irradiated (19 items) foods. Items were categorized by each subheading. Attitudes were assessed using a five-point Likert-type scale with

5 = Strongly Agree and 1 = Strongly Disagree. In Part II of the questionnaire, subjects were asked to indicate a response of "True," "False," or "Unsure" to knowledge statements about genetically engineered (15 items) and irradiated (15 items) foods. Demographic data gathered in Part III of the questionnaire pertained to gender, age, level of education, employment sector, number of years as a RD, and sources of information about new food technologies. Information was collected using open-ended and nonequivalent-item closed-ended questions.

The questionnaire was reviewed for content validity by three Iowa State University (ISU) faculty from Departments of Hotel, Restaurant, and Institution Management, and Food Science and Human Nutrition. The questionnaire was pilot tested with three RDs included in the list from ADA. The three pilot test sample and one faculty member reviewer, who also was on the ADA list, were excluded from the study population. As a result of review and pilot testing, several statements and questions were reworded for clarity and/or conciseness.

The data collection packet sent to the sample of 767 RDs in Iowa consisted of an eight-page booklet. The six-page questionnaire was designed with a cover letter on Iowa Dietetic Association (IDA) stationary as the front page and a business reply mail on the back page.

Data collection

Questionnaires were mailed on February 21, 1996 with a requested return date of March 5, 1996. Of the 767 mailed, 162 were returned by the specified date. Follow-up postcards were sent to the 605 non-respondents on March 8, 1996. The follow up effort generated a final response total of 275 surveys, for a response rate of 35.9%.

Data analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS ® Base 7.0 for Windows,1995, SPSS Inc., Chicago). Of the 275 returned surveys, 269 (35.1%) were complete and usable for statistical analysis. Reliability of section I of the instrument was examined by Cronbach alpha (KR 20).

Descriptive statistics were computed for attitude ratings, knowledge scores, and demographic information. Responses for negatively phrased attitude statements were recorded inversely. Chi-square tests were used to determine significant differences in demographic characteristics between and among categorized groups of age, education level, work place, and information source. Independent t-tests and one-way analysis of variance (ANOVA) were used to determine mean differences of attitude ratings and knowledge scores between and among categorized groups. Pearson product-moment correlation coefficients were used to analyze relationships between attitudes toward and knowledge of genetically engineered and irradiated foods. For all statistical tests, the level of significance (alpha level) was set at .05.

Results and Discussion

Copies of a questionnaire to assess attitudes toward and knowledge of genetically engineered and irradiated foods were sent to Registered Dietitians (RDs) in Iowa (N = 767). Responses from 269 RDs were analyzed. Findings are presented in the following order: demographic characteristics, attitudes toward genetically engineered and irradiated foods, and knowledge of genetically engineered and irradiated foods.

Demographic characteristics of respondents

As shown in Table 1, the majority of respondents were female (97.8%). Almost two-thirds of RDs were between 30 and 49 years of age, with a mean of 41. The Bachelor of Science degree was indicated by 39.4% of RDs as the highest education level completed. Remaining respondents indicated they had completed some graduate work (24.9%), a Master's degree (28.6%), or further education (7.1%). The most frequently reported primary work place was cited in the 'others' category as clinical dietitian (29.7%), while 17.3% of respondents identified a government agency, or a hospital foodservice (10.5%) as the primary work place. A range of less than 1 year to 50 years experience as a RD was reported with a mean of 13.8 years.

Respondents indicated sources most often used to learn about food technologies from a presented list. Professional journals, e.g., Journal of the American Dietetic Association (71.4%), were used most frequently, followed by newspapers (45.7%); broadcasting, e.g., TV, radio (38.8%); and professional meetings (37.2%). Thirteen (4.9%) respondents answered that they had not obtained any information about food technologies.

The number of inquires RDs had received about genetically engineered and irradiated foods in the past 6 months ranged from 0 to 180. Of 269 respondents, 66.9% had never received an inquiry about genetically engineered and irradiated foods, while 10 RDs had received more than 10 inquires.

Chi-square tests were used to identify differences in demographic characteristics among categorized groups of age, education level, work place, and information source. No significant difference in demographic characteristics between.

Attitudes of respondents

Survey participants rated strength of agreement with 51 attitude statements about genetically engineered (32 items) and irradiated foods (19 items) on a five-point Likert-type scale (5 = Strongly Agree, 1 = Strongly Disagree). Reliability for the two categories were .85 and .79, respectively.

Genetically engineered foods

Attitude ratings held by individual RDs for all statements about genetically engineered foods ranged from 2.06 to 4.53 with a group mean rating of 3.36 ± 0.37. Attitude statements about genetically engineered foods with strongest and weakest agreement from Iowa RDs are shown in Table 2. RDs indicated strongest agreement to the statement "I want to know more about genetically engineered foods," with a mean rating of 4.28. This was consistent with findings from previous studies (12, 19) that reported respondents' interest in learning more about biotechnology. Other statements that received positive agreement from RDs included "I would support a ban on the production and purchase of genetically engineered foods," with a mean rating of 3.83, after reverse coding was used. This finding supported results from Hoban and Kendall's (19) survey showing support for the use of biotechnology in agriculture and food production. Dietitians also noted "Universal labeling of genetically engineered foods should be required" (M = 3.86).

The attitude statement with least agreement from RDs about genetically engineered foods was "The use of genetic modification to change animals should be strictly regulated," with a mean rating of 2.35. The use of genetic modification to change animals received less agreement than the statement about use of genetic modification to change plants (M = 2.55).

Respondents also opposed transfer of genetic materials between plants and animals (M = 2.81). A previous study showed similar attitudes using biotechnology to change plants was less morally wrong than genetic manipulation of animals (12).

RDs indicated trust in the food scientist to take necessary actions to provide safe genetically engineered foods with a mean rating of 3.62. Trust in the government (M = 3.16) and food industry (M = 2.90) to take the same actions were lower. These results were consistent with previous studies (12, 19) that identified dietitians as the most trusted and companies as the least trusted information sources. Respondents agreed with the American Dietetic Association's position paper in support of genetically engineered foods, with a mean rating of 3.59.

Irradiated foods

Attitude ratings held by individual RDs for all statements about irradiated foods ranged from 2.58 to 4.76 with a group mean rating of 3.64 ± 0.41. The highest rated attitude statement toward irradiated foods was the same as the highest rated attitude statement about genetically engineered foods; Iowa RDs indicated an interest in learning more about food irradiation (M = 4.20). After reverse coding, the statement "I would support a ban on the food irradiation process" showed a high mean rating (M = 3.96), as shown in Table 3. Comparing with previous studies, RDs disagreed with the ban on the food irradiation process more strongly than college and university foodservice directors and private club managers (20, 21). Dietitians indicated agreement with the benefit of irradiation as a safe way to extend shelf life of foods (M = 3.94). Other statements also indicated positive attitudes held by Iowa dietitians toward food irradiation: "Food irradiation is used by the food industry to mask spoiled foods" (M = 4.0) and "An individual will experience harmful effects from eating irradiated foods" (M = 3.92).

The attitude statement with the lowest mean rating of agreement (3.03) was "More research needs to be done on irradiation before it is used commercially by food processors." Findings are consistent with a study of college and university food service directors' attitudes toward irradiated foods (20). Other attitude statements with low mean ratings were "My clients are concerned about irradiated foods" (M = 3.14) and "I am skeptical of sources of information about irradiated foods" (M = 3.28).

RDs also indicated the food industry holds slightly more responsibility for ensuring the safety of food products treated with irradiation (M = 3.86) than either food scientists (M = 3.83) or the government (M = 3.79). However, respondents trusted food scientists (M = 3.66) to take necessary actions to provide safe irradiated foods more than the government (M = 3.35) or the food industry (M = 3.18). Respondents agreed with the American Dietetic Association's position paper in support of irradiated foods (M = 3.71).

ANOVA

One-way ANOVAs were used to determine mean differences of attitude ratings among groups categorized by age, education, and number of inquiries received by RDs about new food technologies in the past 6 months. Results of ANOVAs in attitudes toward genetically engineered and irradiated foods are shown in Table 4. There was a significant difference in attitudes toward genetically engineered foods by RDs grouped by age ($p \leq .01$). Age group of 30s showed less positive attitudes toward genetically engineered foods, while older age groups indicated higher mean ratings. However, sequential order of mean by age groups was not shown. Education level was not a factor that affected attitudes toward genetically engineered foods in this study.

Attitudes toward irradiated foods were also significantly different for RDs categorized by age ($p \leq .001$). The 30s' age group showed lower mean ratings than other age groups to statements about irradiated foods, while RDs in their 50s indicated the strongest agreement among all age groups.

There were significant differences in attitudes toward irradiated foods among RDs categorized by number of inquiries received about new food technologies in the past 6 months ($p \leq .05$). The more inquiries RDs received, the more positive the attitudes were shown. Education level did not appear to be a factor in influencing attitudes toward irradiated foods.

T-test

Independent t-tests were used to determine differences in attitudes between respondents who requested and did not request study results. There was a significant difference in mean ratings of attitudes toward genetically engineered foods by RDs that requested results of the current study ($t = 2.330$, $p \leq .05$) from those who did not. The group that requested study results showed more positive attitudes ($M = 3.43$) than the group that did not ($M = 3.32$). The desire to learn more about genetically engineered foods is consistent with previous research among consumers, and indicative of acceptance.

Knowledge of respondents

The knowledge test consisted of statements addressing definition, processing, government regulations, labeling, and the availability of products. Survey participants were asked to select a response option of "True," "False," or "Unsure" to statements about genetically engineered (15 items) and irradiated (15 items) foods.

Genetically engineered foods

Knowledge scores for 269 respondents about genetically engineered foods ranged from 0 to 15 of 15 items correctly answered, with a mean of 8.90 ± 3.39. Three-fourths of dietitians selected the correct response to only 4 of the 15 statements, although over 50% of respondents answered 11 of the knowledge statements correctly. Five knowledge statements with most frequent and least frequent correct responses about genetically engineered foods are shown in Table 5.

The most frequent statement answered correctly dealt with practical application of genetic modification (90.3%), while the statement correctly responded least frequently was about labeling of genetically engineered foods. Although respondents indicated the need for more labeling in an attitude statement (M = 3.86), only 17.1% selected the correct response to the statement "Genetically engineered foods require labeling even with no meaningful or significant change in their composition or nutritional value." The other labeling statement "FDA labeling regulations for genetically engineered foods are concerned with the **food product** that results, **not the process** by which it is produced" was correctly answered by 32.8% of dietitians. The unsure option for both labeling-related statements was selected by over 40% of respondents.

An overview of response options selected indicated that when a low number of respondents selected the correct response, a higher percentage selected the "Unsure" option. The statement for which the greatest number of respondents selected "Unsure" was about porcine somatotropin (pST) (n = 167, 62.3%), with only 35.8% of RDs indicating the correct response. A slight majority of respondents (62.5%) knew that the *Flavr Savr* tomato, the first genetically engineered food, was available for purchase at retail stores. However, this relative lack of knowledge may be due to limited geographic availability, or product marketing under another name.

Irradiated foods

Knowledge scores for 269 respondents about irradiated foods ranged from 0 to 15 of 15 items correctly answered with a mean of 7.30 ± 3.31. Five knowledge statements with most frequent and least frequent correct response about irradiated foods are shown in Table 6. Three statements answered correctly by over 70% of respondents dealt with outcomes of food irradiation. Over half also indicated correctly that "All foods are approved for irradiation treatment" was false and "Food irradiation involves the use of ionizing energy applied to foods" was true.

Results showed only 15.6% of RDs were aware that "Irradiation is classified as a food additive by the FDA." This statement had the lowest correct response and the highest percentage (69.1%) selecting the "Unsure" option. Of 269 respondents, 72 (27.0%) knew irradiated chicken and pork were approved for sale at the retail level and 62.5% were unsure. Lack of availability in areas where respondents resided may be one of the reasons for limited knowledge to this statement.

RDs also appeared unaware of labeling requirements for service of irradiated foods, with only 28.8% correctly indicating this statement as false: "It is required that foodservices inform customers if irradiated foods are being served." A common myth about food irradiation is that it eliminates the need for refrigeration of perishable foods. About one-third of dietitians (n = 99, 36.9%) was aware refrigerated storage is needed even for irradiated foods. Results from this study of RDs showed a lower percentage of correct responses to this statement than results of previous studies from college and university foodservice directors and private club managers (59% and 56%), respectively (20, 21).

ANOVA

There were no significant differences in knowledge shown by RDs classified by age groups toward genetically engineered and irradiated foods (Table 7). However, a higher mean score of knowledge was calculated for RDs who had received more inquiries about both genetically engineered ($p \leq .01$) and irradiated foods ($p \leq .001$).

T-test

Independent t-tests were used to determine differences in knowledge scores between respondents who requested study results and those who did not. A significant difference in knowledge scores of genetically engineered ($t = 3.628$, $p \leq .001$) and irradiated foods ($t = 3.673$, $p \leq .001$) was found between the two groups. The RDs who requested study results showed higher knowledge scores than those who did not request study results. Mean knowledge scores of the group requested study results for genetically engineered and irradiated foods were 9.87 and 8.26 out of 15, respectively, while other group had mean of 8.40 and 6.80, respectively.

Correlationship of attitudes and knowledge

RDs with more positive attitudes toward genetically engineered and irradiated foods also showed higher knowledge scores ($r = .242$, $p \leq .001$; $r = .405$, $p \leq .001$). This finding was consistent with previous studies of consumer acceptance of genetic engineering (12) and food irradiation (22, 23).

Conclusions

This study identified attitudes and knowledge held by Registered Dietitians (RDs) in Iowa toward genetically engineered and irradiated foods. They indicated an interest in learning more about new food technologies of genetic engineering and irradiation. RDs also expressed support for the production and purchase of genetically engineered and irradiated foods. More positive attitudes were expressed toward irradiated than toward genetically engineered foods.

RDs indicated the highest trust in food scientists to take necessary actions to provide safe genetically engineered and irradiated foods, followed by trust in the government and the food industry. However, mean ratings indicated relative uncertainty.

RDs appeared knowledgeable about applications of genetic engineering with the three highest knowledge statements for genetically engineered foods related to this concept. RDs were also knowledgeable about benefits of food irradiation. However, RDs did not seem knowledgeable about labeling requirements for both technologies with a degree of uncertainty in responses to statements dealing with this concept. Lack of knowledge about purchasing availability of products from the new food technologies at retail stores may be due to limited geographic availability, or marketing strategies.

Age was positively related to attitudes toward genetically engineered and irradiated foods while education level did not appear to significantly influence attitudes. In irradiated foods, this finding was different from results of previous research that age was negatively associated with acceptance and that higher educated persons were most likely to support a ban on irradiated products (24). Knowledge was significantly affected by number of inquiries received by the responding RDs about new food technologies in the last 6 months, although age or education level were not. Those RDs interested in results of this study reflected significantly more positive attitudes and significantly higher knowledge levels.

RDs' attitudes toward and knowledge of genetically engineered and irradiated foods could have an effect on information provided to clients or affect decisions regarding purchase of these food products for their institutions. As a trusted information source, it is critical for RDs to possess attitudes reflecting unbiased information and have correct knowledge. As genetically engineered and irradiated food products increase in availability, RDs have an important role to play in informing the public about new food technologies (18).

Results from this study could be used in the development of educational materials for health professionals, such as dietitians. Further experimental studies to determine effectiveness of educational efforts targeted to RDs are recommended. A national research is also suggested, because RDs in areas where products from new food technologies are available may possess different attitudes or varying levels of knowledge.

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Table 1. Demographic information of respondents[a]

Characteristic	Number	Percent
Gender		
Male	6	2.2
Female	263	97.8
Age (Years)		
20 - 29	42	15.6
30 - 39	79	29.4
40 - 49	92	34.2
50 - 59	31	11.5
≥ 60	25	9.3
Education level		
B.S. degree	106	39.4
Some graduate work	67	24.9
M.S. degree	77	28.6
Some post-master's work	11	4.1
Ph.D. degree	8	3.0
Primary work place		
Government agency	46	17.3
Hospital foodservice	28	10.5
Private practice (consultant)	24	9.0
Educational institution	22	8.3
Nursing home foodservice	16	6.0
College and university foodservice	7	2.6
School foodservice (K - 12)	5	1.9
Commercial foodservice	1	0.4
Others[b]		
Clinical Dietitian	79	29.7
Others	21	7.9
Not working	13	4.9
Business-Marketing	4	1.5

[a] N = 269

[b] Categories organized by respondents' answers

Table 1. (Continued)

Characteristic	Number	Percent
Information sources about food technology[c]		
Professional journals (e.g., Journal of the American Dietetic Association)	192	71.4
Newspapers	123	45.7
Broadcasting (e.g., TV, Radio)	104	38.8
Professional meetings	100	37.2
Government publications	74	27.6
Workshops/Seminars	70	26.1
Colleagues	56	20.9
College courses	49	18.3
Trade journals (e.g., Restaurants & Institutions)	45	16.8
Popular magazines	37	13.8
Other sources[b]		
Consumer advocacy groups	6	2.2
Commodity groups	5	1.9
Personal experience	5	1.9
Government organizations	2	0.7
Newsletters	4	1.5
I did not obtain any information	13	4.9

[c] Total number and percent values do not equal 269 and 100, respectively, as multiple responses were given.

Table 2. Attitude statements with the highest and lowest mean ratings about genetically engineered foods

Attitude statement	Number[a]	Mean rating[b]
5 items with the highest mean ratings		
I want to know more about genetically engineered foods.	268	4.28 ± 0.65
I support the use of food biotechnology to modify plants' genetic structure to be more resistant to damage by insects, thus reducing pesticide applications.	268	4.09 ± 0.69
I support the use of genetic engineering for non-food purposes such as production of human medicines.	269	3.99 ± 0.72
Universal labeling of genetically engineered foods should be required.	268	3.86 ± 0.88
I would support a ban on the production and purchase of genetically engineered foods.[c]	267	3.83 ± 0.83
5 items with the lowest mean ratings		
I trust the food industry to take necessary actions to provide safe genetically engineered foods.	249	2.90 ± 1.12
I think current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.	266	2.90 ± 0.82
I am opposed to transfer of genetic materials between plants and animals.[c]	268	2.81 ± 0.86
The use of genetic modification to change **plants** should be strictly regulated.[c]	267	2.55 ± 0.97
The use of genetic modification to change **animals** should be strictly regulated.[c]	267	2.35 ± 0.91

[a] Total number of respondents = 269

[b] 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree

[c] Negatively worded item; reverse scoring procedure used.

Table 3. Attitude statements with the highest and lowest mean ratings about irradiated foods

Attitude statement	Number[a]	Mean rating[b]
5 items with highest mean ratings		
I want to know more about irradiated foods.	267	4.20 ± 0.66
Food irradiation is used by the food industry to mask spoiled foods.[c]	265	4.00 ± 0.85
I would support a ban on the food irradiation process.[c]	267	3.96 ± 0.83
Food irradiation is not a safe way to extend the shelf life of foods.[c]	269	3.94 ± 0.77
An individual will experience harmful effects from eating irradiated foods.[c]	264	3.92 ± 0.72
5 items with lowest mean ratings		
I trust the government to take necessary actions to provide safe irradiated foods.	254	3.35 ± 1.03
I am skeptical of sources of information about irradiated foods.[c]	266	3.28 ± 0.93
I trust the food industry to take necessary actions to provide safe irradiated foods.	248	3.18 ± 1.08
My clients are concerned about irradiated foods.[c]	267	3.14 ± 0.96
More research needs to be done on irradiation before it is used commercially by food processors.	266	3.03 ± 1.04

[a] Total number of respondents = 269

[b] 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree

[c] Negatively worded item; reverse scoring procedure used.

Table 4. Analysis of variance in attitudes toward genetically engineered and irradiated foods among respondents

Demographic Characteristics	n	Mean Rating[a]	df	Mean Square	F
Genetically engineered foods					
Age (years)			4	0.497	3.859**
20 - 29	42	3.38			
30 - 39	79	3.28			
40 - 49	92	3.33			
50 - 59	31	3.45			
≥ 60	25	3.58			
No. of inquiry			2	0.202	1.510
0	180	3.33			
1 - 10	79	3.42			
> 10	10	3.41			
Irradiated foods					
Age			4	1.009	6.451***
20 - 29	42	3.55			
30 - 39	79	3.52			
40 - 49	92	3.66			
50 - 59	31	3.89			
≥ 60	25	3.79			
No. of inquiry			2	0.522	3.136*
0	180	3.60			
1 - 10	79	3.72			
> 10	10	3.75			

*p ≤ .05, ** p ≤ .01, *** p ≤ .001

[a] Mean of all statements

Table 5. Knowledge of genetically engineered foods[a]

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
5 items with most frequent correct response				
Practical applications of genetic modification to plants can increase yield, improve resistance to disease, enhance nutritional quality and flavor, and develop traits to withstand the shipping process. (T)[b]	241	90.3	24	9.0
Application of genetic engineering methods to animals can result in greater production efficiency through increased growth rate and milk production, and leaner carcasses. (T)	233	86.6	34	12.6
Foods with increased nutritional value can be created through genetic modification. (T)	211	78.4	50	18.6
Genetically engineered foods are prohibited by all religious groups. (F)	205	76.2	64	23.8
Recombinant bovine somatotropin (r bST) is an animal drug that increases milk produced by dairy cows. (T)	198	73.6	53	19.7
5 items with least frequent correct response				
Genetically engineered foods are a result of recombinant DNA manipulation: the rearrangement of genetic codes and not tissue. (T)	159	59.6	101	37.8
Porcine somatotropin (pST) is a hormone active in hogs that directs dietary energy away from fat disposition toward production of lean muscle. (T)	96	35.8	167	62.3
FDA labeling regulations for genetically engineered foods are concerned with the **food product** that results, **not the process** by which it is produced. (T)	88	32.8	128	47.8
It is possible to transfer genetic material between dissimilar organisms, such as plants and animals, because DNA is chemically identical. (T)	54	20.2	139	52.1
Genetically engineered foods require labeling even with no meaningful or significant change in their composition or nutritional value. (F)	46	17.1	119	44.2

[a] N = 269; Percentages shown do not include incorrect responses, thus percentages do not equal 100%. [b] T = True, F = False

Table 6. Knowledge of irradiated foods[a]

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
5 items with most frequent correct responses				
Shelf life of foods can be extended through treatment with irradiation. (T)[b]	250	92.9	18	6.7
Irradiation can reduce or eliminate microorganisms, insects, and parasites that live on food. (T)	235	87.4	27	10.0
Irradiation of food will result in products with decreased nutritional value. (F)	195	72.5	69	25.7
All foods are approved for irradiation treatment. (F)	165	61.3	101	37.5
Food irradiation involves the use of ionizing energy applied to food. (T)	163	61.3	100	37.6
5 items with least frequent correct responses				
Irradiation does not destroy bacterial toxins present in food. (T)	97	36.2	123	45.9
It is required that foodservices inform customers if irradiated foods are being served. (F)	77	28.8	152	56.9
Irradiated chicken and pork are approved for sale at the retail level. (T)	72	27.0	167	62.5
Spore-forming bacteria, such as *Clostridium botulinum*, can survive even after treatment with irradiation. (T)	49	18.2	180	66.9
Irradiation is classified as a food additive by the FDA. (T)	42	15.6	186	69.1

[a] N = 269; Percentages shown do not include incorrect responses, thus percentages do not equal 100%.

[b] T = True, F = False

Table 7. Analysis of variance in knowledge of genetically engineered and irradiated foods among respondents

Demographic Characteristics	n	Mean Rating[a]	df	Mean Square	F
Genetically engineered foods					
Age (years)			4	24.723	2.209
20 - 29	42	8.71			
30 - 39	79	8.20			
40 - 49	92	9.58			
50 - 59	31	9.39			
≥ 60	25	8.28			
No. of inquiry			2	66.365	6.045**
0	180	8.41			
1 - 10	79	9.84			
> 10	10	10.30			
Irradiated foods					
Age			4	13.385	1.228
20 - 29	42	8.71			
30 - 39	79	8.20			
40 - 49	92	9.58			
50 - 59	31	9.39			
≥ 60	25	8.28			
No. of inquiry			2	73.804	7.055***
0	180	6.78			
1 - 10	79	8.32			
> 10	10	8.60			

** $p \leq .01$, *** $p \leq .001$

[a] Mean number of statements answered correctly

GENERAL CONCLUSIONS

A mail survey to assess attitudes and knowledge held by Registered Dietitians (RDs) in Iowa toward genetically engineered and irradiated foods was administered spring 1996. Of the 767 surveys mailed, 269 (35%) were analyzed. The developed instrument consisted of three parts: attitudes, knowledge, and demographic information. A Likert-type scale was used for rating attitude statements and response options of "True," "False," and "Unsure" were presented in the knowledge section. Demographic information was collected using open-ended and categorical questions. The data collection packet was reviewed and approved by the Iowa State University Human Subjects Review Committee.

The majority of respondents were female (98%) and almost two-thirds of the RDs were between 30 and 49 years of age. Respondents indicated sources most often used to learn information about food technologies were newspapers, broadcasting, and professional meetings, respectively. Some RDs (5%) indicated they had not obtained any information about new food technologies. The most frequently reported primary work place was in the 'others' category as a clinical dietitian.

More positive attitudes were expressed by respondents toward irradiated foods than toward genetically engineered foods, although RDs indicated interest in learning more about both new food technologies. The interest in learning more about these food technologies is consistent with previous research of consumers expressing interest in learning more about genetic engineering of foods (Hoban & Kendall, 1992; Zimmerman et al., 1994).

RDs in this survey indicated support for the production and purchase of genetically engineered and irradiated foods. This finding was consistent with results from surveys to consumers, college and university foodservice directors, and private club managers (Hashim et al., 1996; Hsu & Strohbehn, 1995; Resurreccion et al., 1995; Strohbehn & Hsu, 1994; Zimmerman et al., 1994). Findings from this study were consistent with previous research which showed consumer acceptance of the use of genetic modification on plants, with opposition to the transfer of genetic materials between plants and animals.

RDs indicated the highest trust in food scientists to take necessary actions to provide safe genetically engineered and irradiated foods with less trust in the government and the food industry. Nam's recent survey (1996) of school foodservice officials in Iowa showed the same results. Previous studies of consumers had identified dietitians as the most trusted source of information about genetically engineered foods and food companies as the least trusted sources (Hoban & Kendall, 1992; Zimmerman et al., 1994). Respondents in this study agreed with the American Dietetic Association's position papers in support of genetically engineered foods and irradiated foods. Mean ratings for all attitude statements are shown in Tables A and B of Appendix D.

Overall knowledge scores for all respondents were 8.90 out of 15 items for genetically engineered foods and 7.30 for 15 irradiated foods. The number and percentage of RDs selecting the correct response and "Unsure" option for all knowledge statements are shown in Tables C and D of Appendix D. RDs appeared knowledgeable about applications of genetic engineering and outcomes of food irradiation. However, knowledge statements about lack of labeling requirements for genetically engineered foods without significant changes in composition or nutritional quality were answered correctly by a small percentage of RDs (17%). Respondents were also not aware that it was not required for foodservices to inform clients if irradiated foods were served (29%). RDs did not indicate awareness of availability of genetically engineered or irradiated foods at the retail level. Lack of knowledge may be due to limited geographic availability, or marketing strategies. Results from this study showed a low percentage of correct responses to the false statement that irradiation eliminated the need for refrigeration.

Findings from this study indicated RDs were somewhat less knowledgeable about certain aspects of food irradiation than school foodservice officials (Nam, 1996), college and university foodservice directors (Strohbehn & Hsu, 1994), and private club managers (Hsu & Strhobehn, 1995). This may be due to lack of work experience in the foodservice sector, as 47% of respondents reported primary work place as clinical dietitian or government agency, and thus low awareness of new food technologies.

Age was positively related to attitudes toward genetically engineered and irradiated foods while education level did not appear to significantly influence attitudes. This finding conflicted with results from previous research that indicated age was negatively associated with acceptance of irradiated foods (Bord & O'Connor, 1989). Knowledge was significantly affected by the number of inquires received by the responding RDs about new food technologies in the last six months, although age or education level were not. Those RDs interested in study results reflected more positive attitudes and higher knowledge levels (Table E in Appendix D).

RDs' attitudes toward and knowledge of genetically engineered and irradiated foods could have an effect on information provided to clients, or an impact on decisions regarding purchase of these food products for their institutions. As a trusted information source, it is critical that RDs possess attitudes reflecting unbiased information and have correct knowledge. RDs have an important role to play in informing the public about these new food technologies as products become more widely available.

While the response return of approximately one-third was expected, one reason for non-response may have been lack of awareness of these two new food technologies. The high percent of "Unsure" responses for the knowledge section supports this assumption. Findings from this study indicated the need for educational efforts.

Results from this study can be used in the development of educational materials for health professionals, such as dietitians. Further experimental studies to determine effectiveness of educational efforts and developed materials targeted to RDs are recommended. A national research study is also suggested because RDs in areas where genetically engineered and irradiated food products are available may have different attitudes or knowledge.

APPENDIX A.

DEFINITION OF TERMS

DEFINITIONS OF TERMS USED IN THESIS

Genetic engineering: A technique used to modify genetic information in a living cell, with reprogram for a desired purpose such as production of a substance that the cell would not naturally produce.

Hybridization: Pairing of an RNA and a DNA strand, or pairing of two different DNA strands to create new strains or characteristics of a living cell.

Recombinant DNA (rDNA): DNA strands that have been assembled with the use of restriction enzyme. Often creating of new DNA (rDNA) takes place by splicing together fragments from different species of cells.

Transgenic: An organism that contains within its germ-line genome both parental and foreign DNA sequences.

Irradiated food: Food treated by beams of energy from a radioactive source, such as cobalt or cesium, or energy from an electron beam generator for purposes of preservation and improvement of food safety.

Registered dietitian: An expert in dietetics who has met academic requirements and passed the registration exam, both established by the American Dietetic Association (ADA).

APPENDIX B.

HUMAN SUBJECTS REVIEW

Information for Review of Research Involving Human Subjects

Iowa State University

(Please type and use the attached instructions for completing this form)

1. Title of Project: Iowa Dietitians' Knowledge of and Attitudes toward New Food Technology: Genetic engineered and Irradiated Foods

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are protected. I will report any adverse reactions to the committee. Additions to or changes in research procedures after the project has been approved will be submitted to the committee for review. I agree to request renewal of approval for any project continuing more than one year.

SeungHee Wie	2/5/96	Wie Seung Hee
Typed Name of Principal Investigator	Date	Signature of Principal Investigator

Hotel, Restaurant, and Institution Management	11 Mackay Hall	4-1730
Department	Campus Address	Campus Telephone

3. Signatures of other investigators / Date / Relationship to Principal Investigator

Signatures of other investigators	Date	Relationship to Principal Investigator
Catherine H. Strohbehn	2/5/96	Major Professor

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4. Principal Investigator(s) (check all that apply)
   ☐ Faculty ☐ Staff ☒ Graduate Student ☐ Undergraduate Student

5. Project (check all that apply)
   ☒ Research ☒ Thesis or dissertation ☐ Class project ☐ Independent Study (490, 590, Honors project)

6. Number of subjects (complete all that apply)
   768 # Adults, non-students ___ # ISU student ___ # minors under 14 ___ # minors 14 - 17 ___ other (explain)

7. Brief description of proposed research involving human subjects: **(See instructions, Item 7. Use an additional page if needed.)**

   See attached.

(Please do not send research, thesis, or dissertation proposals.)

8. Informed Consent: ☐ Signed informed consent will be obtained. (Attach a copy of your form.)
   ☒ Modified informed consent will be obtained. (See instructions, item 8.)
   ☐ Not applicable to this project.

9. Confidentiality of Data: Describe below the methods to be used to ensure the confidentiality of data obtained. (See instructions, item 9.)

The number on the questionnaire will be used only to track non-responses and for the purpose of follow-up correspondence. Demographic data from subjects will be categorized for purposes of analyses. Responses from subjects will be reported in summary form.

10. What risks or discomfort will be part of the study? Will subjects in the research be placed at risk or incur discomfort? Describe any risks to the subjects and precautions that will be taken to minimize them. (The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological or emotional risk. See instructions, item 10.)

No discomforts or risks will be expected. Participation in this research is voluntary.

11. CHECK ALL of the following that apply to your research:
    - ☐ A. Medical clearance necessary before subjects can participate
    - ☐ B. Samples (Blood, tissue, etc.) from subjects
    - ☐ C. Administration of substances (foods, drugs, etc.) to subjects
    - ☐ D. Physical exercise or conditioning for subjects
    - ☐ E. Deception of subjects
    - ☐ F. Subjects under 14 years of age and/or ☐ Subjects 14 - 17 years of age
    - ☐ G. Subjects in institutions (nursing homes, prisons, etc.)
    - ☐ H. Research must be approved by another institution or agency (Attach letters of approval)

If you checked any of the items in 11, please complete the following in the space below (include any attachments):

Items A - D Describe the procedures and note the safety precautions being taken.

Item E Describe how subjects will be deceived; justify the deception; indicate the debriefing procedure, including the timing and information to be presented to subjects.

Item F For subjects under the age of 14, indicate how informed consent from parents or legally authorized representatives as well as from subjects will be obtained.

Items G & H Specify the agency or institution that must approve the project. If subjects in any outside agency or institution are involved, approval must be obtained prior to beginning the research, and the letter of approval should be filed.

Last Name of Principal Investigator Wie

Checklist for Attachments and Time Schedule

The following are attached (please check):

12. [X] Letter or written statement to subjects indicating clearly:
    a) purpose of the research
    b) the use of any identifier codes (names, #'s), how they will be used, and when they will be removed (see Item 17)
    c) an estimate of time needed for participation in the research and the place
    d) if applicable, location of the research activity
    e) how you will ensure confidentiality
    f) in a longitudinal study, note when and how you will contact subjects later
    g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [ ] Consent form (if applicable)

14. [ ] Letter of approval for research from cooperating organizations or institutions (if applicable)

15. [X] Data-gathering instruments

16. Anticipated dates for contact with subjects:

First Contact	**Last Contact**
February 21, 1996	March 22, 1996
Month / Day / Year	Month / Day / Year

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:

October 1, 1996
Month / Day / Year

18. Signature of Departmental Executive Officer / Date / Department or Administrative Unit

Thomas [signature] 2-5-96 HRIM

19. Decision of the University Human Subjects Review Committee:

X Project Approved ___ Project Not Approved ___ No Action Required

Patricia M. Keith 2-12-96 PM Keith
Name of Committee Chairperson / Date / Signature of Committee Chairperson

GC:1/90

Information for Review of Research Involving Human Subjects
Iowa State University

Principal Investigator: Seung Hee Wie

7. Brief description of proposed research involving human subjects:

   The objectives of this study are

   - Determine attitudes of Iowa Registered Dietitians (RDs) toward genetic engineered and irradiated foods.
   - Determine knowledge level of Iowa Registered Dietitians (RDs) about genetic engineered and irradiated foods.
   - Compare attitudes toward genetic engineered and irradiated foods among respondents grouped by age, educational level, employment sector, and number of years as RD.
   - Compare knowledge level about genetic engineered and irradiated foods among respondents grouped by age, level of education, employment sector, and number of years as RD.

   All 768 Registered Dietitians enrolled in Iowa Dietitian Association will be invited to participate in this study.

   The methodology of data collection is a mail questionnaire.

8. Informed Consent:

   a) The purpose of the questionnaire and the procedures to complete it are described in the cover letter and /or on the questionnaire.
   b) No discomforts or risks will be expected.
   c) The results from this research can contribute to improved educational materials for sanitation and food safety courses in colleges and universities.
   d) There is no alternative procedure.
   e) The procedure is straightforward. Also as indicated in the cover letter, subjects can contact us for any questions concerning the procedures.
   f) The subject is invited, not required, to participate in the study, and is free to withdraw from the study by not returning the questionnaire.
   g) There is no means of relating respondents' questionnaires to identify. The number on the questionnaire will be used only to track non-responses and for the purpose of follow-up correspondence.
   h) It will take approximately 20 minutes to complete the questionnaire.

APPENDIX C.

DATA COLLECTION INSTRUMENT

IDA

IOWA DIETETIC ASSOCIATION

February 21, 1996

Dear Registered Dietitian,

A **Registered Dietitian(RD)** has been defined as a food and nutrition expert who can separate facts from fads and translate the latest scientific breakthroughs into practical food choices. As key communicators on food safety and nutrition, RDs have a crucial role to play in informing the public about the potential of technological advances to add value and benefits to the food supply.

The Department of Hotel, Restaurant, and Institution Management at Iowa State University, with support of the Iowa Dietetic Association (IDA), is conducting a study to assess knowledge level and attitudes held by Iowa RDs toward genetically engineered and irradiated foods. Your response is critical to the success of this study. It will take approximately 20 minutes to complete the questionnaire. Please return this questionnaire to us by **March 5**.

The information provided will be treated in strict confidence and reported only in group form. The number on the questionnaire will be used only to track non-responses, and for the purpose of follow-up correspondence.

We appreciate your participation and cooperation. If you have any questions, please feel free to contact either of us. Thank you very much for your time.

Sincerely,

Wie SeungHee

SeungHee Wie
Graduate Student
College of Family and Consumer Sciences
Department of Hotel, Restaurant, and
Institution Management
11 MacKay Hall
Ames, Iowa 50011-1120
515 294-4636

Catherine H. Strohbehn

Catherine H. Strohbehn, Ph.D., R.D.
Adjunct Assistant Professor
College of Family and Consumer Sciences
Department of Hotel, Restaurant, and
Institution Management
9W MacKay Hall
Ames, Iowa 50011-1120
515 294-7549

I. Attitudes toward New Food Technology

Direction. Please tell us how you feel about some of the new food technologies. Using the 5-point scale described below, indicate how strongly you agree or disagree with the following statements.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

I-A. Genetically Engineered Foods

1.	I am familiar with genetic engineering technology.	1 2 3 4 5
2.	I have a crucial role to play in informing the public about the potential of technological advances to add value and benefits to the food supply.	1 2 3 4 5
3.	I am concerned about genetically engineered foods.	1 2 3 4 5
4.	My clients are concerned about genetically engineered foods.	1 2 3 4 5
5.	I think that it is necessary to use genetic engineering on plants and animals to improve the quality and nutritional value of foods.	1 2 3 4 5
6.	I do not intend to purchase and eat genetically engineered foods at home.	1 2 3 4 5
7.	Concerns about genetically engineered foods outweigh the benefits.	1 2 3 4 5
8.	More research needs to be done before genetically engineered foods are used by processors.	1 2 3 4 5
9.	I would support a ban on the production and purchase of genetically engineered foods.	1 2 3 4 5
10.	Because of the potential to improve nutrient quality of food, government funding for genetically engineered food research should be increased.	1 2 3 4 5
11.	Only companies who make the products will benefit from genetically engineered foods.	1 2 3 4 5
12.	I want to know more about genetically engineered foods.	1 2 3 4 5
13.	I am skeptical of sources of information about genetically engineered foods.	1 2 3 4 5
14.	An individual will experience harmful effects from eating genetically engineered foods.	1 2 3 4 5
15.	The current practice of trimming excess carcass fat is cost-effective and efficient, so genetic engineering of animals to reduce fat is not necessary.	1 2 3 4 5
16.	Even though the Food and Drug Administration (FDA) has declared the safety of using bovine somatotropin (bST), I am cautious about recommending products of bST to my clients.	1 2 3 4 5

		Strongly Disagree				Strongly Agree
17.	Because the risk of chronic diseases increases with total and saturated fats in the diet, it is imperative that animal agriculture develops new strategies to reduce carcass fat.	1	2	3	4	5
18.	The use of genetic modification to change **plants** should be limited.	1	2	3	4	5
19.	The use of genetic modification to change **plants** should be strictly regulated.	1	2	3	4	5
20.	The use of genetic modification to change **animals** should be limited.	1	2	3	4	5
21.	The use of genetic modification to change **animals** should be strictly regulated.	1	2	3	4	5
22.	The use of genetic engineering to change characteristics of plants is more acceptable than use to change characteristics of animals.	1	2	3	4	5
23.	I support the use of food biotechnology to modify plants' genetic structure to be more resistant to damage by insects, thus reducing pesticide applications.	1	2	3	4	5
24.	I support the use of genetic engineering for non-food purposes such as production of human medicines.	1	2	3	4	5
25.	I support the use of food biotechnology to create genetic modifications of fruits and vegetables to improve quality characteristics such as freshness and taste.	1	2	3	4	5
26.	I am opposed to transfer of genetic materials between plants and animals.	1	2	3	4	5
27.	Universal labeling of genetically engineered foods should be required.	1	2	3	4	5
28.	I trust the ___________ to take necessary actions to provide safe genetically engineered foods.					
	a. government	1	2	3	4	5
	b. food industry	1	2	3	4	5
	c. food scientist	1	2	3	4	5
29.	I think current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.	1	2	3	4	5
30.	I agree with the American Dietetic Association's position paper in support of genetically engineered foods.	1	2	3	4	5

I-B. Irradiated Foods

31.	I am familiar with irradiation treatment.	1	2	3	4	5
32.	The ___________ holds responsibility for ensuring the safety of food products treated with irradiation.					
	a. government	1	2	3	4	5
	b. food industry	1	2	3	4	5
	c. food scientist	1	2	3	4	5
33.	Food irradiation is not a safe way to extend the shelf-life of foods.	1	2	3	4	5
34.	I am concerned about irradiated foods.	1	2	3	4	5

		Strongly Disagree				Strongly Agree
35.	My clients are concerned about irradiated foods.	1	2	3	4	5
36.	I do not intend to purchase and eat irradiated foods at home.	1	2	3	4	5
37.	Concerns regarding food irradiation outweigh the benefits.	1	2	3	4	5
38.	Food irradiation is used by the food industry to mask spoiled foods.	1	2	3	4	5
39.	More research needs to be done on irradiation before it is used commercially by food processors.	1	2	3	4	5
40.	I would support a ban on the food irradiation process.	1	2	3	4	5
41.	I want to know more about irradiated foods.	1	2	3	4	5
42.	I am skeptical of sources of information about irradiated foods.	1	2	3	4	5
43.	An individual will experience harmful effects from eating irradiated foods.	1	2	3	4	5
44.	I trust the ___________ to take necessary actions to provide safe irradiated foods.					
	a. government	1	2	3	4	5
	b. food industry	1	2	3	4	5
	c. food scientist	1	2	3	4	5
45.	I agree with the American Dietetic Association's position paper in support of irradiated foods.	1	2	3	4	5

II. Knowledge of New Food Technology

Direction. Please indicate whether the following statements related to genetically engineered and irradiated foods are true or false by circling the T or F. If you are unsure, circle the U/S.

II-A. Genetically engineered foods

1.	Biotechnology involves modification of living organisms on their subcellular components to provide products, processes, or services.	T	F	U/S
2.	Recombinant DNA (rDNA) involves identifying, isolating, and then splicing together pieces of DNA: usually a single, characterized gene.	T	F	U/S
3.	Genetically engineered foods are a result of recombinant DNA manipulation: the rearrangement of genetic codes and not tissue.	T	F	U/S
4.	Genetically engineered foods are prohibited by all religious groups.	T	F	U/S
5.	Application of genetic engineering methods to animals can result in greater production efficiency through increased growth rate and milk production, and leaner carcasses.	T	F	U/S

6.	Recombinant bovine somatotropin (r bST) is an animal drug that increases milk produced by dairy cows.	T	F	U/S
7.	Bovine somatotropin(bST) is a protein hormone found naturally in cows and is necessary for milk production.	T	F	U/S
8.	Porcine somatotropin (pST) is a hormone active in hogs that directs dietary energy away from fat disposition toward production of lean muscle.	T	F	U/S
9.	FDA labeling regulations for genetically engineered foods are concerned with the **food product** that results, **not the process** by which it is produced.	T	F	U/S
10.	Genetically engineered foods require labeling even with no meaningful or significant change in their composition or nutritional value.	T	F	U/S
11.	It is possible to transfer genetic material between dissimilar organisms, such as plants and animals, because DNA is chemically identical.	T	F	U/S
12.	Foods with increased nutritional value can be created through genetic modification.	T	F	U/S
13.	Practical applications of genetic modification to plants can increase yield, improve resistance to disease, enhance nutritional quality and flavor, and develop traits to withstand the shipping process.	T	F	U/S
14.	The first genetically engineered food, a slow-softening tomato (*Flavr Savr*), is available for purchase at retail stores.	T	F	U/S
15.	Tomato, potato, cotton, and corn are just a few species in which transgenic plants (new genetic varieties from manipulation of DNA) have been produced.	T	F	U/S

II-B. <u>Irradiated Foods</u>

16.	Food irradiation involves the use of ionizing energy applied to food.	T	F	U/S
17.	Irradiation can reduce or eliminate microorganisms, insects, and parasites that live on food.	T	F	U/S
18.	Irradiation does not destroy bacterial toxins present in food.	T	F	U/S
19.	Food irradiation can aid in reduction of pesticide applications and residues.	T	F	U/S
20.	Shelf life of foods can be extended through treatment with irradiation.	T	F	U/S
21.	Irradiated foods do not need refrigerated storage.	T	F	U/S
22.	Irradiation of food will result in products with decreased nutritional value.	T	F	U/S
23.	All foods are approved for irradiation treatment.	T	F	U/S
24.	Irradiation is classified as a food additive by the FDA.	T	F	U/S
25.	Spore-forming bacteria, such as *Clostridium botulinum*, can survive even after treatment with irradiation.	T	F	U/S
26.	It is required that all irradiated foods sold at the retail level be labeled as "treated with irradiation."	T	F	U/S

27. It is required that foodservices inform customers if irradiated foods are being served. T F U/S

28. Irradiated food ingredients used in processed food items in small amounts, such as spices, do not need to be labeled. T F U/S

29. Irradiated chicken and pork are approved for sale at the retail level. T F U/S

30. Irradiated fresh produce is approved for sale at the retail level. T F U/S

III. About Yourself

Direction. Please provide information about yourself. The information collected will be kept confidential.

1. Gender: _____ Male _____ Female

2. Age: _________

3. Education: (Check highest level completed)

   _____ B.S. degree

   _____ Some graduate work

   _____ M.S. degree

   _____ Some post-master's work

   _____ Ph.D. degree

4. Your primary work place:

   _____ College and university foodservice

   _____ Commercial foodservice

   _____ Educational institution

   _____ Government agency

   _____ Hospital foodservice

   _____ Nursing home foodservice

   _____ Private practice (consultant)

   _____ School foodservice (K - 12)

   _____ Others (Please identify)

   ____

5. Your title: ________________________________

6. How many years have you been a registered dietitian? ________ Years

7. From what sources have you obtained information about food technologies of genetic engineering and irradiation? (Check all that apply)

_____ Broadcasting (e.g. TV, Radio)

_____ College courses

_____ Colleagues

_____ Government publications

_____ Newspapers

_____ Popular magazines

_____ Professional journals (e.g. Journal of the American Dietetic Association)

_____ Professional meetings

_____ Trade journals (e.g. Restaurants & Institutions)

_____ Workshops/Seminars

_____ Other sources (Please identify)

____

_____ I did not obtain any information

8. Please estimate the number of inquires you have received about genetically engineered or irradiated foods in the past 6 months (since September 1995). ____________________

We appreciate your contribution to this study. Please check if you would like a copy of our research results and include a business card. Yes _____ No _____

Thank you very much!

Please fold outside this questionnaire so the address shows, tape, and mail (not staple).

206-2662

S. Wie/C. Strohbehn
HRIM, 11 MacKay

No postage necessary if mailed in the United States

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 675 AMES, IOWA

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APPENDIX D.

ADDITIONAL TABLES

Table A. Respondents' attitudes toward genetically engineered foods

Attitude statement	Number[a]	Mean rating[b]
I want to know more about genetically engineered foods.	268	4.28 ± 0.65
I support the use of food biotechnology to modify plants' genetic structure to be more resistant to damage by insects, thus reducing pesticide applications.	268	4.09 ± 0.69
I support the use of genetic engineering for non-food purposes such as production of human medicines.	269	3.99 ± 0.72
Universal labeling of genetically engineered foods should be required.	268	3.86 ± 0.88
I would support a ban on the production and purchase of genetically engineered foods.[c]	267	3.83 ± 0.83
I support the use of food biotechnology to create genetic modifications of fruits and vegetables to improve quality characteristics such as freshness and taste.	268	3.81 ± 0.79
I have a crucial role to play in informing the public about the potential of technological advances to add value and benefits to the food supply.	268	3.81 ± 0.86
An individual will experience harmful effects from eating genetically engineered foods.[c]	269	3.79 ± 0.73
The current practice of trimming excess carcass fat is cost-effective and efficient, so genetic engineering of animals to reduce fat is not necessary.[c]	269	3.69 ± 0.90
I do not intend to purchase and eat genetically engineered foods at home.[c]	268	3.66 ± 0.87
Only companies who make the products will benefit from genetically engineered foods.[c]	268	3.65 ± 0.84
I trust the food scientists to take necessary actions to provide safe genetically engineered foods.	253	3.62 ± 0.93
I agree with the American Dietetic Association's position paper in support of genetically engineered foods.	265	3.59 ± 0.71
Because the risk of chronic diseases increases with total and saturated fats in the diet, it is imperative that animal agriculture develops new strategies to reduce carcass fat.	269	3.54 ± 0.99
Concerns about genetically engineered foods outweigh the benefits.[c]	269	3.48 ± 0.84

[a] Total number of respondents = 269

[b] 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree

[c] Negatively worded item; reverse scoring procedure was used.

Table A. (Continued)

Attitude statement	Number[a]	Mean rating[b]
I am familiar with genetic engineering technology.	269	3.20 ± 1.02
More research needs to be done before genetically engineered foods are used by processors.	269	3.20 ± 0.90
The use of genetic engineering to change characteristics of plants is more acceptable than use to change characteristics of animals.	268	3.18 ± 0.99
I trust the government to take necessary actions to provide safe genetically engineered foods.	257	3.16 ± 1.05
My clients are concerned about genetically engineered foods.[c]	266	3.15 ± 0.95
The use of genetic modification to change **plants** should be limited.[c]	269	3.15 ± 0.94
Because of the potential to improve nutrient quality of food, government funding for genetically engineered foods research should be increased.	267	3.14 ± 0.88
I am skeptical of sources of information about genetically engineered foods.[c]	269	3.10 ± 0.85
I think that it is necessary to use genetic engineering on plants and animals to improve the quality and nutritional value of foods.	268	3.09 ± 0.89
Even though the Food and Drug Administration (FDA) has declared the safety of using bovine somatotropin (bST), I am cautious about recommending products of bST to my clients.[c]	265	3.06 ± 1.06
I am concerned about genetically engineered foods.[c]	268	2.93 ± 0.98
The use of genetic modification to change **animals** should be limited.[c]	267	2.93 ± 0.95
I trust the food industry to take necessary actions to provide safe genetically engineered foods.	249	2.90 ± 1.12
I think current governmental regulations are sufficient to protect the public from risks associated with genetically engineered foods.	266	2.90 ± 0.82
I am opposed to transfer of genetic materials between plants and animals.[c]	268	2.81 ± 0.86
The use of genetic modification to change **plants** should be strictly regulated.[c]	267	2.55 ± 0.97
The use of genetic modification to change **animals** should be strictly regulated.[c]	267	2.35 ± 0.91

[a] Total number of respondents = 269

[b] 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree

[c] Negatively worded item; reverse scoring procedure was used.

Table B. Respondents' attitudes toward irradiated foods

Attitude statement	Number[a]	Mean rating[b]
I want to know more about irradiated foods.	267	4.20 ± 0.66
Food irradiation is used by the food industry to mask spoiled foods.[c]	265	4.00 ± 0.85
I would support a ban on the food irradiation process.[c]	267	3.96 ± 0.83
Food irradiation is not a safe way to extend the shelf life of foods.[c]	269	3.94 ± 0.77
An individual will experience harmful effects from eating irradiated foods.[c]	264	3.92 ± 0.72
The food industry holds responsibility for ensuring the safety of food products treated with irradiation.	250	3.86 ± 0.82
The food scientist holds responsibility for ensuring the safety of food products treated with irradiation.	250	3.83 ± 0.79
The government holds responsibility for ensuring the safety of food products treated with irradiation.	258	3.79 ± 0.85
I do not intend to purchase and eat irradiated foods at home.[c]	268	3.71 ± 0.93
I agree with the American Dietetic Association's position paper in support of irradiated foods.	263	3.71 ± 0.72
I trust the food scientists to take necessary actions to provide safe irradiated foods.	251	3.66 ± 0.89
I am familiar with irradiation treatment.	268	3.60 ± 0.95
Concerns regarding food irradiation outweigh the benefits.[c]	267	3.56 ± 0.94
I am concerned about irradiated foods.[c]	268	3.47 ± 1.00
I trust the government to take necessary actions to provide safe irradiated foods.	254	3.35 ± 1.03
I am skeptical of sources of information about irradiated foods.[c]	266	3.28 ± 0.93
I trust the food industry to take necessary actions to provide safe irradiated foods.	248	3.18 ± 1.08
My clients are concerned about irradiated foods.[c]	267	3.14 ± 0.96
More research needs to be done on irradiation before it is used commercially by food processors.	266	3.03 ± 1.04

[a] Total number of respondents = 269

[b] 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, 1 = Strongly Disagree

[c] Negatively worded item; reverse scoring procedure was used.

Table C. Respondents' knowledge of genetically engineered foods[a]

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
Practical applications of genetic modification to plants can increase yield, improve resistance to disease, enhance nutritional quality and flavor, and develop traits to withstand the shipping process. (T)[b]	241	90.3	24	9.0
Application of genetic engineering methods to animals can result in greater production efficiency through increased growth rate and milk production, and leaner carcasses. (T)	233	86.6	34	12.6
Foods with increased nutritional value can be created through genetic modification. (T)	211	78.4	50	18.6
Genetically engineered foods are prohibited by all religious groups. (F)	205	76.2	64	23.8
Recombinant bovine somatotropin (r bST) is an animal drug that increases milk produced by dairy cows. (T)	198	73.6	53	19.7
Biotechnology involves modification of living organisms on their subcellular components to provide products, processes, or services. (T)	182	67.9	77	28.7
Bovine somatotropin (bST) is a protein hormone found naturally in cows and is necessary for milk production. (T)	177	65.8	80	29.7
Tomato, potato, cotton, and corn are just a few species in which transgenic plants (new genetic varieties from manipulation of DNA) have been produced. (T)	171	63.6	96	35.7
The first genetically engineered food, a slow-softening tomato (*Flavr Savr*), is available for purchase at retail stores. (T)	168	62.5	96	35.7

[a] N = 269; Percentages shown do not include incorrect responses, thus percentages do not equal 100%.

[b] T = True, F = False

Table C. (Continued)

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
Recombinant DNA (rDNA) involves identifying, isolating, and then splicing together pieces of DNA: usually a single, characterized gene. (T)[b]	164	61.2	99	36.9
Genetically engineered foods are a result of recombinant DNA manipulation: the rearrangement of genetic codes and not tissue. (T)	159	59.6	101	37.8
Porcine somatotropin (pST) is a hormone active in hogs that directs dietary energy away from fat disposition toward production of lean muscle. (T)	96	35.8	167	62.3
FDA labeling regulations for genetically engineered foods are concerned with the **food product** that results, **not the process** by which it is produced. (T)	88	32.8	128	47.8
It is possible to transfer genetic material between dissimilar organisms, such as plants and animals, because DNA is chemically identical. (T)	54	20.2	139	52.1
Genetically engineered foods require labeling even with no meaningful or significant change in their composition or nutritional value. (F)	46	17.1	119	44.2

[b] T = True, F = False

Table D. Respondents' knowledge of irradiated foods[a]

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
Shelf life of foods can be extended through treatment with irradiation. (T)[b]	250	92.9	18	6.7
Irradiation can reduce or eliminate microorganisms, insects, and parasites that live on food. (T)	235	87.4	27	10.0
Irradiation of food will result in products with decreased nutritional value. (F)	195	72.5	69	25.7
All foods are approved for irradiation treatment. (F)	165	61.3	101	37.5
Food irradiation involves the use of ionizing energy applied to food. (T)	163	61.3	100	37.6
Food irradiation can aid in reduction of pesticide applications and residues. (T)	150	55.8	79	29.4
It is required that all irradiated foods sold at the retail level be labeled as "treated with irradiation." (T)	142	52.8	107	39.8
Irradiated food ingredients used in processed food items in small amounts, such as spices, do not need to be labeled. (T)	114	42.7	135	50.6
Irradiated fresh produce is approved for sale at the retail level. (T)	113	42.3	140	52.4
Irradiated foods do not need refrigerated storage. (F)	99	36.9	91	34.0
Irradiation does not destroy bacterial toxins present in food. (T)	97	36.2	123	45.9
It is required that foodservices inform customers if irradiated foods are being served. (F)	77	28.8	152	56.9
Irradiated chicken and pork are approved for sale at the retail level. (T)	72	27.0	167	62.5

[a] N = 269; Percentages shown do not include incorrect responses, thus percentages do not equal 100%.

[b] T = True, F = False

Table D. (Continued)

Statement	Responded Correctly		Selected Unsure	
	Number	Percent	Number	Percent
Spore-forming bacteria, such as *Clostridium botulinum*, can survive even after treatment with irradiation. (T)[b]	49	18.2	180	66.9
Irradiation is classified as a food additive by the FDA. (T)	42	15.6	186	69.1

[b] T = True, F = False

Table E. Differences in attitudes and knowledge between RDs grouped by request for result

		n	Mean[a]	SD	t
Attitudes					
Genetically engineered foods					
Would you like a copy of our research results?	Yes	91	3.43	0.39	2.330*
	No	178	3.32	0.35	
Irradiated foods					
Would you like a copy of our research results?	Yes	91	3.71	0.45	1.937
	No	178	3.60	0.38	
Knowledge					
Genetically engineered foods					
Would you like a copy of our research results?	Yes	91	9.87	2.96	3.628***
	No	178	8.40	3.47	
Irradiated foods					
Would you like a copy of our research results?	Yes	91	8.26	2.92	3.673***
	No	178	6.80	3.39	

* $p \leq .05$, *** $p \leq .001$

[a] Mean of respondents for all statements

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