

Consumer Attitudes and Market Response to Irradiated Food



International Consultative Group on Food Irradiation

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**International Consultative Group on Food Irradiation
(ICGFI)**

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Foreword

The International Consultative Group on Food Irradiation (ICGFI) was established on 9 May 1984 under the aegis of FAO, IAEA and WHO. ICGFI is composed of experts and other representatives designated by governments which have accepted the terms of the "Declaration" establishing ICGFI and have pledged to make voluntary contributions, in cash or in kind, to carry out the activities of ICGFI.

The functions of ICGFI are as follows:

- ❑ to evaluate global developments in the field of food irradiation;
- ❑ to provide a focal point of advice on the application of food irradiation to Member States and the Organizations; and
- ❑ to furnish information as required, through the Organizations, to the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food, and the Codex Alimentarius Commission.

As of May 1998, the following countries are members of ICGFI:

Argentina, Australia, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Czech Republic, Ecuador, Egypt, France, Germany, Ghana, Greece, Hungary, India, Indonesia, Iraq, Israel, Italy, Republic of Korea, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Pakistan, People's Republic of China, Peru, Philippines, Poland, Portugal, South Africa, Syrian Arab Republic, Thailand,

Tunisia, Turkey, Ukraine, United Kingdom, United States of America, Viet Nam, and Yugoslavia.

No treatment would be a success and no further research is warranted if consumers are not willing to accept the end product. Recognizing that consumers will ultimately decide whether to accept irradiated foods or not, the ICGFI at its 12th Meeting held in Vienna in 1995 decided to compile data on consumer attitude surveys and market trials of irradiated food conducted in several countries during the past two decades. Such data and their evaluation were considered essential for policy makers in the government, food industry and consumer organizations to decide further actions on food irradiation.

This publication was prepared by Dr. Christine M. Bruhn, Director of the Center for Consumer Research, University of California, Davis, USA, on behalf of ICGFI. It clearly demonstrates the perception of the public with regard to the irradiation of food and the critical role which objective information has played in influencing consumer acceptance of irradiated food. After undergoing peer review and comments by national contact points of ICGFI and subsequent revisions by the author, this document was approved for publication as one of the information documents by the 14th ICGFI Meeting. The ICGFI Secretariat gratefully acknowledge the valuable contribution of Dr. Bruhn and those who were involved in reviewing this document. This document was professionally edited by Mr. R. Peniston-Bird, a former editor of the IAEA.



Executive Summary

Consumer awareness of food irradiation is increasing. In certain countries, labelled irradiated foods have become standard commodities. In others, irradiated foods are available to a limited number of consumers, and in some, irradiated foods are not permitted. Where irradiated foods are available, consumers have purchased because of their satisfaction with product quality and safety.

When irradiated foods are made available for purchase, most people buy without hesitation. Availability in the marketplace is itself an endorsement of safety. When specifically asked about food irradiation, people have questions about product safety, nutritional quality, potential harm to employees, and potential danger from living near an irradiation facility. These concerns appear to be derived from the association of irradiation with radioactivity and nuclear power plants. In some countries these concerns are perpetuated by special interest groups.

It is normal to seek reassurance as to the safety and effectiveness of any new process or technology. Because the lay consumer is not informed about food processing technologies, it is appropriate to make information available. Although many may not avail themselves of the information, for those who do, the content will reinforce positive views and provide reassurance for those with questions. In some countries information is currently provided by professional societies or health organizations. In other countries, information is very limited.

The subsequent sections of this publication provide an overview of research findings on consumer acceptance and marketing trials of irradiated food in various countries. Owing to differences in research techniques, sampling methods and questions, the results are not often directly compatible. Since the majority of available research comes from the USA, the first section is devoted to this country. An overall view of food irradiation technology is given by Diehl (1995) and Thorne (1991). Subsequent sections deal on a country by country basis with other national findings. Where there are only a limited amount of data for given countries, these are given in Table VII, and no specific section is devoted to such countries.

A safety endorsement by the ministry of health or other respected health authorities would contribute to the consumer's positive view. Some consumers may be philosophically opposed to food irradiation. Information is unlikely to affect acceptability among these individuals. Concern about safety decreases in most people when they receive information about food irradiation.

This paper reviews consumer attitude studies and market testing of irradiated food in the period 1984-1997 and came to the following conclusions:

- ❑ People in several countries have purchased irradiated food.
- ❑ In some markets, the availability of a high quality produce item out of season was an important benefit. In other markets, high quality imported products were of significant interest.
- ❑ Greater microbiological safety was a benefit in other markets.
- ❑ Consumers will buy irradiated foods.

In conclusion, regulatory authorities must be encouraged to permit the sale of irradiated items when wholesomeness has been established and the food industry should not hesitate to utilize this safety and quality enhancing technology.





United States Of America

Attitude studies

Early research indicated that consumers were unfamiliar with food irradiation and recommended that consumers receive information about the process and be offered a choice of irradiated and non-irradiated foods in the marketplace (Titlebaum et al., 1983; Wiese Research Associates, 1984; Bruhn et al., 1986a).

Relative food safety concerns

Consumer attitude surveys are more accurately interpreted by comparing change over time, contrasting attitudes towards one area with those of another within the same sample, and recognizing that the process of asking will cause some respondents to express concern. For example, when nutrition or food safety concerns are specifically identified, the number of persons expressing concern is two to three times higher than when no topics are so identified (Opinion Research, 1995).

Although irradiation has been studied extensively since the 1950s, to the lay person it is a new technology. Some consumers will express concern about any technology, new or long established. Technologies which have been used for years, such as freeze-drying, freezing, and microwaving of food, generated major concern among a small percentage of readers of a popular magazine (McNutt, 1985). Some persons are highly averse to risk. Therefore it is unrealistic to expect nobody to express concern about irradiation or any other technology.

When consumers are given the opportunity to express food safety concerns, microbiological hazards and spoilage are mentioned most frequently (Table I).

When specifically asked about several potential food safety areas, most consumers, 82%, classify contamination by germs or bacteria as a serious hazard. Pesticide residues are classified as serious by 66% and product tampering by 65% of consumers. It is interesting to note that some applications of food irradiation reduce the risk from microbiological contamination while other applications replace some uses of pesticides, two areas where concern is greatest.

About one-third of consumers classified irradiation as a potential serious health hazard (Table II). This is comparable to those viewing nitrites as serious, 28%. About one quarter of the consumers surveyed were uncertain about the potential hazard from food irradiation. The number of consumers concerned about irradiation has decreased significantly over time from 43% in the late 1980s to 33% in 1997 (Table III).

Similarly, a study in Georgia (n = 446) found consumer concerns about pesticides, animal drug residues, growth hormones, food additives and bacteria were significantly higher than concern about food irradiation (Resurreccion et al., 1995). Concern ratings for irradiation and naturally occurring toxins were comparable. Irradiation was 'no problem' for 20% of respondents, a better rating than for other food safety issues such as additives (11%), growth hormones (8%), animal drugs (7%) and pesticides (7%).

A nationwide survey conducted for the produce industry found that 22% of consumers believed irradiated foods were not a hazard, even though the question was phrased: "What concerns do you have with buying irradiated fresh produce?" (The Packer, 1993).



In a nationwide survey, the Gallup Organization asked consumers to use a ten point scale to rate their concern with several food processing methods. Consumers were told to use '1' to denote no concern and '10' for significant concern. No technology or practice received a mean rating near 'no concern'. Common industrial practices such as canning and pasteurization were rated 5.6 and 5.8 respectively. Irradiation, food preservatives, and rinsing in chlorinated water received similar concern ratings of 7.3, 7.1, and 7.4 respectively (Table IV).

Effect of educational information

Information about food irradiation has led to a positive view by the public and by health professionals. After interviewing twenty-six groups of women totalling 195 individuals, Bord and O'Connor concluded that the extent to which the public accepts or rejects irradiated food depends on the presence or absence of information. (Bord and O'Connor, 1989). Interviews with consumers showed that those who knew something about irradiation and responded correctly to information about the technology were significantly more accepting of it (Bord and O'Connor, 1989). This is consistent with early research in which consumer preference for irradiation and chemical treatments were compared. Within the overall sample there was no difference in preference, but among those who had heard of irradiation, 39% preferred that technology compared to 24% who preferred chemical preservatives (Louis Harris and Associates, 1985). A 1988 survey of professional home economists found that few knew the facts about irradiation (Johnson, 1990). After viewing a 90-minute teleconference, 300 home economists, dietitians, educators and students exhibited a significant change in knowledge and acceptance of the process.

These and other studies (Table V) indicate that concern about irradiation is comparable to or less than other commonly used food handling methods.

Many consumers have not formed an opinion about irradiation (Abt Associates, 1996; Opinion Research, 1987-1995; The Packer, 1993; Resurreccion et al., 1995; Pszczola, 1992). In the nationwide Food Marketing Institute Surveys, between 20% and 35% of consumers indicated that they did not know how to judge the safety or hazard of irradiated foods (Table III). Probably a much larger proportion of the population is not well-informed about this technology.

In a study in Georgia, 72% of respondents had heard of irradiation, although 88% of those said they did not know very much about the process and 30% thought that irradiated food was radioactive (Resurreccion et al., 1995).

Consumer studies consistently demonstrate that when provided with scientific information, a high percentage of consumers are willing to buy, and prefer, irradiated foods (Bruhn et al., 1986b; Bruhn and Schutz, 1989; Gallup Organization et al., 1993). Consumers indicate that endorsements by a respected health authority increase their confidence in the safety of this technology.

The effect of information and product samples on consumer attitudes was documented in a Purdue University study (Pohlman et al., 1994). About half the sample of 178 residents were willing to buy irradiated foods following exposure to information about the process. After viewing an eight-minute video tape, *The Future of Food Preservation, Food Irradiation*, subjects demonstrated a significant positive change in knowledge, and willingness to buy irradiated food increased to 90%. Among those who both saw the video tape and sampled irradiated strawberries, willingness to buy increased to 99%. These results cannot be generalized to the entire population since a university community has a disproportionate number of people with more formal education; nevertheless, this study demonstrates high acceptance among specific segments of the population.





The Future of Food Preservation, Food Irradiation video tape and other educational items were shown to military personnel (Schutz, 1994). In follow-up interviews, the percentage of soldiers who expressed major concern in the control group (which received no educational intervention) decreased from 33% to 29% and those expressing no concern increased from 8% to 27%, perhaps due to repeat exposure to the concept of irradiation. Among those soldiers viewing the video tape, 17% expressed major concern and 38% no concern about irradiated food. The percentage of soldiers likely to select irradiated food in the military dining facility increased from 21% initially to 61% after viewing the video tape. Over 80% indicated they were likely to choose irradiated field rations.

A United States Department of Agriculture (USDA) funded project in California and Indiana evaluated the impact of a brief educational programme on community leaders' attitudes to and knowledge of food irradiation (Bruhn and Mason, 1996). After a brief introduction, the video tape, *The Future of Food Preservation, Food Irradiation* was shown. This was followed by a question and answer period and a summary of the effect of irradiation on food. Consumers gained knowledge of specific food irradiation facts and their interest in purchasing irradiated foods increased. Initially programme participants had little (37%) or no (31%) knowledge about food irradiation, with only 2% believing they had a lot of knowledge. Following the presentation, the percentage of those believing they were very or somewhat knowledgeable increased to 21% and 59% respectively.

In addition, concern about the safety of irradiated foods decreased. After respondents had viewed a video and engaged in a discussion, the percentage very concerned about irradiated food remained constant at 4% but the figure of 15% somewhat concerned dropped to 7%, whilst those who were confident that irradiated food was safe increased from 25% to 44% and those who

were very confident increased from 14% to 36%. Those likely or very likely to try irradiated food increased from 57% to 83% with 27% very likely and 56% likely to buy. There was no difference in attitudes or knowledge between California and Indiana consumers.

Characteristics of acceptors and rejecters

Adoption of new technologies is led by innovators. Early users of new technologies often have higher income, have a higher standard of living, have a more prestigious occupation, and possess a more positive self-identity. They also have a greater ability to deal with abstractions, greater rationality, higher intelligence scores, are more favourable towards change, and can cope better with uncertainty (Rogers and Shoemaker, 1971). Scientific literacy plays a significant role in greater acceptance of nuclear power and probably also influences the acceptance of irradiated food. Those who viewed nuclear power positively were more likely to have education in the sciences, as opposed to the humanities, to read newspapers frequently, and to include science-related television programmes in their leisure activities (Jenkins-Smith and Rouse, 1992).

Although the majority of people respond positively to information about food irradiation, a minority oppose the technology. Those opposed to food irradiation are highly concerned about the use of chemicals on food, place a high value on an 'ecologically balanced world,' oppose the use of nuclear technology, and prefer to eat only unprocessed or 'organic' food (Bruhn et al., 1986a; Bruhn et al., 1987; Brand Group, 1986). Irradiation rejecters were estimated to constitute 5-10% of the population (Brand Group, 1986).

Demographic factors have been related to views towards irradiation. Women are more concerned about all issues that may affect food safety, including irradiation (Abt Associates, 1996; Opinion Research, 1987-95;





Center for Produce Quality, 1992; Terry and Tabor, 1990). People with formal education at high school level and above are more likely to purchase irradiated foods (Terry and Tabor, 1990; Resurreccion et al., 1995). Correspondingly, introductions of products in California, Florida, Illinois, Kansas, and Missouri found good acceptance in up-scale markets (Bruhn and Noel, 1987; Marcotte, 1992; Pszczola, 1992; Terry and Tabor, 1987; Terry and Tabor, 1990).

Product benefits

Recent experience with mandatory safe food handling labels on meat and poultry products indicates that such statements may be used to convey information to consumers (Abt Associates, 1997).

Label statements can be used to describe why products are irradiated (Schutz et al., 1989). Schutz and co-workers measured consumer attitudes towards several label statements. Almost two-thirds of consumers considered products bearing the label statement 'Irradiated to extend shelf-life' or 'Irradiated to retard spoilage' were fresher than non-irradiated products, 22% were uncertain, and less than 4% thought the food would not store well. Products bearing the label, 'Irradiated to control microbes' were thought to be safer than non-irradiated products by almost 42% of the sample, with 28% uncertain and only 14% thinking that safety would be lower. Thirty-six per cent of consumers also thought that products with this label would be higher quality, 25% did not know and 12% felt quality would be lower. About half the consumers expected irradiated products to be more expensive, with 5% to 10% saying less expensive, depending on the label statement. The label having the lowest impact was 'Irradiated for quarantine control'; however, 42% were more willing to buy this product, with 23% being uncertain. All statements increased consumer interest in purchase, with 'Irradiated to control microorganisms' generating the greatest response.

Applications for extended shelf-life, quality, or variety

Consumers responded positively to the benefits of irradiation applied to specific products. People were interested in purchasing irradiated tropical fruit, 54%, and irradiated soft fruits, 43% (Schutz et al., 1989).

Irradiated strawberries were evaluated favourably in a Kansas City study. Irradiated and non-irradiated strawberries, sometimes supplemented with educational information about irradiation, were given to consumers in malls and supermarkets (Terry and Tabor, 1990). Consumers were asked to treat the strawberries as they normally would, then return a questionnaire. About 400 questionnaires were returned. People considered irradiated strawberries either comparable or superior in appearance and colour compared with non-irradiated berries. Irradiated berries ranked well in freshness and firmness, with little difference in perceived taste. Information about irradiation increased people's intention to buy, both at an equal price or at a small premium. People expressed greater willingness to pay higher prices for irradiated berries when fact sheets about the process were included with the samples. In total, 80% of consumers reported they were pleased with irradiated strawberries, 67% were pleased with the non-irradiated berries. Half the consumers felt their supermarket should offer irradiated strawberries and about a third were uncertain.

The Food Marketing Institute nationwide survey found 15% of consumers were very likely and 43% somewhat likely to buy irradiated products to keep them fresh longer (Abt Associates, 1996).

Applications to enhance food safety

In a nationwide survey in the late 1980s, 57% of consumers preferred irradiated to non-irradiated pork, and 58% irradiated to non-irradiated poultry; additionally, 58% preferred irradiated to fumigated spices (Schutz et al., 1989). Similar positive responses to





irradiated foods were found in a study in Georgia in the early 1990s (Resurreccion et al., 1995). About half the consumers expressed an interest in buying irradiated pork and poultry, with 27% and 34%, respectively, expressing uncertainty. Thirteen to 18% indicated they would buy more of these products if they were irradiated and properly labelled. Half the consumers felt irradiation of fruits and vegetables was not necessary; however, 40% or more believed irradiation of pork, poultry, and seafood was 'very necessary'.

A nationwide survey conducted by Gallup found that 22% of consumers were very likely and 30% likely to buy irradiated poultry; 20% were very likely and 28% likely to buy irradiated pork; 20% very likely and 25% likely to buy irradiated seafood products; and 19% very likely and 31% likely to buy irradiated beef products (Gallup Organization et al., 1993). Additionally, 60% indicated they would pay 10 cents more for irradiated hamburger.

Consumers appear to value the use of irradiation to destroy microorganisms which cause foodborne illness. The nationwide Food Marketing Institute surveys found 46% of respondents were somewhat likely and 23% very likely to purchase irradiated products to kill germs. This sample included only those who had heard of irradiation previously. A 1997 survey found 40% of respondents were likely and 20% very likely to purchase irradiated products (Abt Associates, 1997).

Two economic studies investigated consumer willingness to pay a premium for irradiated products in a simulated market situation. An Iowa study used an auction technique to investigate consumer reaction to the benefits of irradiating pork (Fox et al., 1993). After auctioning a variety of products, students were given sandwiches made with irradiated or non-irradiated pork and were given the opportunity to bid for the product they did not have. The study indicated a very high level of acceptability of irradiated

pork in a sample of 58 undergraduate students. Twenty-six of twenty-nine subjects paid a premium for irradiated pork to reduce the risk of contracting trichina. Only one of twenty-nine students paid to avoid the irradiated product, due to an aversion to the irradiation process. Using a similar technique, study participants in Arkansas proved willing to pay a premium of US \$0.75 for a sandwich made with irradiated chicken (Bailey, 1996).

Consumers do not always carry out purchase intentions. In a simulated market study conducted in Georgia, initially 44% indicated they would purchase irradiated ground beef. When given the opportunity to select ground beef labelled irradiated, 52% selected the product, including 61% who said they would buy and 31% who initially said they would not. After receiving information on the process, 71% selected beef labelled irradiated, including 62% who had initially said they would not purchase the irradiated product (Gallup Organization et al., 1993).

Consumer interest in food irradiation has increased, perhaps as a result of media reporting the strong endorsement by health officials following United States Food and Drug Administration (FDA) approval of irradiation of red meat in December, 1997. A telephone survey conducted in March 1998 showed nearly 80% of consumers said they would be somewhat interested (47%) or very interested (33%) in buying food labelled, 'Irradiated to kill harmful bacteria' (Throssell and Grabowski, 1998). Almost 87% said they thought irradiation would lower to some extent or to a great extent the risk of food poisoning due to hamburgers in restaurants. When asked how necessary they thought irradiation was for a list of foods, consumers ranked poultry with the largest percentage of 'very necessary', (67%), followed by pork (65%) and ground beef (64%). Survey respondents showed a strong preference for irradiation information from medical and health professional sources.





Destruction of disease-causing bacteria had the greatest consumer appeal. Ninety-one percent recognized that irradiation does not replace proper food handling.

Influence of price

Economic analysis indicate that price influences willingness to buy. Whereas lower income groups were sensitive to price, the higher income groups were likely to purchase irradiated food at lower, identical, or higher prices (Terry and Tabor, 1987). Attitude studies demonstrate that over half of consumers expect and are willing to pay more for irradiated foods (Schutz et al., 1989; Resurreccion et al., 1995).

Market experiences

Consumer response to labelled irradiated food has been positive. Irradiated mangoes sold well in Florida in 1986 (Giddings, 1986). In March 1987, irradiated Hawaiian papayas were available as a one day trial at two markets in Southern California (Bruhn and Noel, 1987). Consumers could taste both the irradiated papaya and the traditional papaya. Leaflets were available explaining irradiation, and knowledgeable persons were present to respond to questions. Interest in purchasing irradiated fruits in the future was high in both markets, 66% and 80%. Irradiated papayas out-sold the identically priced non-irradiated counterpart by more than ten to one. Additionally, irradiated apples marketed in Missouri were favourably received (Terry and Tabor, 1990).

A record amount of irradiated strawberries was sold in a Florida produce market in the winter of 1992. On the first day of sales, 600 pints of irradiated berries priced at US \$2.00 each were sold compared to 450 pints of non-irradiated berries priced at US \$1.29. When prices were equal, the two types of berry sold equally; when irradiated berries were cheaper, they sold at a higher rate than the non-irradiated

fruit. Consumers who did not find the berries too expensive, who trusted their retailer, distrusted activists, were more knowledgeable, and/or trusted health and scientific authorities were very likely to buy the irradiated strawberries (Marcotte, 1992).

In March 1992, Carrot Top, a produce and grocery store in the Chicago area, featured irradiated strawberries, grapefruit, and juice oranges (Pszczola, 1992). Owner James Corrigan, in a newsletter survey of his customers, found about 70% of them had heard about irradiation, but 90% felt they had not received enough information. After investigating the process himself, he shared information with his customers via the newsletter and made both pro and anti material available at the point of sale.

Carrot Top sold 1200 pints of strawberries, of which approximately 90%-95% were irradiated. The non-irradiated and irradiated berries were at the same price with a 'buy one, get the other free' promotion. Corrigan had hoped that people would choose one of each and compare, but instead customers took two irradiated pints. Over the first weekend, he sold 172 cases of irradiated berries compared to only six cases of non-irradiated. Grapefruit and juice orange also sold well, with about 90% irradiated and 10% non-irradiated. Carrot Top also featured irradiated tomatoes, mushrooms, and onions with similar sales success. In his second year of operation and thereafter, Corrigan indicated that irradiated produce continued to out-sell non-irradiated produce by twenty to one (Corrigan, 1995).

In 1995 tropical fruit from Hawaii was sold at Carrot Top and several Midwest markets in conjunction with a study to determine quarantine treatment. From 1995 to October, 1996, eleven shipments of fruit consisting of papaya (10 020 pounds¹), atemoya (7302 pounds), rambutan (1168 pounds), lychee (3080 pounds), starfruit (2264 pounds), banana (380 pounds), Chinese taro (30 pounds), and oranges (200 pounds) were shipped to

¹ pound (lb) = 0.4536 kilogram (kg)





Isomedix plant near Chicago for irradiation between 0.25 kGy and 1.0 kGy (Wong, 1996). By June of 1997, 100 000 pounds of tropical fruit had been sold (Wong, 1997). Fruit was well received by consumers; however, one retailer withdrew due to threats from an activist organization.

Additional shipments of irradiated mango, avocado, sweet potato and Korean melon were not sold but used solely for sampling at Carrot Top and 255 pounds of atemoya, 64 pounds of rambutan and 136 pounds of star fruit were irradiated in Hawaii and air freighted to Seattle, San Francisco and Los Angeles for sampling to promote Kauai tourism.

The market response to irradiated poultry was tested in Kansas. In 1995, labelled irradiated poultry captured 60% of the market share when priced 10% lower than store brand, 39% when priced equally, and 30% when priced 10% higher (Anonymous, 1995). In 1996 market share increased to 63% when the irradiated product was priced 10% lower than the store brand, 47% when priced equally, and 18% and 17% when priced 10% or 20% higher (Fox, 1996). The irradiated product sold better in the more up-scale store, capturing 73% of the market when priced 10% lower, 58% when priced equally, and 31% and 30% when priced 10% or 20% higher. Information on irradiation was available, but few consumers picked up the material. This is consistent with other attitude surveys and marketplace data that indicate irradiation is more accepted in up-scale markets. Although information on irradiation should be available, many consumers do not question safety since product availability is itself an endorsement of safety.

Although the Kansas marketing experience was positive, researchers felt that consumers were not fully aware of the benefits irradiation provided since few picked up the educational material available in the supermarket.

In February 1997, from a random sample of 250 households, 98 subjects were recruited to participate in a consumer marketing project (Fox and Olson, 1998). Participants were asked to read the USDA information leaflet about food irradiation and were shown packages of irradiated and store-brand non-irradiated chicken breasts. No other information about food irradiation was provided.

Participants were then asked to indicate their preference for the irradiated or non-irradiated chicken at each of four alternative prices as described in the earlier studies. When irradiated and non-irradiated chicken were priced equally, 80% of participants purchased irradiated chicken in the market experiment. This compares with 81% who had indicated a preference for irradiated chicken in an earlier mail survey. At the 10% discount price, 84% purchased irradiated chicken in the market experiment, compared with 87% who indicated a preference for irradiated in the mail survey. When irradiated chicken was offered at a 10% price premium, over 35% selected the irradiated product in the market experiment, compared with about 30% in the mail survey.

The authors concluded that a majority of consumers exposed to unbiased, scientifically based information about food irradiation will purchase irradiated poultry products. (Fox and Olson, 1998)



Outside The United States Of America

Tables VII, VIII and IX provide summaries relating to consumer attitudes in countries other than the USA. These are discussed in further detail on a country by country basis in the subsequent sections.

Argentina

Irradiated onions and garlic were first sold in a supermarket in the Buenos Aires area in 1985. Prior to the first marketing, consumers were informed about food irradiation in the local TV, radio and press. Within three days of marketing, the entire ten tonnes of irradiated product were sold (Curzio et al., 1986; Curzio and Croci, 1990).

Consumers were given a survey to complete regarding their reasons for purchase and satisfaction with the products. Fifty-three per cent of the forms were returned. Seventy-two per cent of buyers recorded just one reason for purchasing, the remaining 28% recorded two reasons. Of those recording one reason, product quality was most frequently indicated, by 72%, with 19% noting interest in treatment and 9% responding to the price, which was 20% lower than that of the non-irradiated onions. Of those checking two reasons, 57% noted quality and treatment and 38% quality and price. Ninety-five per cent rated the onion quality as very good, 4% as good; 32% rated that of the garlic as very good and 61% as good. The investigators concluded that the public will respond favourably, when informed about the irradiation process, and offered a quality product.

In 1986, irradiated onions were sold in August, when the fresh product was on the market and in October when fresh products were not available (Urioste et al., 1990). On both occasions, irradiated onions were sold

at a rate of one tonne per day. In both trials, the most important reason for purchase was the treatment. However, in October, when fresh onions were not available, a better appearance became an important reason.

Irradiated onions were rated very highly in August, with 98% of respondents indicating they liked the product strongly (82%) or slightly (16%), while in October, preference decreased slightly, with 88% liking the product (23% strongly and 65% slightly). The investigators noted that for this variety irradiation did not prevent spoilage due to microorganisms. Consumers were very receptive to purchasing the product again, with 91% from the August test saying that they definitely would purchase, and 92% from the October test. In August, the negative response from some consumers was related to a preference for food that had not received any processing.

The investigators concluded that an education campaign and endorsement by the Ministry of Health would be crucial for acceptance by consumers. They predicted significant opportunities for irradiation of onions and other foods.

In October 1988, irradiated onions were offered in a supermarket patronized by high and middle-income consumers. Irradiated onions, priced the same as non-irradiated ones, were sold for three days. Of the 600 people surveyed, 72% were female and 28% male. Over 90% of them were uninformed about food irradiation; however over 80% were willing to try irradiated onions. Fewer than 1% said they had concerns about the safety of the process.

A number of those who purchased irradiated onions responded to questions after





consumption. The sample of 121 people consisted of 87% women and 23% men. Most people purchased irradiated onions out of curiosity about the new product. A majority responded that they liked the irradiated onions very much, the rating being 50% among people younger than 30 years, 71% for people aged 31-50, and 83% for people over 51. Most people said the irradiated onions tasted different from the non-irradiated ones. Of respondents under 30 years of age, 89% said they would buy irradiated onions again, 85% of those aged 31-50 would do so, and 98% of respondents over 51.

The investigators concluded that there was a need to educate the public about food irradiation. Irradiated and non-irradiated products should both be offered so that consumers could see the benefits of the irradiated product. The study demonstrated that there is a domestic market for irradiated food.

Bangladesh

Irradiated dried fish was marketed through normal channels every 15 days over the length of the storage test (Matin et al., 1988). Non-irradiated fish was also offered for sale. Irradiated fish carried labels indicating the product had been disinfected by gamma radiation. The food industry and consumers found that the irradiated fish was of higher quality and had better appearance. By the end of the storage test, most of the non-irradiated fish had spoiled.

Irradiated onions were test marketed 6-9 months after irradiation and storage at 20-37 °C and 70-95% relative humidity. More than two tonnes were marketed each month between September and January. The onions were labelled 'Irradiated to prevent sprouting'. The researchers reported that consumers preferred the irradiated onions.

China, People's Republic of

Numerous irradiated foods have been

market tested in China (International Consultative Group on Food Irradiation, 1992). Irradiated apples have been sold at regular prices in Shanghai since 1984. Consumers purchasing the irradiated apples in Shanghai received a leaflet explaining irradiation and a consumer acceptance form. Over one thousand forms were returned. Consumer acceptance was high, with 84% finding quality and flavour acceptable. Ninety-three per cent of consumers said that they would purchase the produce again, and that food irradiation should be further developed.

The Chengdu people's market and department stores have conducted continuous market testing of garlic, ginger, hot pepper and meat products, with over 3000 consumer evaluation forms being completed. Consumer acceptance averaged 70%, with students giving the highest rating of 74% and office workers recording 68%. Willingness to buy ranged from 68% for hot peppers to 72% for ginger.

In 1991-92, over 200 t of seasonings and meat products and 2500 t of irradiated sweet potato wine were supplied to ten cities for test marketing. The products sold well; however no mention was made of consumer surveys.

Between 1990 and 1995, 36 190 t of irradiated products were marketed in China (Chen Qixun, 1996). These included apples, 80 t; garlic, 28 500 t; meat products, 950 t; potatoes, 150 t; onion, 200 t; rice, 850 t; spices and seasonings, 920 t; sweet potato wine, 1200 t; tomatoes, 40 t; dehydrated vegetables, 2100 t; other foods, 850 t.

France

Irradiated strawberries were test marketed in May and June 1987 in Lyon (Laizier, 1987). Two tonnes of products, packed in covered plastic trays, labelled 'Protected by ionization', and priced 30% higher than the non-irradiated product, sold well. In the





long term, however, irradiated strawberries were priced too high to compete economically (Ehlermann, 1997). Labelled irradiated frog legs sell well. Market tests have also involved boned chicken breast and Camembert cheese made from raw milk. Mechanically deboned poultry meat is available to the food industry in commercial quantities. Other irradiated products appear regularly on the market (Ehlermann, 1997).

Indonesia

Since August of 1994, test marketing of irradiated brown rice, mungbean, and glutinous rice has been conducted by a private company (Hilmy, 1996). In a one year period, 1460 t of product were sold through thirteen co-operative stores and seven small shops in Jakarta, Bogor and Bekasi.

Italy

Irradiated potatoes were test marketed in 1976 in Bologna, Milan, Rome and Pescara (Baraldi, 1977). Consumers could purchase 10 and 20 kg bags of potatoes labelled 'Irradiated for the purpose of preventing sprouting'. Information on irradiation was available in the media and through a consumer brochure. Those who purchased potatoes returned a postcard indicating their preference for the irradiated potatoes because quality and storability were better.

Republic of Korea

Attitude tests in the Republic of Korea (ROK) indicated a potential positive response from consumers (Cho et al., undated). A sample of radiation workers and the general public found that 94% of the workers (n = 324) and 72% of the public (n = 376) had heard of food irradiation; however, only 58% and 32% knew the process had been approved by the ROK government and international organizations. Additionally, 10% of radiation workers and 40% of the public either did not know or were uncertain whether irradiated foods were the same as

food contaminated by radionuclides.

Despite a lack of information about irradiation, 67% of the workers and 55% of the public were willing to buy irradiated food when the process was used to improve microbiological safety. Consumers preferred irradiated to chemically preserved food. The authors concluded that if the benefits and safety of food irradiation were explained, the public would accept the process. Women and people with less formal education were more concerned about irradiation. Men and those with more education had a more positive attitude towards the process.

From 1994 to June 1996, several irradiated products were market tested and found acceptable to consumers (Cho, 1996). The volumes are shown in Table VII.

Malaysia

Through personal interviews in selected regions of Malaysia, 1029 consumers reflecting the ethnic diversity of the population were queried as to their knowledge of food irradiation and interest in purchasing irradiated food (Othman et al., 1990). Nearly two-thirds of the consumers were not aware of food irradiation and less than 2% were knowledgeable about the process. Of those aware of irradiation, 80% obtained information from television and publications, and 20% from the radio, seminars or exhibitions. Those with higher formal education and those living near a nuclear energy facility were more aware of food irradiation. Irradiation was considered somewhat dangerous by 52% of the consumers and safe by 10%, with 38% expressing no opinion.

Initially the thought of eating irradiated food led 65% to express concerns about their health, with 15% willing to eat irradiated food. After hearing that irradiation was endorsed for safety by the Ministry of Health, 54% indicated they would eat irradiated food, 36% had doubts, and 10% were still afraid.





Netherlands

In the early 1980s a small group of Dutch women were found to be very concerned about irradiation. However, when informed about the process, the women viewed its potential benefits favourably (Defesche, 1983).

A questionnaire distributed to a panel of 1158 found the percentage concerned about becoming ill due to improperly processed foods and those concerned about the use of irradiation were comparable, with slightly fewer concerned about the safety of pesticides and preservatives (Cramwinckel and van Mazijk-Bokslag, 1989). Twenty-six per cent were very concerned about irradiation and 24% were somewhat concerned. Women were more concerned about these issues than men. Concern about irradiation was significantly correlated with concern about use of food additives and preservatives. Consumers who were not concerned had more faith in experts' arguments in support of irradiation. Both concerned and less concerned consumers were most receptive to information that supported their point of view. However, very concerned people were responsive to arguments that irradiated food is more hygienic. More extensive information about irradiation did not appear to lessen concern about the process; rather it increased sensitivity to the potential hazards of other food handling methods.

All the consumers were given mushrooms, which they were told were irradiated. Actually, half of the consumers received irradiated and half non-irradiated mushrooms. The mushrooms that were actually irradiated were judged significantly better, by both the very concerned and the not concerned consumers.

Since the very concerned group was more sensitive to arguments that food becomes safer through irradiation, the authors concluded that concern may be more related to technical issues, such as the fate of radioac-

tive waste, rather than to the food itself.

An early 1990s study of consumer attitudes found 25% interpreted irradiation as excellent and positive while a further 14% described irradiation positively (Ogilvie Market Research, 1992). One-third would probably or definitely buy labelled irradiated products, one-third definitely would not buy irradiated products, and the other third were undecided.

Labelled irradiated spices, deep-frozen brown shrimp, and other products are regularly on the market (Ehlerman, 1997).

Pakistan

From 1984 to 1990, irradiated potatoes, onions, and dried fruits were marketed at different times in various shops in Peshawar. Consumers found them more acceptable than the non-irradiated counterparts. One tonne each of irradiated potatoes and onions were test marketed at a provincial fruit and vegetable show in January and February 1991 (Khan, 1992). Only 15% of the 300 consumers who completed a survey form were aware of food irradiation and fewer still, 11%, knew that irradiation of potatoes, onions, and spices was permitted in Pakistan. A high proportion, 70%, had doubts about the safety of irradiated foods; however, after seeing the display at the fruit and vegetable show, 69% indicated that their doubts were removed, 11% still had concerns, and 20% were uncertain. Thirty-nine per cent said they were willing to buy irradiated food and to convince others to buy it, and 57% thought food irradiation should be commercialized.

Philippines

Onions were irradiated, stored and marketed in a pilot test in 1985. Consumer attitudes were not surveyed; however, the investigators observed customers and tracked sales volume (Lustre et al., 1985). Twenty vendors co-operated in the sale of





irradiated onions. The vendors expressed interest in the process and commented on the quality of the onions. The term 'irradiated' did not generate fear.

Reaction to irradiated onions differed in the market place. Most consumers picked up a bag, examined it briefly, and then purchased the irradiated onions. Some consumers asked questions as to product safety, approval by governmental testing agencies, and product characteristics. Most of these customers purchased the irradiated products. A minority of customers, three in three years, refused to buy the product, saying it might cause cancer.

Sales of irradiated onions were high. Sales of the irradiated Red Creole variety by various retailers were between 29% and 54% higher than the non-irradiated varieties. Consumers responded more strongly to the highly perishable Yellow Granex variety, with sales of irradiated exceeding non-irradiated by 50% to 71%. The irradiated bulbs had no sprouts, were slower to decay, and were firmer.

It is a common practice to mark down the price of sprouted onions to increase sales, and then eventually to dump those that do not sell. The majority of irradiated Red Creole onions, 77%-88%, according to vendor, were sold at regular prices compared with 31%-46% of non-irradiated. Similarly, 71%-95% of the irradiated Yellow Granex variety were sold at regular price, compared with 21%-56% of the non-irradiated.

The investigators concluded that a comparison of the quantity of good quality onion bulbs indicates that irradiation will reduce losses at the grower, shipper, and retailer level. The Yellow Granex variety that was irradiated enabled the grower to reduce losses by 32%, the shipper by 47%, and retailers by 54%.

Market tests with irradiated onions continue (Aleta, 1996). In 1994 1 t of Yellow

Granex and 4 t of Red Creole onions were irradiated, stored for 5 and 7 months respectively, and test marketed. In 1995, 3 t each of Yellow Granex and Red Creole onions were test marketed.

Poland

Irradiated onions and potatoes sold well in market tests in two cities (Fiszer, 1988). Four tonnes of onions and 3 t of potatoes were stored in uncontrolled conditions for 9 months previous to the sale. Ninety-seven per cent of the consumers responding to a survey evaluated the products positively, and said they would like to buy them again.

South Africa

An extensive marketing and educational programme was conducted in South Africa prior to the introduction of irradiated foods (van der Linde and Brodrick, 1985). In 1978 and 1979 twenty supermarkets sold labelled irradiated potatoes, 113 t, mangoes, 20 t, papayas, 20 t, and strawberries, 7 t. The irradiated products were judged acceptable by 90% of buyers.

Researchers are experimenting with novel convenience foods processed through food irradiation (den Drijver et al., 1987). Several popular dishes which cannot be satisfactorily prepared by alternative methods, such as canning or retorting, were irradiated. Twelve dishes were tested including grilled chicken, curried chicken, bacon, curried beef, and a Malaysian dish called bobotie. The products were evaluated by a large number of groups, including hikers and sea voyagers, over a 6 year period. Researchers indicate high acceptance.

Approximately 200 members of the Defence Force tested the products and showed an overwhelming preference for the irradiated product over freeze-dried and canned counterparts. Ten groups of eight people viewed a four minute video about irradiation, participated in a discussion





about safety, and sampled the products. Researchers reported that the majority indicated a predisposition to purchase and use the irradiated products.

Many products are irradiated, labelled with the radura emblem and the words 'irradiated' or 'radurised' and made available to the general public (Bruhn and Mason, 1996). The volume of irradiated products increased from 8368 t in 1993 to 8702 t in 1994 and 9258 t in 1995. The greatest volume of products included spices and herbs, honey products, torulite yeast, garlic, egg products, and fresh vegetables.

Between 1987 and 1988, approximately 20 000 portions of shelf-stable meat items were sold to the military (Bruhn, 1996). The quantity increased to 25 000 in 1989 and 1990, then over 400 000 from 1991 to 1993. The quantity decreased to over 200 000 in 1994 and 1995 due to restructuring of the military. In 1989 sales of shelf-stable meat items to non-military customers began, with 2859 portions sold in the first year, increasing to almost 10 000 in 1992, up to 22 355 in 1995, and 25 579 in 1996. Sales increased owing to approval to sell in selected hiking and outdoor shops and a marketing programme which included tasting. A marketing survey among the general population found that initially 15% indicated they were likely to purchase the irradiated food. After receiving visual information, those willing to buy increased to 54%. After receiving information and tasting the food, 76% indicated they would purchase the irradiated shelf-stable product, while 5% said they probably would not buy. Sales continue to increase. The irradiated products are particularly popular among yachtsmen and other outdoor enthusiasts.

Thailand

In 1986 irradiated onions were sold at five shops and one department store during a 3 month period when regular onions

were scarce (Nouchpramool et al., 1992). Records of sales were kept and a consumer questionnaire administered. Economic analysis showed marketing of irradiated onions would be profitable. The following year 160 t of irradiated onions were sold at the rate of 4-10 t per day at fourteen shops during the same time period. Consumers readily purchased these onions, even at a slightly higher price than the non-irradiated ones.

Nham, fermented pork sausage consumed raw in Thailand, is often contaminated by *Salmonella* and occasionally by *Trichinella spiralis* (Prachasitthisak et al., 1989). In 1986, labelled irradiated Nham was sold side by side with the traditional product. A consumer survey (n = 138) showed that 34% of the buyers selected irradiated Nham out of curiosity and 66% considered it safer from harmful microorganisms. Satisfaction was high: 95% of the consumers indicated they would purchase irradiated Nham again. During the 3 month test, irradiated Nham outsold the non-irradiated product by a ratio of ten to one. Although irradiated Nham was originally sold in supermarkets and purchased by those with more formal education, today it is widely available. A walk along the streets of Bangkok in 1995 revealed that the irradiated product was sold by many street merchants.

Between 1993 and 1995, limited market trials were conducted with 2 t of irradiated fragrant rice (Ungsunantwiwat, 1996). The rice was well received, but the volume was not expanded owing to limited manpower. Additionally, 1.2 t of sweet tamarind were irradiated and test marketed. Between 1994 and the first 9 months of the 1996 fiscal year, the quantity of irradiated Nham increased from 64 to 76 to 67 t. During the same period the quantity of spices irradiated increased from 33 to 53 to 101 t. The enzyme bromelain was irradiated in quantities of 90 to 117 to 86 t, and herbs, 10 to 26 to 86 t.





United Kingdom

Consumers in Great Britain appear to be lacking in knowledge about irradiation and few are interested in purchasing irradiated foods. Interviews with 198 shoppers in Manchester and Salford shortly after the Chernobyl nuclear power accident found 12% of consumers were prepared to buy irradiated foods, while 70% said they would not buy them (Ford and Rennie, 1987). People under 25 years and women were most negative about the technology. Concern about health risks, including cancer, was the most prevalent reason for unwillingness to purchase irradiated food. Concern about nutrient value and general lack of information about the process was also expressed. Although educational attainment was related to knowledge about irradiation, there were no clear relationship between more knowledge and greater or lesser willingness to buy irradiated foods.

To explore further the relationship between knowledge and acceptance, consumers were asked about several common food terms. People recognized the names of

many food terms; however, only 63% knew the meaning of the terms. The authors noted that if a term was familiar, the consumer tended to accept it without question and was unconcerned about the process. The authors concluded that an educational programme about irradiation is essential so that people can make an informed choice.

In 1989, a survey conducted for the Association for Consumer Research found half the people interviewed had not heard of food irradiation. Fewer than one in five agreed that food irradiation prevents food poisoning, and over half of the people thought irradiation should not be permitted in the United Kingdom (Survey Research Group, 1990). Consumers wanted irradiated food labelled, and indicated they preferred conventional food preservation methods.

In a summary of research in Great Britain, P. A. Thomas (undated) noted that public knowledge of the process of irradiation changed little from 1986 to 1988. Thomas believed the public must be assured that irradiated foods are safe and that the irradiation process is monitored for safety.

Additional market trials which took place in Bangladesh, Cuba, Germany, Indonesia, and Yugoslavia were summarized in the Food Irradiation Newsletter (Vol. 14, No. 1, 1990) IAEA, Vienna. There is no doubt that consumers would accept irradiated foods if given scientifically based information about the process and when the irradiated product offers clear advantages.





Summary

Marketing studies clearly demonstrate that consumers are receptive towards irradiated food and will select it in preference to a non-irradiated equivalent when they perceive benefits. The public's knowledge of food processing methods in general, and food irradiation in particular, is very limited. Although in the USA, due to government funded educational programmes and occasional media coverage, accurate scientific information about food irradiation is reaching a small number of consumers, most people there are not well informed about the advantages of this technology. In other countries the level of public knowledge is extremely low. When irradiated foods are introduced into an area, public recognition of the process will increase.

Attitude studies in the USA and elsewhere indicate that consumer information should explain the benefits of the process of irradiation, the effect of irradiation on food flavour and wholesomeness, should review

worker and environmental safety, and feature endorsement by recognized health experts. The relative credibility of health experts may differ between countries. In the USA, these are taken to include the American Medical Association, the American Dietitians Association, the Food and Drug Administration, the Department of Agriculture, and the World Health Organization (Gallup Organization et al., 1993). These and other scientific and health organizations have endorsed the safety of irradiated foods.

Increased understanding by consumers and utilization of irradiation by the food industry will increase consumer welfare by enhancing food safety through a reduction of foodborne pathogens, increasing the availability of a wide variety of nutritious, flavourful, high quality fruits and vegetables, and reducing food spoilage. The majority of consumers respond positively to these benefits.



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Table I. Consumer perception of greatest threats to food safety
(Source: Food Marketing Institute [Abt Associates, 1997])
(Spontaneous mentions)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Spoilage /germs	36	29	27	36	46	41	52	49	69
Pesticide residues	16	19	20	18	13	14	15	17	10
Chemicals	11	16	15	13	8	12	11	10	6
Tampering	20	14	8	6	7	4	4	4	1
Preservatives	7	8	7	6	6	7	6	5	<1
Radiation/irradiation	1	1	1	1	0	0	<0.5	<0.5	0
n =	772	1005	1004	1000	1006	1008	1011	1007	1011

Table II. Perception of potential health hazard, 1997
(Source: Food Marketing Institute [Abt Associates, 1997])

	Serious hazard	Somewhat hazardous	Slight hazard	No hazard	Not sure
Contaminated by bacteria	82	13	5	1	1
Residues such as pesticides	66	24	8	2	2
Antibiotics and hormones used in poultry / livestock	43	36	13	4	5
Food handling in supermarket	45	36	15	3	1
Irradiation	33	23	13	8	24
Nitrites in food	28	37	12	5	18
Additives and preservatives	21	50	19	7	2
Food produced by biotechnology	15	31	16	10	28





Table III. Consumer concern about irradiated food
(Source: Food Marketing Institute [Abt Associates, 1997])

(Question: I'm going to read a list of food items that may or may not constitute a health risk. For each one, please tell me if you believe it is a serious health hazard, somewhat of a hazard, a slight hazard, or not a hazard at all.)

	Serious hazard	Somewhat hazardous	Slight hazard	Not a hazard	Not sure
1987	43	29	NA	8	20
1988	36	29	NA	10	24
1989	42	24	NA	10	24
1990	42	29	NA	11	18
1991	42	31	NA	9	18
1992	35	28	NA	10	27
1993	35	28	NA	13	28
1994	38	30	NA	13	20
1995	30	24	NA	12	35
1996	29	26	11	8	27
1997	33	23	13	8	24

NA = Not asked

Table IV. Consumer concern about food processing and storage techniques
(Source: Gallup Organization et al., 1993)

	Not at all concerned %	Extremely concerned %	Mean concerned %
Chemical treatments such as chlorination	4	36	7.4
Irradiation	7	35	7.3
Food preservatives	5	28	7.1
Pasteurization	16	24	5.8
Canning	15	20	5.6
Fermentation	15	18	5.5
Freezing	19	19	5.4

Based on a scale of: 1 = Not at all concerned to 10 = Extremely concerned





Table V. Consumer attitudes and perceptions in the USA

Topic	Result	Reference
Concern	55% Concerned about pesticides in food 43% Concerned about preservatives in food 38% Concerned about food irradiation	Wiese Research Associates, 1984
Key messages to reduce concern	85% There is no irradiation or chemical residue left in the food 80% Irradiated foods are used by those with immunity problems 75% Irradiation is used on medical products 68% Irradiation is FDA approved	Wiese Research Associates, 1984
Likely to buy	28% Would buy irradiated foods for a higher price to delay spoilage 44% Would not buy irradiated foods for a higher price to delay spoilage 28% Do not know if they would buy	Kiddler et al., 1984
Preference	23% Prefer irradiation to chemical preservatives 3% Prefer preservatives 44% Felt they did not know enough to judge	Good Housekeeping Institute, 1985
Concern	75% Think pesticides residues are a serious hazard 4% Think pesticides are not a hazard at all 37% Think irradiation is a serious hazard 13% Think irradiation is not a hazard at all	Louis Harris and Associates, 1986
Concern	After receiving information, most conventional consumers expressed a minor concern and were willing to buy irradiated food. Those strongly opposed to the process maintained that stance.	Bruhn et al., 1986a
Willing to purchase	66-80% Would buy picked ripe / irradiated papaya in the future	Bruhn et al., 1987
Concern	53% Feel totally comfortable or somewhat comfortable in serving irradiated food to their family	Bord and O'Connor, 1989
Likely to buy	75% Would buy chemically disinfected chicken at a price premium 66% Would purchase irradiated chicken at a price premium	Roberts and Ravensway, 1989
Preference	58% Preferred irradiated spices and dried vegetables to fumigated spices and dried vegetables 54% Preferred irradiated tropical fruits to fumigated tropical fruits 43% Preferred irradiated to non-irradiated soft fruit 58% Preferred irradiated to non-irradiated poultry 57% Preferred irradiated to non-irradiated pork	Schutz et al., 1989





Table V . Consumer attitudes and perceptions in the USA (Cont'd)

Topic	Result	Reference
Likely to buy	69% Willing to pay more for a 50% bacteria reduction in irradiated beef	Malone, 1990
	78% Willing to pay more for a 50% bacteria reduction in irradiated chicken	
Satisfaction	80% Stated they were pleased with irradiated straw berries	Terry and Tabor, 1990
	51% Felt irradiated straw berries should be featured in their favourite supermarket	
Concern	81% Consider pesticides to be a serious hazard	The Packer, 1991
	48% Consider irradiation to be a serious hazard	
Concern	53% Would be very/somewhat likely to serve irradiated fresh/frozen poultry to their families to minimize the risk of Salmonella poisoning	Burson-Marsteller, 1992
Willing to purchase	91% Did not have enough information to form an opinion	Carrot Top, 1992
	50% Interested in trying an irradiated food	
	86% Think irradiated foods should be labelled	
Concern	35% Pesticides are an extremely serious problem	Resurreccion et al., 1995
	14% Irradiation is an extremely serious problem	
	08% Pesticides are not a problem	
	20% Irradiated is not a problem	
Preference	47% Prefer irradiated to non-irradiated meat and poultry	Resurreccion et al., 1995
	48% Prefer irradiated to non-irradiated pork	
Likely to buy	45% Would buy labelled irradiated food	Resurreccion et al., 1995
	19% Would not buy irradiated food	
Necessity of irradiation	44% (very) 27% (somewhat) necessary for seafood	Resurreccion et al., 1995
	41% (very) 32% (somewhat) necessary for poultry	
	40% (very) 33% (somewhat) necessary for pork	
	32% (very) 37% (somewhat) necessary for beef	
Concern	53% Expressed concern about irradiation	The Packer, 1993
	22% Were positive about irradiation	
Likely to buy	54% Very or somewhat likely to buy irradiated rather than non-irradiated meat	Gallup Organization et al., 1993
	60% Willing to pay 10 cents more for irradiated ham burger	
	52% Very or somewhat likely to buy irradiated poultry	
	48% Very or somewhat likely to buy irradiated pork	
	45% Very or somewhat likely to buy irradiated seafood	
	50% Very or somewhat likely to buy irradiated beef	



Table V. Consumer attitudes and perceptions in the USA (Cont'd)

Topic	Result	Reference
Likely to buy	71% Purchased irradiated ground beef after educational intervention	Gallup Organization et al., 1993
Concern	Confidence increased when safety endorsed by: 56% American Medical Association 50% U.S. Food and Drug Administration 49% U.S. Department of Agriculture 46% World Health Organization	Gallup Organization et al., 1993
Concern	33% Initially expressed major concern and 8% no concern about irradiation 29% Expressed major concern and 27% no concern in follow-up interview 17% Expressed major concern after viewing Purdue University video tape 35% Expressed minor concern after viewing Purdue University video tape 38% Expressed no concern after viewing Purdue University video tape	Schutz, 1994
Likely to select	21% Likely to select irradiated food in military facility 61% Likely to select irradiated food after viewing video tape 82% Likely to select irradiated field rations after viewing video tape	Schutz, 1994
Likely to buy	54-69% Likely to buy irradiated food 90-99% Likely to buy irradiated food after viewing and trying irradiated strawberries	Pohlman et al., 1994
Likely to buy	15% Very likely to buy irradiated products to keep them fresh longer 43% Somewhat likely to buy irradiated products to keep them fresh longer 23% Very likely to buy irradiated products to kill germs or bacteria 46% Somewhat likely to buy irradiated products to kill germs or bacteria	Abt Associates, 1996
Concern	52% Very concerned about salmonella in poultry 57% Very concerned about the safety of irradiated poultry Authors conclude consumers lack knowledge and have fears about what has been proven to be an effective method of combating a significant public health problem	Barth et al., 1996
Willing to pay	Participants were willing to pay a premium of US \$0.75 for a sandwich made with irradiated chicken	Bailey, 1996





Table V I. Test market results: U S A

Results	Reference
In September 1986 2 tonnes of labelled irradiated mangoes were sold within a week in a market in Florida	Giddings, 1986
Irradiated papaya outsold non-irradiated by more than 10 to 1	Bruhn et al., 1987
Irradiated produce outsold non-irradiated 10 to 1 in initial weeks, 20 to 1 thereafter	Conrigan, 1992
Irradiated apples sold successfully in Missouri	Terry and Tabor, 1990
Irradiated poultry sold in Iowa/Kansas captured: 60% of market share when priced 10% lower 39% when priced equally 30% when priced 10% higher than non-irradiated poultry	Anonymous, 1995
Market share for irradiated poultry increased: 63% when priced 10% less 47% when priced equally 18% and 17% when priced 10% to 20% higher	Fox and Olson, 1998



Table V II. Consumer attitudes towards irradiated food outside the USA

Argentina			
Willing to purchase	91–92%	would definitely purchase irradiated foods	Urioste et al., 1990
Preference	Primary reason for purchasing irradiated onions and garlic was product quality		Curzio et al., 1986
Preference	Primary reason for purchasing irradiated onions and garlic was product quality		Curzio and Croci, 1990
Australia			
Willing to purchase	10%	Would purchase irradiated foods	Newell et al., 1989
	62%	Would not purchase irradiated foods	
	28%	Were unsure if they would purchase irradiated foods	
Concern	69%	Of those who would not purchase irradiated foods said reason was health concerns	Newell et al., 1989
	61%	Of those who would not purchase irradiated foods said reason was insufficient knowledge about the irradiation process	
Bangladesh			
Preference	87%	Prefer irradiated onion (1984 study)	Matin and Bhuiya, 1990
	85%	Prefer irradiated dried fish (1985 study)	
	87%	Prefer irradiated dried fish (1986 study)	
	65–75%	Wish to eat irradiated potatoes more often	
Canada			
Awareness	24%	Consider themselves familiar with irradiation	Dialogue Canada, 1988
	55%	Are aware of irradiation but do not consider themselves familiar with it	
Concern	33%	Among those familiar with irradiation have favourable opinion of food irradiation	Consumers' Association of Canada, 1990 .
	33%	Among those familiar with irradiation have an unfavourable opinion of food irradiation	
	33%	Among those familiar with irradiation have no opinion on food irradiation	
	39%	Of those who have heard of irradiation said they would prefer its use over the use of chemical preservatives	
	14%	Worry a lot about irradiation	
	42%	Worry a lot about pesticides	





Table V II. Consumer attitudes towards irradiated food outside the USA (Cont'd)

Canada (Cont'd)			
Concern	23%	Were completely or most confident that foods treated with irradiation are safe	Grocery Products Manufacturers Council, 1993
	51%	Were somewhat or very doubtful about the safety of irradiated foods	
	38%	Were completely or mostly confident that pesticides in fruits and vegetables are safe	
	52%	Were somewhat or very doubtful about the safety of pesticides in fruits and vegetables	
China			
Awareness	67%	Have heard of irradiated foods	Chen Qixun et al., 1991
	72%	Were willing to buy them	
Concern	36%	Had misgivings about irradiated food before receiving information.	Xu Zhicheng, 1995
	49%	Had no misgivings about irradiated foods before receiving information	
	83%	Indicated that their doubts were removed after having seen information about irradiated	
	10%	Indicated that their doubts were not removed after having seen information on food irradiation	
Willing to purchase	93%	Would buy irradiated apples for tasting	Xu Zhicheng, 1995
	93%	Believed that irradiated foods should continue development and use	
	95%	Would like additional items of irradiated food	
Indonesia			
Awareness	24%	Of lecturers at state universities were not aware of irradiation	Maha, 1995
	69%	Did not know that irradiation for commercial purposes was approved in Indonesia	
Willing to purchase	14%	Were not interested in buying irradiated food	Maha, 1995
	70%	Judged irradiated food to be equal to non-irradiated food	
	20%	Judged irradiated food to be superior to non-irradiated food	
Korea, Republic of			
Willing to purchase	55%	Were willing to buy irradiated food when irradiation was used to increase microbiological safety	Cho et al., undated



Table V II. Consumer attitudes towards irradiated food outside the USA (Cont'd)

Korea, Republic of (Cont'd)			
Willing to purchase	37%	Would buy irradiated foods	Kwon et al., 1992
	51%	Needed more information before deciding to buy irradiated foods	
	35%	Would prefer irradiation over chemical treatments	
Malaysia			
Awareness	63%	Unaware of irradiated food	Othman et al., 1990
	10%	Thought irradiation was not dangerous	Othman et al., 1990
	34%	Thought irradiation was dangerous	
	18%	Thought irradiation was very dangerous	
Willing to consume	48%	Worried about health	Othman et al., 1990
	16%	Very worried about health	
	After safety assurance by government:		
	54%	Would eat irradiated food	
	36%	Still had doubts	
	10%	Were afraid to eat irradiated food	
Mexico			
Willing to purchase	62%	After receiving information, said they would eat irradiated food	Bustos, 1991
	17%	After receiving information, said they would not eat irradiated food	
	20%	After receiving information, were still unsure	
Netherlands			
Concern	6%	Have negative associations (scary, danger, cancer) evoked in response to the term food irradiation	Feenstra et al., 1988
	41%	Have correct associations with food irradiation (preservation, radiation)	
	56%	Are against irradiation	
	34%	Are neutral to irradiation	
Concern	7%	Were very concerned about the use of pesticides	Cramwinckel et al., 1989
	23%	Were very concerned about the possibility of becoming ill due to improperly processed food	
	26%	Are very concerned about the use of irradiation to extend the shelf-life of foods	





Table V II. Consumer attitudes towards irradiated food outside the USA (Cont'd)

Netherlands (Cont'd)			
Concern	25%	Interpreted irradiation to be excellent/good/positive	Ogilvie Market Research, 1992
	14%	Interpreted irradiation with additional varied positive comments	
	29%	Interpreted irradiation with varied negative comments	
Willing to purchase	33%	Would probably or definitely not buy a labelled irradiated product	Ogilvie Market Research, 1992
	32%	Would probably or definitely buy a labelled irradiated product	
Pakistan			
Concern	70%	Initially had doubts about the safety of irradiated food	Khan, 1992
	69%	After seeing display, no longer had doubts about safety	
Poland			
Willing to purchase	97%	Of those buying irradiated onions and potatoes would like to buy them again	Fischer, 1988
Willing to purchase	90%	Estimated willing to purchase irradiated potatoes, based on market tests between 1987-1990	Fischer et al., (undated)
Thailand			
Willing to purchase	96%	Were willing to pay 1 Baht more for irradiated Nham	Prachasitthisak et al., 1989
Concern	66%	Of those who bought irradiated Nham, bought it because they believed it was safe for consumption, including no risk of pathogens	Prachasitthisak et al., 1989
South Africa			
Willing to purchase	15%	Initially likely to purchase shelf-stable irradiated entrees	Bruyn, 1996
	54%	Likely to buy after exposed to visual information	
	29%	Not likely to buy after exposed to visual information	
	76%	Likely to buy after information and tasting irradiated food	
	5%	Not likely to buy after information and tasting irradiated food	



Table V III. Irradiated items produced for commercial purposes (As of July 1997)

Country	Products
Argentina	Cocoa powder, spices, spinach,
Bangladesh	Dried fish, onions, potatoes, pulses
Belgium	Dehydrated vegetables, frozen food, spices
Brazil	Fruits, grain, spices, vegetables
Canada	Spices
Chile	Dehydrated vegetables, onions, potatoes, spices
China	Apple, bean sauce, dried litchi, dry beef slice, flavour sauce, food, garlic, ginger spice, hot pepper, onion, pear, potato, rice, sausage, sliced beef, spice, spirits from sweet potato, Szechwan salted vegetables, Szechwan sausage, tomato, Zhangchan duck
Croatia	Dried beef noodles, food ingredients, spices
Cuba	Beans, onions, potatoes
Czech Republic	Dry food ingredients, spices
Denmark	Spices
Finland	Spices
France	Dried fruit, frog legs, frozen shrimp, poultry (frozen deboned chicken), spices, vegetable seasonings
Germany	Spices
Hungary	Enzyme, onions, spices
Indonesia	Rice, spices
Iran	Dried fruits, nuts, spices
Israel	Spices, condiments, dry ingredients
Italy	Spices
Japan	Potatoes
Korea, Republic of	Alcohol products, dried condiment, dried fish, dried meat, dried mushroom, dried vegetables, ginseng products, shellfish powder, soy sauce powder, soybean paste powder, starch, yeast, and enzyme products
Mexico	Dry food ingredients, spices
Netherlands	Dehydrated vegetables, egg powder, frozen products, packaging material, poultry, shrimp, spices
Norway	Spices
South Africa	Baby food, beef stock, biltong and dried sausage, cereal, dehydrated vegetables, dried casein, egg products, fish, fresh vegetables, garlic, honey products, jelly, mango, marinade, nuts, papaya, peanut butter, potato, processed food, shelf stable food, shelf-stable meat products, snack food, soup, soy mixtures, straw berries, tea, torulite yeast, fruits, shelf-stable food
Thailand	Enzymes, fermented pork sausages, onions, spices
United Kingdom	Spices
United States of America	Fruits, poultry, spices, tropical fruits, vegetables
Yugoslavia	Spices





Table IX .Sales in tonnes of test marketed irradiated products in the Republic of Korea 1994–1996

Product	1994	1995	1996
Dried mushrooms	110	98	–
Dried condiments	1679	1736	550
Dried meat	62	37	20
Dried fish and shellfish powder	305	285	140
Soybean paste powder	105	75	20
Soy sauce powder	100	92	40
Starch	107	81	20
Dried vegetables	–	780	580
Yeast and enzyme products	–	7	11
Algae products	–	10	8
Ginseng products	31	23	9

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