Editorial

Food Irradiation: A Public Health Opportunity

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Public health scientists have had an interest in food irradiation for a hundred years and more. The first investigations occurred within a few years of the discovery of x-ray and short wavelength by the German physicist Roentgen, in 1895. German and French scientists carried on studies on pasteurization of food by radiation until 1914 and the war years. The problem was an unacceptable taste following irradiation. In 1921, the x-ray was reported by the scientists of the United States Department of Agriculture (USDA) to be effective in killing *Trichinella* cysts in pork and that it could kill disease-causing organisms and halt food spoilage.

A recent review states that food irradiation was the first entirely new method to preserve food since thermal canning and pasteurization of fluids, such as wine, beer, and milk in the nineteenth century.[1] These methods of food preservation were all considered to be processes, but in 1958 the Food and Drug Cosmetic Act designated food irradiation as an additive, under pressure from protesters. Scientific research has never found evidence to call radiation an additive that remained in food.

In the early 1900s, American scientists at the Massachusetts Institute of Technology initiated studies on the effect of radium rays on bacteria.[2] Many studies were undertaken over the first half of the twentieth century to determine how ionizing radiation could be used to provide more and safer foods to humanity on a worldwide basis. However, the paucity of suitable radiation sources, and their high cost, prevented the full benefits from their uses in food and biomedical research from being ascertained.

Since 1950, the beneficial effects of ionizing radiation have been observed, in addition to its potential to reduce the incidence of foodborne diseases. Among the beneficial effects are (1) inhibition of post-harvest sprouting in tubers (potatoes) and bulbs (onions); (2) disinfestation of fruits, vegetables, and grain of insects; (3) delay of ripening in fruits; (4) elimination of pathogens using substerilization doses (pasteurization) in meat, seafood, fruits, poultry and eggs, fruit juices, and vegetables; (5) elimination of pests, such as the screw-worm fly, which preys on cattle, the Mediterranean fruit fly, and the tsetse fly, by the release of sterile insects; and (6) with sterilization doses, production of an array of prepackaged meats, poultry, and seafood that can keep for years without refrigeration.[3]

Worries about nuclear weapons began to cross over into food irradiation research after the war. The nuclear age did make available large enough quantities of radiation-source material; however, this gain was not sufficient to make food irradiation a more acceptable option, owing to public fears of anything remotely suggesting nuclear exposure.

Josephson stated earlier[4]:

> The midwife attending the birth of food irradiation was the development of nuclear fission and its military use at Hiroshima and Nagasaki. This stigma has attached itself to food irradiation's origins and has dogged its progress in the United States and abroad ever since. It is likely that if food irradiation had been spawned as an outgrowth of medical application of nuclear energy, the public today would be enjoying the benefits of this new method for preserving food.

The industrial use of radiation processing is certainly not new. Electron-beam irradiation began to come into prominence in the 1950s. Currently, an estimated 700 or more units routinely crosslink wire and cable (including the wires in the telephone) or modify plastics and other materials to enhance their physical strength. Radiation processing with cobalt-60 (^{60}Co) gamma had its American beginnings in the mid-1960s, when the Ethicon division of Johnson & Johnson installed the first unit to sterilize sutures. Because of its properties (a "cold" process, no chemical residuals, deep penetrability, and unmatched reliability to sterilize), many manufacturers of single-use disposables began to convert their products to this mode

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of sterilization. Currently, there are about 170 cobalt-60 industrial irradiators in operation worldwide, including about 65 in North America. Approximately 50% of all medical disposables are radiation sterilized, together with a wide array of consumer products, including cosmetic raw materials, food packaging, bandages, spices, and baby bottle nipples.

The operation of irradiators and the shipment of radioisotopes is licensed and governed by the Nuclear Regulatory Commission and Department of Transportation. Stringent regulations have been key factors in making this industry safe, efficient, and practical. These same high standards of performance will be applied to foods to help ensure safer products.

Employees in the industries using radiation number in the thousands, with millions of work-hours logged. There have been no accidents of note in the operations, nor have there been any accidents in moving cobalt 60 since the 1960s when cobalt 60 rods were being delivered around the United States, Canada, Latin America, and overseas. This is a great safety record.

The introduction of gamma irradiation for treating food, combined with the horrors of nuclear weapons, convinced the lawmakers to control the development of nuclear technology for treating foods. In 1958 when the Food, Drug, and Cosmetic Act was passed by the American Congress, there were many unanswered questions: Would foods be made radioactive, and what would be the effect of this additional radioactivity above that of background radiation upon humans? Would there be new toxic products formed in the irradiated foods? Would carcinogens be formed? Would there be excessive loss of nutrients? Would molecular fragments from packaging materials migrate onto the foods in amounts derogatory to the health of consumers? In the killing of pathogens, would new microbiologic problems evolve? What radiation doses would be safe to use? What effect would radiation have on taste, odor, color, and texture of the food? Also, what adverse effect, if any, would result to the environment should there be accidents? What sources of radiation (gamma and machine) and what doses would be suitable for irradiation?

The American Congress, with successful lobbying by well-known public figures in the movie and entertainment circles, convinced Congress to keep food irradiation under tight control. To do this, a legal fiction was created that ionizing radiation used to treat food is a food additive. The 1958 law assured the public that no irradiated food could be approved for consumption without a lengthy drawn-out procedure, thereby singling out and stigmatizing foods so treated for a long period needed for research, petition writing to the Food and Drug Administration (FDA) and the USDA, and months or years for evaluation.[5]

After 1962, when Josephson was placed in charge of the food irradiation research and development program of the Department of Defense (DOD), the top priority was to try to sort out the diverse claims, pro and con, about irradiated foods. During his tenure as head of the program, the United States Army Medical Services completed studies for testing in rats, mice, and beagle dogs, using 21 foods representing all major food classes in the diets of Americans. In a June 1965 hearing by the Joint Committee on Atomic Energy, the Surgeon General submitted a statement that all foods irradiated at sterilizing doses up to 5.6 Mrad (56 kGy) using ^{60}Co, or electrons at energies below 10 MeV, were wholesome; that is, safe to eat and nutritionally adequate.[6] Irradiated foods are eaten worldwide: spices, dried fruits and nuts, as well as fresh fruit and meat, including chicken, pork, and beef. Seafood and frog legs are irradiated to ensure freshness.

Nutritional assessments showed that the irradiation process was no more destructive to nutrients than other commercially used processes. There were no more toxic products formed than might normally be found in a single charbroiled hamburger. Thus, irradiation poses no untoward effect on the health and well-being of consumers.

The microbiologic standard for irradiation-sterilized foods was to use a radiation dose sufficient to reduce a theoretic population of spores of *Clostridium botulinum* by 12 logarithms. This standard, recommended by the National Academy of Sciences-National Research Council Advisory Committee to the army's program on food irradiation, was adopted. Despite thorough testing in the ensuing years, there was no evidence of any selective "resistance" to irradiation demonstrated with *C. botulinum.*

Thousands of irradiated components of meals have been served to volunteers. In every respect the irradiated foods have come through with flying colors. Irradiated foods have been eaten by astronauts on the moon flight, in many space missions, and by military personnel in several parts of the world.

Every conceivable possibility for harm has been carefully considered. None has been found, nor have any chemicals formed that are unique to food irradiation. In the meantime, irradiated foods have been approved by the health authorities in 40 countries.

Between 1964 and 1997 the World Health Organization (WHO), in concert with the Food and Agricultural Organization (FAO) and the International Atomic Energy Agency (IAEA), held a series of meetings of experts from many countries to assess the quality and safety of irradiated foods.[7-11] The latest meeting, in September 1997, recommended approval of irradiated foods, without restrictions, for all doses up to the highest dose compatible with organoleptic properties. At each meeting, the internationally recognized health authorities have concluded that all foods irradiated at doses as high as would maintain acceptable taste are safe to eat without the need for further toxicologic testing.

In view of the foregoing, food scientists believe that the FDA and the USDA should follow the WHO/FAO/IAEA

recommendation that food irradiation is a process and should not be regarded as an additive.

Scientists have felt for three decades that the legal fiction designating ionizing radiation as a food additive, instead of a food process, unjustly penalized food irradiation and helped delay its application almost 30 years. On the other hand, it stimulated those working in the field to perform at the highest level of good science, thus convincing the scientific community worldwide that food irradiation has an important role in combatting hunger and disease. Overall, the objective of demonstrating that food irradiation is a safe and beneficial process has essentially been achieved. Now it is necessary to "educate" government officials as well as health workers, food processors, marketers, and the public regarding the safety and advantages of food irradiation.

Among an estimated 76,000,000 cases of foodborne infection each year in the United States, there are approximately 6000 deaths. The time has come to use food irradiation more widely for the benefit of mankind. In the application of ionizing radiation to protect the public health against foodborne pathogenic bacteria, public health officers face the same arguments that were voiced against pasteurization at the beginning of the century, and in opposition to canned or frozen food later. In the history of pasteurization, the authors cite many disbeliefs of pasteurization under headings of sanitation, nutrition, physical and bacteriologic quality, public health and safety, and economics. Conditions such as loss of hair, skin tone, and sexual potency, as well as general well-being, were blamed on pasteurization. Interestingly, all of these mistaken beliefs are cited against the irradiation of food.

Food irradiation is recognized as another method of preserving food and ensuring its wholesomeness by sterilization or cold pasteurization and has wide application worldwide. If it had been in place in the United States, recent foodborne disease outbreaks caused by *Escherichia coli* 0157:H7, which are found in food-producing animals, would not have occurred. If one attempts to tabulate the tens of thousands of *Salmonella*, *Campylobacter*, *Yersinia*, *Listeria*, and *E. coli* foodborne disease outbreaks related to poultry and meat, the totals exceed millions of human illnesses. Over 40 years ago, the Delaney Act institutionalized the mistaken belief that gamma rays are an additive to food. Fortunately Congress did not redefine the electromagnetic spectrum that encompasses all kinds of rays and waves.

How many thousands of deaths and illnesses could have been prevented if public health authorities had implemented food irradiation and educated the public as to its benefits will never be known.

The morbidity and medical expense of meat- and poultry-borne diseases can be prevented, just as milk-borne disease has been prevented by pasteurization. All of the bacteria previously cited can be present in unpasteurized or raw milk even though USPHS Grade A standards require that milk be free of disease-causing organisms. Imagine the public outcry if governments allowed the marketing of unpasteurized milk in which *Salmonella* were found, or if *E. coli* virulent strains went unchecked, or if *Listeria* were present in soft cheese or *Campylobacter* was found in school meals.[12]

Since 1984 when the Secretary of Health, Margaret Heckler, endorsed food irradiation after lengthy studies had proven its safety, and if public health officers had spoken out for the irradiation of foods that are known to carry pathogenic bacteria, events like the *E. coli* 0157:H7 outbreaks from undercooked hamburger (3 deaths and more than 400 cases) that occurred in the northwest United States in January 1993 could have been prevented. Even as this article is being written, no national, state, or local health authority is speaking out to require pasteurization by irradiation of hamburger meat patties, of which some tens of millions are consumed daily. The public health authorities of Florida, Minnesota, and Texas recently have endorsed the use of radiation for the pasteurization of meat and poultry and other foods. But the States cannot pass legislation until the Federal regulations are approved and published (Dec. 23, 1999; effective Feb. 2000). The same attitude and apathy exists in Europe, where *Listeria*-contaminated pork meat and other food caused the death of 63 persons in France, as reported in 1993. Since then, *Listeria* has become a serious public health problem in America.

In the early 1990s, Steele and Engel stated[13]:

> The advancement of food preservation hygiene since the time of early civilizations has been marked by the increased longevity of man. In the 20th century, human mortality has had a constant decrease. The extension of human life and well being is attributable to good public health practices, immunization of all children and adults, chlorination of potable water, sewage disposal of human and industrial waste, and food hygiene, including pasteurization. All have contributed to improved life and longer survival of human beings. The irradiation of food will further improve human health by the prevention of foodborne disease (i.e., *Salmonella*, *Campylobacter*, *Listeria*, *Yersinia* and various *Escherichia coli* infections). The constant decline of gastric cancer in the United States parallels the introduction of pasteurization, refrigeration, and processing of food, all of which contributed to better hygiene.

One hesitates to ask who is in charge of the protection of the public health in these United States or that of our neighbors in the Americas or Europe. The anti-activists can always be relied on to oppose new technologies, and among them are powerful interests. These may be public health activists, environmentalists, protesters, food processors, wholesalers, retailers, and

producers. All, for many reasons, are saying the consumer is not ready, does not want it, or is against it.

To belie the consumer indifference or fear, one can cite the USDA survey of consumer attitude research and actual market tests by Susan Conley, which says 70% of the American public wants safe food and will accept food irradiation to ensure it being so. The University of California survey by Christine Bruhn found Californians of the same mind. A University of Georgia survey went further and found the consumer willing to pay more for irradiated food that would offer the same protection as pasteurized food. The consumer said the same in surveys by the Food Science Departments at Purdue, Iowa State, and Kansas State Universities. More recently, several national consumer surveys have found the public seeking an opportunity to test irradiated foods. Why have public health scientists not given the consumer the benefits of food irradiation?

A hundred years ago Massachusetts Institute of Technology (MIT) scientists reported on the irradiation of disease-causing bacteria.[2] In 1921 Schwartz of the USDA found that ionizing radiation would kill *Trichina* cysts in pork. In 1953, the late S.E. Gould of the University of Miami and Wayne State University reported, at a conference organized by the American Medical Association, that the control of trichinosis by radiation was feasible.[14-16] In 1958, food sterilized by irradiation was approved for use by human volunteers in studies approved by the Surgeon General of the army.[5] That same year, 1958, food irradiation was downplayed by the United States Congress, which defined it as a dangerous food additive, which was contrary to scientific findings worldwide. In 1965, the Surgeon General of the army with MIT scientists and food scientists of many universities proclaimed food irradiation a practical and safe process.[6] Subsequent studies verified the safety and effectiveness of food irradiation. In 1984, Margaret Heckler, the Secretary of Health and Health Services, told the national food processors that all the research supported the use of food irradiation and would ensure safer and better food for the American public.[13]

Where were the national public health leaders who spoke for irradiation? The American Medical Association was among the few early supporters, as was the American Council on Science and Health, Council for Agricultural Science and Technology, and the American Veterinary Medical Association, but the American Public Health Association was outspoken against food irradiation. They opposed any discussion of resolutions supporting irradiation.

The only academic support came from universities and colleges with food science and home economics departments. Strangely some public health schools and medical colleges were afraid to support food radiation, or spoke against it, calling it dangerous and destructive. So-called health letters warned their readers against food processors who would cover-up failed hygiene.

The history of pasteurization of milk, the frozen food industry, and earlier, the canning of food were likewise attacked as dangerous and likely to lead to moral decay of society.

Public health workers and policy makers have been lax in not encouraging the use of food irradiation. Among the first public health leaders to speak out on the importance and value of food irradiation was James Mason, MD, the Assistant Secretary of Health, HHS, in an editorial in Public Health Reports.[17] The conclusion read: "The bottom line on food irradiation is that the nation deserves to have — and should claim — the health benefit this technology will surely provide. We don't know how great that benefit will be — but we do know it will be significant."

Two years later, Philip R. Lee, MD, the Assistant Secretary of Health, Director of the United States Public Health Service stated[18]: "It is the U.S. Public Health Service's responsibility to use what we know to protect and improve the health of the public. Each modern food-processing advance — pasteurization, canning, freezing — produced criticism. Food irradiation is no different. It is up to leaders in the health professions to dispel the myths.

The technology of food irradiation has languished too long already. Perhaps our nation has become dangerously complacent about the importance of public health measures. The current health care debate offers both a mandate and an opportunity to increase the understanding of the importance of public health for ensuring personal health. If this message is lost, efforts to advance and protect the nation's health will not succeed."

While the United States endeavored to implement food irradiation, WHO, under the leadership of Dr. F.K. Kaferstein, former Director of the WHO Programme of Food Safety and Food Aid, has supported and promoted irradiation worldwide. As a matter of fact, the WHO has been involved in the assessment of the wholesomeness of irradiated food since the 1960s. In 1980, an Expert Committee concluded that irradiation of any food up to an overall average level of 10 kGy presents no toxicologic hazard and is of no concern regarding microbiologic safety or nutritional adequacy. The 1994 WHO report, "Safety and Nutritional Adequacy of Irradiated Food,"[19] was described by the *Journal of the American Dietetic Association* as the best peer review of the world literature with regard to clarity, conciseness, and information.

Finally, in 1997, the WHO, jointly with FAO and IAEA, convened yet another meeting of experts, a Study Group on High-Dose Irradiation.[20] This group concluded that food irradiated to any dose appropriate to achieve the intended technologic objective is both safe to consume and nutritionally adequate. Recognizing that in practice the dose applied to eliminate the biologic hazard would be below those doses that would compromise sensory

quality, the study group concluded that no upper dose limit needed to be imposed. Accordingly, irradiated foods are deemed wholesome throughout the technologically useful dose range from below 10 kGy to envisioned doses above 10 kGy.

The International Atomic Energy Agency in cooperation with the FAO has supported research and demonstration of food irradiation projects worldwide. In their most recent study, done jointly with the Pan American Health Organization, the studies of irradiating shellfish and other foods were most successful.[21] The survival of oysters after irradiation ensures their wholesomeness. The International Atomic Energy Agency has had a long history of the preservation of food with irradiation in the developing world, as demonstrated by projects in Asia. The Pan American Health Organization has been promoting food irradiation in the Americas from Mexico to Chile for many years.

The use of food irradiation will ensure greater health for man worldwide—fulfilling the objective "Health for All in 2000."

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