ALABAMA COOPERATIVE Extension SYSTEM

HE-727

Food Irradiation

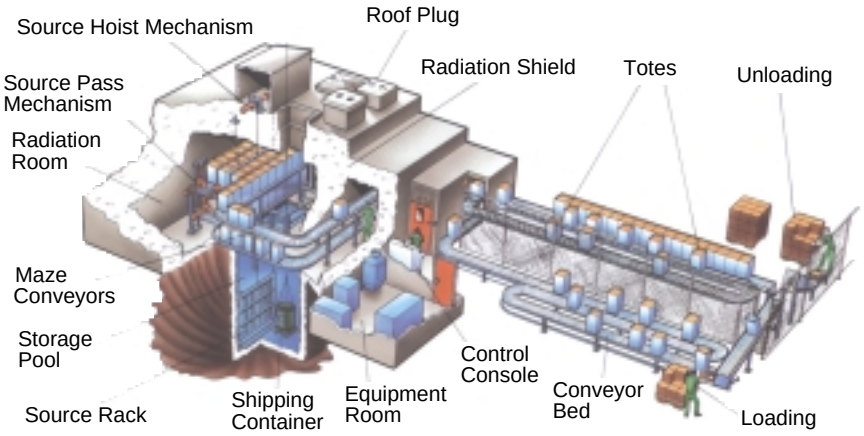
What Is Food Irradiation

Food irradiation preserves meat, produce, and seasonings with high-energy gamma rays to improve product safety and shelf life. Spices, seasonings, potatoes, fresh fruits and vegetables, and meats and poultry may be irradiated. This method of preservation prevents growth of food poisoning bacteria, destroys parasites, and delays ripening of fruits and vegetables. Food irradiation could be used to reduce or replace chemical preservatives used in foods. More than 40 years of research on food irradiation has established that foods exposed to low-levels of irradiation are safe and wholesome, and they retain high quality.

Principles Of Food Irradiation

Foods such as poultry are processed, packaged with oxygen-permeable film, and transported fresh or frozen to an irradiation facility. Currently the only commercial poultry irradiation facility approved by the U.S. Department of Agriculture (USDA) is Food Technology Services, Inc., in Mulberry, Florida. At the irradiation facility, the palletized product is transferred by conveyor to an irradiation chamber. Here the food is exposed to gamma rays from a radioactive source such as cobalt^{60} (main source for gamma processing of foods) or cesium^{137} at a controlled rate. The gamma rays evenly penetrate the food product, killing harmful microorganisms, parasites, or insects without altering the nature of the food. These rays do not remain in the food.

Gamma rays are more powerful than the rays emitted by a microwave oven. Rays from a microwave oven



Typical food irradiation facility (courtesy Nordian International, Ontario, Canada).

cause food to heat rapidly, whereas gamma rays, with much shorter wavelengths and higher frequencies, penetrate through the food so rapidly that no heat is produced. After food is irradiated, it is stored and may be transported back to the processing plant for further handling and packaging. Once the food has been irradiated, it must be handled appropriately to prevent recontamination.

The irradiation cell (source) consists of cobalt^{60} or cesium^{137} rods in stainless steel tubes. These tubes are stored in water and raised into a concrete irradiation chamber to dose the food. Over a period of years the cobalt^{60} or cesium^{137} rods slowly decay to non-radioactive nickel and non-radioactive barium, respectively. No radioactive waste is produced at a food irradiation facility, and no irradiation facility could have a meltdown that could jeopardize the safety and health of plant workers and other citizens of a community. Food irradiation facilities do not have nuclear reactors. The food is exposed only to the degrading of the cobalt^{60} or the cesium^{137}.

Foods may be irradiated with electron beams produced from **accelerators.** This method of irradiation can only be used on foods less than 4 inches thick because of the limited penetrating capacity of the electron beams. This method would be very effective on food such as hamburger patties.

The irradiation dose applied to a food product is measured in terms of kilograys (kGy) (Table 1). One kilogray is equivalent to 1,000 grays (Gy), 0.1 megarad (Mrad), or 100,000 rads. The basic unit is the gray, which is the amount of irradiation energy that 1 kilogram of food receives. The amount of irradiation applied to a food product is carefully controlled and monitored by plant quality control personnel and USDA inspectors. The irradiation dose applied to a food product will depend upon the composition of the food, the degree of perishability, and the potential to harbor harmful microorganisms. The amount of radiation that a food product absorbs is measured by a **dosimeter.**

Table 1. Irradiation Conversion Units.

1,000,000 rads = 1 megarad (Mrad)
1 gray (Gy) = 100 rads
1 kilogray (kGy) = 100,000 rads
1 kGy = 100 kilorads (Krads)
1 kGy = 0.1 Mrad
10 kGy = 1 Mrad

Foods Currently Being Irradiated

Internationally, foods such as apples, strawberries, bananas, mangoes, onions, potatoes, spices and seasonings, meat, poultry, fish, frog legs, and grains have been irradiated for many years. In Japan more than 20,000 pounds of potatoes are irradiated each year to prevent sprouting. In the Netherlands more than 18,000 pounds of foods such as strawberries, spices, poultry, dehydrated vegetables, and frozen products are irradiated daily. Belgium irradiates more than 8,000 tons of food per year. Canada has approved the irradiation of potatoes, onions, wheat flour, fish fillets, and spices and seasonings. Today more than 35 countries have approved irradiation of some 40 different food products.

In the United States spices and seasonings have been approved by the Food and Drug Administration (FDA) to be irradiated up to 30 kGy to reduce the number of microorganisms and insects. Irradiation of spices and seasonings reduces the dependency for the chemical fumigant methyl bromide. Fruits such as avocados, mangoes, and papayas imported into the United States have been approved by the FDA to receive irradiation treatments up to 1 kGy maximum to control non-native insects such as the Mediterranean fruit fly or Medfly. Potatoes and onions have been approved to receive 0.05 to 0.15 kGy to inhibit sprouting, while a maximum of 1 kGy can be applied to grains, such as wheat and oats, to prevent insect infestation. Raw pork has been approved to receive irradiation dosages up to 1 kGy to destroy trichinae, a deadly parasite.

In 1990 the FDA approved the irradiation of poultry up to dosages of 3 kGy to eliminate harmful bacteria such as *Salmonella* spp., *Escherichia coli 0157:H7, Campylobacter jejuni,* and *Listeria monocytogenes.* In September 1992, the USDA Food Safety and Inspection Service (FSIS) approved facilities to irradiate raw, packaged poultry. The irradiation and inspection of meat and poultry products is under the jurisdiction of the FSIS. The advantages of food irradiation are improved product safety and shelf life.

Safety Of Irradiated Foods

Irradiated foods have been found to be safe and wholesome, while maintaining color, flavor, aroma, and texture (mouthfeel). More than 40 years of scientific research has shown that irradiated foods do not cause cancer, genetic mutations, or tumors. For example, the U.S. Army and the USDA fed 600,000 pounds of irradiated chicken to several generations of laboratory animals over a 6-year period and found irradiated chicken to be safe and to pose no toxic hazards to laboratory animals. Also, dry milk powder irradiated at 45 kGy (four and a half times greater than the international maximum approved level) has been found to cause no mutations or tumors over nine successive generations of laboratory animals. No adverse effects were observed in 400 Chinese human volunteers fed a balanced diet, 60 to 66 percent of which was irradiated food, over a 15-week period.

Prior to and during the 1960s, the U.S. Army conducted research on high-dose sterilization of meat products and found that these products could be held for many years without refrigeration. After a 10-year safety testing program, including a feeding study with human volunteers consuming 32 to 100 percent of the diet as irradiated food for seven 15-day periods within a year, the army concluded that irradiated foods are safe and wholesome. These results led NASA to irradiate foods for astronauts to consume during space flights. Also, for several years, irradiated foods have been fed to many immuno-suppressed hospital patients who need added protection from possible harmful microorganisms that may be present in untreated foods.

One of the major concerns of irradiated foods is that unknown by-products may be produced in the food during the irradiation process and that the safety of these products is not known.

Yet, according to the International Consultative Group on Food Irradiation (ICGFI), the by-products produced in foods treated with irradiation are naturally present in foods and formed by heat processing. The Joint Expert Committee on Food Irradiation (JECFI) of the World Health Organization (WHO), Food and Agriculture Organization (FAO), and the International Atomic Energy Agency (IAEA) concluded that irradiated foods were safe and wholesome at irradiation levels up to 10 kGy. FDA's Bureau of Foods Irradiated Food Committee (BFIFC) found that more than 90 percent of all these compounds in irradiated foods are similar to those found in foods treated by other preservation methods such as heating, drying, or freezing. The BFIFC concluded that a diet consisting of food irradiated at 1 kGy (the approved level for fruits, vegetables, pork, and grains in the United States) would not contain a significant amount of these compounds. The irradiation process produces very small changes in the chemical composition of foods. These changes have not been found to be harmful or dangerous.

Nutritional Quality Of Irradiated Foods

Food proteins, carbohydrates, and fats have been found to be relatively stable to irradiation up to 10 kGy. Minerals have been reported to be stable to irradiation. However, vitamins A, C, E, and B_1 (thiamine) tend to be susceptible to irradiation at dosages of 1 kGy or above. These vitamins are also sensitive to heat processing. All of the other vitamins tend to be relatively stable to irradiation up to 5 kGy. Thiamine is one of the most radiation-sensitive vitamins. For example, the thiamine content of raw frozen pork chops treated with 1 kGy of gamma irradiation was reduced by 11.3 percent (cooked 17.6 percent),

whereas thiamine losses in raw irradiated frozen chicken breasts at 3 kGy were 7.8 percent (cooked 8.4 percent). However, this reduction in the thiamine content of pork and chicken is minimal and would not create a risk of thiamine deficiency in the diet.

The percent of vitamins lost in a food product will depend upon the irradiation dose, the food's composition, temperature of the food being irradiated, and the presence or absence of oxygen. Vitamins are more susceptible to irradiation in the presence of oxygen and at temperatures above freezing. Generally, the greater the irradiation dose, the greater the loss of vitamins. A joint committee of FAO, WHO, and IAEA claims that the losses of vitamins in foods treated with irradiation doses of 1 kGy or less are minimal and compatible with losses of vitamins in foods heat treated and stored for extended periods of time. Low-dose irradiation does not cause a significant decrease in the nutritional quality of foods.

Effects Of Irradiation On Harmful Bacteria In Poultry And Meat Products

In the United States, six million cases of foodborne disease are reported annually with more than 9,000 of these cases resulting in death. These numbers are likely to increase as more individuals eat away from home and consume more convenience or processed foods. For instance, a recent outbreak of *E. coli* 0157:H7 in the state of Washington resulted in the death of three children. And, hundreds of people who ate the undercooked hamburger meat prepared at a fast-food chain were hospitalized. These casualties may have been averted, if the ground beef had been irradiated or properly cooked. Food irradiation at a dosage level of 3 kGy or less in combination with proper handling, processing, and storage would help eliminate the incidence of foodborne disease caused by *Salmonella* spp., *Staphylococcus aureus, Aermonas hydrophila, L. monocytogenes, C. jejuni,* and *E. coli.* Irradiation dosages up to 3 kGy effectively eliminate more than 99 percent of these harmful bacteria in poultry and fresh meats. Irradiation destroys harmful bacteria and other microorganisms by altering the genetic material needed for growth and reproduction.

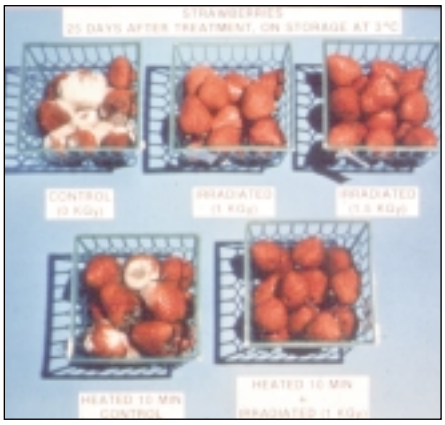
Although low-dose irradiation (3 kGy or less) is effective in destroying most harmful bacteria, it does not prevent the growth or toxin production of *Clostridium botulinum,* the organism that produces the deadly toxin that causes botulism. Much higher irradiation doses, up to 30 to 60 kGy, are needed to destroy this organism in foods. Sodium nitrite, a food additive used in cured meats to prevent botulism, could be reduced as much as 66 percent (120 mg/kg to 40 mg/kg) with an irradiation dose of 7.5 kGy. These products were found to have an excellent shelf life of more than 90 days at 39°F and exhibit good odor, flavor, texture, and color.

The dose of irradiation needed to eliminate microorganisms in food will depend upon the type, amount, and growth stage of the microorganisms present and the properties of the food including moisture, pH, temperature, oxygen present, and nutrient composition.

Irradiation suppresses the microbiological contamination of foods and cannot be used to cover up spoiled foods. Thus irradiation of quality food coupled with good food-handling practices would reduce the incidence of foodborne disease.

The Consumer And Irradiated Foods

Consumer response to irradiated foods has been very good. In March 1987, test markets of irradiated Hawaiian papayas in two Southern California stores outsold the non-irradiated product by more than 10 to 1. During the first quarter of 1993, Carrot Top, Inc., in Northbrook, Illinois, reported irradiated strawberries outsold non-irradiated berries by a ratio of 20 to 1 when consumers were provided information on food irradiation. This store is now selling irradiated strawberries, Vidalia onions, and chicken to its consumers. In July 1993, Laurenzo's Market and Italian Grocery in Miami, Florida, reported selling their first shipment of irradiated poultry (approximately 1,200 pounds) at a rate of 100 pounds of poultry per day initially, followed by 40 to 80 pounds per day thereafter. The store offers irradiated as well as non-irradiated poultry to its customers. The irradiated poultry makes up approximately 10 percent of the store's total poultry sales.



Strawberries treated by irradiation.

These results indicate that informed consumers like and will buy irradiated foods. The main reasons consumers choose irradiated foods are increased shelf life and superior product quality. To date, no single test market of irradiated foods has been unfavorable when the consumer has been provided information about food irradiation.

Consumers favor the FDA's approval of labelling irradiated foods with the international logo and the words "treated by irradiation," "treat-

International food irradiation logo.

ed with irradiation," or "irradiated." Processed foods containing irradiated ingredients do not require the irradiation label. The FDA considers the labelling of irradiated foods informative since preservation of foods by irradiation is no different from other preservation methods.

As with any food preservation process such as pasteurization, canning, freezing, and refrigeration, irradiation will add to the cost of food. For example, irradiated chicken and beef may cost up to 10 cents more per pound than non-irradiated poultry and meat products. As with any other technology, as the procedure is used more and more the cost will decrease. This is a small price to pay for improved product safety and increased shelf life.

Government agencies such as FDA, USDA, FAO, and WHO have approved the use of food irradiation. The food industry has not actively pursued food irradiation since consumer response nationally is not known. Retailers have been hesitant to place irradiated foods on their shelves in fear of boycotts and demonstrations by some citizen action groups whose claims and misconceptions about the safety of irradiated foods are unsubstantiated through years of scientific research.

As consumers become aware of the irradiation process and benefits of food irradiation, such as elimination of harmful bacteria and extended shelf life, more irradiated foods will begin to appear in grocery stores across the country.

Summary

Food irradiation can be used to combat foodborne diseases, including the emergence of disease-causing organisms such as *C. jejuni*, *E. coli*, and *L. monocytogenes*. Food irradiation is not a substitute for proper handling, cooking, and storage of food. Care must be taken to ensure that irradiated foods do not become recontaminated. Also, food irradiation could be used in place of fumigants used to kill mold and insects on produce and grains. Food irradiation has been studied more extensively than any other food additive, yet there is only limited application in this country.

Food irradiation has been endorsed by FAO, WHO, USDA, the American Medical Association (AMA), and the Institute of Food Technologists (IFT) as a safe and practical method for preserving a variety of foods and reducing the risk of foodborne disease. International imports and exports of fresh foods could be expanded, increasing the abundance of food worldwide. Food irradiation makes food safer to eat, improves quality, and extends shelf life.

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