Department of Food Science
Food Irradiation

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To Zap or not to Zap?

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Why irradiate food products?
Approximately 25% of all food products are lost after harvesting due to insects, vermin, and spoilage. Currently, a significant number of chemicals are used on food products for preserving/preventing insect losses. In roots and tubers, sprouting can be a major cause of losses. In developing countries where handling, transportation, and storage conditions are less adequate than in the United States these losses are significantly greater. In addition, foodborne diseases caused by pathogenic bacteria result in an estimated 9,000 deaths each year and 24 million cases of illness annually in the United States alone. Irradiation has the potential to significantly reduce both food production losses and foodborne illness.

What is irradiation?
Irradiation is the deliberate process of exposing an item to certain types of radiation energy to bring about desirable changes. Ionizing radiation is radiant energy that has the ability to break chemical bonds. There are three types of ionizing radiation that can potentially be used in food irradiation: electron beams (machine generated), X-rays - (machine generated), and gamma rays (occur naturally from radioactive decay of Cesium 137 or Cobalt 60). Cobalt-60 is most commonly used for food irradiation, though electron beam is finding increasing application.
Currently, there are a number of non-food related products being irradiated (cosmetics, wine corks, hospital supplies, medical products, packaging materials) mostly to achieve non-thermal sterilization. The radiation dose refers to the amount of these gamma rays absorbed by the product and is measured in Grays (Gy). 1 Gy = 1 Joule of absorbed energy / kg of product. Most treatment levels are on the order of 1 to 10 kGy (1 kGy = 1000 Gy).

Why was food irradiation approved by the Food and Drug Administration (FDA) ?
Because of the seriousness of the food safety issue and the lack of adequate control measures to ensure 100% bacteria free food, irradiation is seen as an additional tool that can be used for improving food safety. In particular, *E. coli*, salmonella, and a number of other pathogenic bacteria are sensitive to irradiation. Approved doses for meat and poultry can reduce salmonella and *E. coli* populations from 99.9% to 99.999%. Hundreds of studies found no health-related issues from consuming irradiated food at levels less than 10 kGy. Some studies indicate that in irradiated pork the available thiamin may be reduced up to 50%. However, the average person would lose less than 2.3% of their thiamin intake eating irradiated pork, most comes from cereal grains (cereals, breads, and pastas). This is not an issue if one eats a well balanced

diet. It is also important to note that in canned beef only 21% of the thiamin is retained compared to 23% retained for gamma irradiated beef, and 44% retained in electron irradiated beef.

Other vitamin losses vary depending on the particular vitamin. A study comparing vitamin levels in irradiated and non-irradiated cooked poultry found comparable vitamin levels except a modest decrease in Vitamin E (35%) was noted. Vitamin losses can also be reduced by irradiating frozen products in vacuum-packed containers. Other studies suggest that vitamin losses in irradiated products can be reduced to l0% or less.

Ionizing radiation can also be used to produce sterile, shelf-stable products. Irradiation has been demonstrated to produce no harmful effects at levels up to and above 60kGy. At these high levels, there have been some significant vitamin losses, but the product is commercially sterile and has a shelf-life comparable to canned foods. High levels of irradiation have already been approved for foods for NASA's Space Program and for immune-compromised hospital patients.

Uses of Food Irradiation

Irradiation can be used to sterilize (eliminate all microorganisms) food products at levels above 10 kGy. In the range of 1-10 kGy it can be used to pasteurize food (eliminate a significant number of microorganisms including those of public health significance). In some products it can be used as an insect disinfestation treatment (less than 1 kGy). It can be used as a sprout inhibition technique in potatoes and onions (less than 0.5 kGy). It can delay ripening of certain fruits (less than 0.3 kGy) and eliminate trichinosis in pork (less than 1.0 kGy).

Foods Approved for Irradiation by the FDA

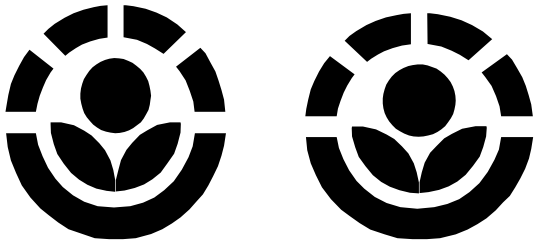
Table 1 shows the foods and levels of irradiation approved by the FDA.

Table 1. Foods, dosage, purpose and date approved, for irradiation by the FDA (IFT, 1998).

Product	Dose (kGy)	Purpose	Date Approved
Wheat, wheat flour	0.2-0.5	Insect disinfestation	1963
White potatoes	0.05-0.15	Sprout inhibition	1964
Pork	0.3-1.0	Control Trichinella spiralis	7/22/85
Enzymes (dehydrated)	10 max	Microbial control	4/18/86
Fruit	1 max	Disinfestation, delay ripening	4/18/86
Vegetables, fresh	1 max	Disinfestation	4/18/86
Herbs	30 max	Microbial control	4/18/86
Spices	30 max	Microbial control	4/18/86
Vegetable Seasonings	30 max	Microbial control	4/18/86
Poultry, fresh or frozen	3 max	Microbial control	5/2/90
Meat, packaged and frozen[a]	44 or greater	Sterilization	3/8/95
Animal feed and pet food	2-25	Salmonella control	9/28/95
Meat, uncooked and chilled	4.5 max	Microbial control	12/2/97
Meat, uncooked and frozen	7.0 max	Microbial control	12/2/97

[a] For meats used in the National Aeronautics and Space Administration space program.

How Will the Consumer Know That Food is Irradiated?
Retail food products are required to display the radura symbol in a green color:



Treated with irradiation Treated by irradiation

Food processors may also add additional information explaining why irradiation was used such as "treated with irradiation to inhibit spoilage" or “treated with irradiation instead of chemicals to control insect infestation”.

What Happens When a Food is Irradiated?
When ionizing radiation passes through a food product, some energy is absorbed by some chemical bonds. Some bonds rupture and produce free radicals which are highly reactive and unstable. They instantaneously rejoin with neighboring compounds and the results are called radiolytic compounds. These are similar to the compounds produced by heating (thermolytic compounds). There is no significant difference in the compounds generated from ionizing radiation versus those generated from heating. Roughly one bond per million is broken for each kGy of applied ionizing radiation. The uniqueness of irradiation is that DNA (microorganisms and insects have a lot of DNA compared to plant cells) is very sensitive to irradiation. Irradiation of DNA at the approved levels causes base damage, breaking of DNA strands, and crosslinking. All of these result in the loss of the organism's ability to reproduce.

Can one measure applied irradiation levels in a food product?
Yes, when food is irradiated a dosimeter is inserted with the food to measure the amount of radiation absorbed. In addition, there are a number of independent irradiation detection methods being investigated. Because there are no major changes in the physical, chemical, or sensory properties in an irradiated product, development of detection methods must focus on the very minor changes that occur in the food. Detection methods measuring the level of DNA damage has shown promise in uncooked foods. However, the method needs further development to distinguish cooked food DNA damage to irradiation DNA damage. The results for both are very similar. Other research has shown potential for using electrical impedance in potatoes and electron spin resonance in bone containing foods. Thermoluminescence techniques may be used in fruits, vegetables, and grains. A method which looks promising for monitoring irradiation at levels above 0.5 kGy is the measurement of cyclobutanone. Cyclobutanone forms in very small amounts, 0.5 to 5 ppm, when fatty acids are irradiated. It does not show up in thermally processed foods. However, similar compounds are produced in thermally processed foods. Current research is focusing on developing universally accepted methods of detection or recommended detection methods for particular products.

Is irradiated food safe?
Based on all the scientific information available there is no greater health risk from irradiated food than non-irradiated food. Irradiated foods are not radioactive. No scientific studies have shown irradiated foods causes cancer (even in tests where all the food in the diet was irradiated at levels 10 times the approved levels). No food is 100% safe. Proper sanitation, handling, and preparation are needed for any food product. In some instances, irradiated foods may be safer and may be preferred over non-irradiated foods because of the reduced microbial populations; no need for fumigants for quarantine treatment of imported products, and increased shelf-life. Foods can also be packaged and then irradiated, thus reducing the potential sources of contamination. However, once the package is opened it once again susceptible to microorganism contamination.

Who regulates food irradiation?
Food irradiation is approved by the FDA. Congress gave the FDA the authority to regulate food irradiation as an additive in the Food Additives Amendment to the 1958 Food, Drug and Cosmetic Act. However, due to regulatory requirements it is the responsibility of the USDA to develop guidelines for irradiation of meat and poultry products. The USDA guidelines are currently being revised to encompass the red meats approval (Dec 2, 1997). After these are released irradiated red meats can be legally produced in the United States.

Are irradiated food products currently available in the United States?
There are a number of products marketed that are currently being irradiated such as chicken, potatoes, onions, spices and wheat flour. The amount of food irradiation for sale is very small and therefore the local supermarket may not have them. Food processors and distributors are hesitant to provide a product that may create public controversy. Most agree that irradiation is a way to provide safer products to the consumer, but the consumer demand for irradiated foods must pull these products into the market. Food processors indicate they do not wish to be the first entering the market with irradiated foods. As consumers become aware of the benefits and start asking for irradiated products more will become available locally.

What will irradiation costs?
Irradiation has been estimated to cost from a half-cent to seven cents per pound of product depending on a number of factors such as product type, product volume, batch or continuous process, irradiation source, and irradiator facility location.

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