Radiation Processing: A Tool for Food Processing and Preservation

Anurag Chaturvedi*

Dept. of Home Science, PJTSAU, Rajendranagar, Hyderabad (500 030), India

Corresponding Author

Anurag Chaturvedi*

e-mail: anuragchaturvedi1955@gmail.com

Article History

Article ID: IJEP94
Received in 15th April, 2016
Received in revised form 20th April, 2016
Accepted in final form 13th May, 2016

Abstract

Food irradiation is the process of exposing food to waves or rays of energy. This energy travels through the food killing potentially life-threatening bacteria. The process also is referred to as "cold pasteurization" because harmful bacteria are destroyed without the use of heat or raising the temperature of the food. Irradiation technology allows food processors to destroy harmful bacteria that can cause serious illness and even death. Food irradiation can improve the safety of food for these individuals and will prolong a food's shelf life, thus reducing spoilage and waste. Radiation was also shown to have potential use in combination with various conventional food processing techniques for use as what is known as 'hurdle technology'. This could help reduce the radiation doses required to get desired effects with respect to preservation of perishable foods including fruits, vegetables with intermediate moisture foods, fish and meat products. Irradiation can be used to destroy or inactivate organ-isms that cause spoilage and decomposition, thereby extending the shelf life of foods. It is an energy-efficient food preservation method that has several advantages over traditional canning. The resulting products are closer to the fresh state in texture, flavor, and color. As India ranks second in production of vegetables and fruits but due low shelf life of the commodity and improper post harvest management practices percentage of export for those commodity are reducing. Radiation can be a useful tool in maximizing the shelf life and for maintaining the quality of the product.

Keywords: Pasteurization, preservation, radiation, World Health Organization

1. Introduction

India has immense potential for the export of agriculture and horticulture products, milk and milk products, meat, mutton, pork, hides, skins and textiles. For this location specific research support for post harvest handling of these items need to be generated to suit the specifications of the importing countries. The new economic policy and WTO agreements have opened a vast arena for global marketing of agro based products. This necessitates establishment of a strong link between the farmers, processors and global markets. It also requires conforming to the sanitary and phyto-sanitary standards of the importing countries in terms of Hygienization and sanitization of the fresh and processed products.

1. Food Processing Industry Sub-Sectors

- Grains
- Milk and milk products
- Poultry and meat
- Fisheries
- Fruits and vegetables
- Packaged and convenience foods
- Beverages and soft drinks
- Spices

2.1. Post-harvest food losses (%)

Commodity group	India	US
Grain and grain products	20-30	32
Vegetables	30-50	25
Fruits	30-50	23
Meat, Poultry and Fish	20-30	16

2. Food Irradiation

Food irradiation is the process of exposing food to waves or rays of energy. This energy travels through the food killing potentially life-threatening bacteria. The process also is referred to as "cold pasteurization" because harmful bacteria are destroyed without the use of heat or raising the temperature of the food. Irradiation technology allows food processors to destroy harmful bacteria that can cause serious illness and even death. The pathogens that irradiation kills, like E. coli 0157:H7, Salmonella, and Campylobacter, are particularly dangerous for the elderly, young children,

and individuals with weak immune systems. Food irradiation can improve the safety of food for these individuals and will prolong a food's shelf life, thus reducing spoilage and waste.

Scientists began food irradiation research in the early 1950's. The U.S. Food and Drug Administration (FDA) approved the irradiation of wheat in 1963, and potatoes in 1964. Spices, which are the most commonly irradiated foods, gained FDA approval in 1983. More recently, the FDA has approved the use of irradiation for pork (1985), poultry (1992), and refrigerated or frozen uncooked red meat in December 1997. For decades hospitals have used irradiation to sterilize medical devices—everything from baby bottle nipples to pacemakers and bone replacements. NASA also recognizes the usefulness and safety of irradiation: foods eaten by U.S. astronauts today are irradiated.

Based on a broad spectrum of national and international scientific evidence, the FDA, American Medical Association, and World Health Organization all agree that irradiated food products are safe to consume. Moreover, 35 other countries around the world have approved the use of irradiation on food. Foods irradiated at the levels approved by the FDA present no health risk. Just like the irradiated medical devices used in hospitals, the irradiated food U.S. astronauts and consumers eat, are not radioactive. That's because the level of irradiation used has just enough energy to kill harmful bacteria. Food irradiation does not have the energy to split atoms, which is what causes exposed objects—in this case, food molecules—to become radioactive. The waves or rays of irradiation simply pass through the food and destroy deadly bacteria like E. coli 0157:H7, Campylobacter, and Salmonella, thus making the food safer to eat. Consumers will know if a food has been irradiated if it bears the international radura symbol (green petals in a broken circle) and the written statement: "treated by irradiation" or "treated with radiation

Radiation was also shown to have potential use in combination with various conventional food processing techniques for use as what is known as 'hurdle technology'. This could help reduce the radiation doses required to get desired effects with respect to preservation of perishable foods including fruits, vegetables with intermediate moisture foods, fish and meat products. Along with these developments, the major international development came through the recognition by a Joint Expert Committee of World Health Organization (WHO), Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA) that food irradiated up to a maximum dose of 10 kGy was safe and did not require toxicological evaluation.

3.1. Major functions achieved by irradiation of food

- Insect disinfestation of stored products
- Inhibition of sprouting in tubers and bulbs and rhizomes
- Delay in fruit ripening
- Destruction of microbes responsible for food spoilage
- Elimination of pathogens and parasites of public health importance
- To overcome quarantine barriers

Type of food	Radiation dose in kGy	Effect of treatment
Meat, poultry, fish, shellfish, some vegetables, baked foods, prepared foods	20 – 71	Sterilization. Treated products can be stored at room temperature without spoilage. Treated products are safe for hospital patients who require microbiologically sterile diets.
Astronauts food	45+	
Meat, poultry, fish, Red meat Poultry Shell eggs	1.1 to 10 4.5 / 7 3 3	Delays spoilage by reducing the number of microorganisms in the fresh, refrigerated product. Kills some types of food poisoning bacteria and renders harmless disease-causing parasites (e.g., trichinae).
Spices and other seasonings	Up to a maximum of 30	Reduces number of microorganisms and insects. Replaces chemicals used for this purpose.
Strawberries and some other fruits	1 to 5	Extends shelf life by delaying mold growth.
Grain, Rice, Semolina(rawa), Whole wheat flour (atta) and maida, fruit, vegetables, and other foods subject to insect infestation	0.1 to 2	Kills insects or prevents them from reproducing. Could partially replace post-harvest fumigants used for this purpose.
Bananas, avocados, mangoes, papayas, guavas, and certain other non-citrus fruits	Maximum 1	Delays ripening
Potatoes, onions, garlic, ginger	0.05 to 0.15	Inhibits sprouting
Dehydrated vegetables, other foods, Raisins, figs and dried dates	Variable doses	Desirable changes (e.g.) reduces rehydration time
Sprouts seeds	8	Control illness causing microorganisms

*Gray (Gy) is SI unit of energy absorbed (1 Joule kg^{-1}) by food from ionizing radiation ; KiloGray (kGy= 1000 Gy)

3.2. Applications of radiation of food (below table)

3. Positive Impact of Irriadiation

4.1. Major benefits

The role of radiation processing in improving food hygiene is being widely recognised. According to the World Health Organization (WHO), more than one billion cases of acute diarrhea occur in children under the age of 5 years in developing countries caused by contamination of food by micro-organisms including Salmonella and Campylobacter sp. The Centre for Disease Control and Prevention, USA, estimates that there are 76 million cases of food-borne illnesses resulting in 325,000 hospitalizations and 5000 deaths annually in the US. Although all are at risk, children, people over age 55, diabetics, and those whose immunity is compromised are especially vulnerable.

The high penetration power of radiation is useful to eliminate radiation-sensitive pathogenic microorganisms such as Salmonella, Vibrio, Listeria, Campylobacter and Escherichia coli O157: H7 from pre-packaged foods including poultry, meat and fishery products. Most of these organisms have low sensitivities to radiation, with D10 values (dose required for 90% killing) of 1 kGy or less.

Presence of insects and parasites in importing foods has been a cause of great concern with respect to internationally traded agro-based foods. This has adversely affected export of fruits and vegetables from Asian to European countries. These foods are currently treated with fumigants such as methyl bromide, ethylene-di-bromide, ethylene oxide, etc. for disinfestation purposes. This world-wide practice will be discontinued and could be replaced by radiation processing.

4.2. Pesticide fumigants

Low doses have also been shown to be as effective as pesticide fumigants for dis-infesting grain products prior to shipment and storage, and for reducing microbial and insect contamination on fresh fruits and vegetables. For example, grapefruit grown in Mexico, Central America, and South America frequently are infested with larvae of the Mexican fruit fly, Anastrepha ludens. To prevent entry of this insect into the importing country, grapefruits need to be quarantined and treated with ethylene di bromide. A study reported that 20 grays for 0.25, 0.5, 1.0, or 100 minutes reduced adult emergence of Mexican fruit flies from larvae by more than 99%.

4.3. Preservation

Irradiation can be used to destroy or inactivate organ-isms that cause spoilage and decomposition, thereby extending the shelf life of foods. It is an energy-efficient food preservation method that has several advantages over traditional canning. The resulting products are closer to the fresh state in texture, flavor, and color. Using irradiation to preserve foods requires no additional liquid, nor does it cause the loss of natural juices. Both large and small containers can be used and food can be irradiated after being packaged or frozen.

4.4. Control food borne illness

Irradiation can be used to effectively eliminate food pathogens that cause foodborne illness by:

4.4.1. Radiation pasteurization

Disease-causing bacteria are estimated to be responsible for two thirds of the food borne disease outbreaks that occur annually throughout the world. Improved food-handling practices could reduce the number of illnesses from this source; but radiation pasteurization gives us an additional, complementary tool with which to deal with the problem.

4.4.2. Radiation sterilization

Foods that are sterilized by irradiation can be stored for years without refrigeration just like canned (heat sterilized) foods. With irradiation it will be possible to develop new shelf-stable products. Sterilized food is useful in hospitals for patients with severely impaired immune systems, such as some patients with cancer or AIDS. These foods can be used by the military and for space flights. Radiation sterilization has been used to sterilize food for NASA's astronauts and for some patients with impaired immune systems. At present, radiation sterilization is not planned for significant commercial production of foods.

4.4.3. Disinfestation

Low-dose irradiation can kill insects in grains and other stored foods. Disinfestation by irradiation can substitute for some of the former uses of the now-banned fumigant ethylene di bromide (EDB). The possibility of such a replacement is one of the major reasons for renewed interest in irradiation show promise as an alternative to these post harvest fumigants. With irradiation there would be fewer pesticide residues in treated foods.

Packaging will be required whenever irradiation is used as a quarantine treatment. It is possible—and there has been much enthusiasm about the prospect—that killing insects with irradiation might increase the amount of food available in developing countries. Irradiation alone cannot do the job, but irradiation combined with effective methods of storage, chemical additives and/or packaging to prevent re-infestation could accomplish it.

4.5. Control sprouting, ripening

4.5.1. Sprout inhibition

Very-low-dose irradiation treatment inhibits the sprouting of vegetables such as potatoes, onions and garlic. Irradiation can replace the chemicals currently used for this purpose. Several countries including India, have approved this treatment for white potatoes and garlic on a commercial scale.

4.5.2. Delay of ripening

Low-dose irradiation delays ripening and therefore extends the shelf life of some fruits, including strawberries, bananas,

mangoes, papayas, guavas, cherries, tomatoes and avocados.

4.5.3. Physical improvements

Irradiation can produce desirable physical changes in some foods. Bread made from irradiated wheat has greater loaf volume when certain dough formulations are used, and irradiated dehydrated vegetables reconstitute more quickly than nonirradiated vegetables.

In closing, it can be stated that food irradiation is not a miracle process that can convert spoiled food into high-quality food. It is equally true that not all foods are suitable for radiation treatment, just as not all foods are suitable for canning, freezing, drying, etc. Food irradiation has two main benefits to the health and well-being of humans: the destruction of certain food borne pathogens, thus making the food safer; and prolongation of the shelf life of food by killing pests and delaying the deterioration process, thus increasing food supply.

Radiation processing technology can therefore, strengthen nation's food security, improve food safety and boost export of agricultural commodities. The time is now most favorable to exploit this technology with initiative to integrate the technology with national mainstream.

4. Conclusion

India has immense potential for the export of agriculture and horticulture products, milk and milk products, meat, mutton, pork, hides, skins and textiles. For this location specific research support for post harvest handling of these items need to be generated to suit the specifications of the importing countries. Radiation can be use in combination with various conventional food processing techniques for use as what is known as 'hurdle technology'.