Ionising radiation treatment for food preservation

- Xinhao DAI

Introduction (principles & how it works)

Irradiation (gamma rays, electrons or X-rays) is applied to foods for promoting food safety and eliminating and reducing pests that are harmful to plants and plants products ((EFSA), 2011). The first use of food irradiation occurred in 1957 in Germany, in which a spice manufacturer in Stuttgart started to improve the hygienic quality of its products by irradiating them with electrons, using a van de Graaff generator. After some hesitations whether to grant permissions for marketing irradiated food, the International Project in the Field of Food Irradiation (IFIP) was created in 1970, aiming to carry out a worldwide research program on the health safety of irradiated food (Diehl, 2002). The committee concluded in 1980 that the irradiation of any food commodity up to an overall average dose of 10kGy presented no toxicological hazard and no special nutritional or microbiological problems (WHO, 1981).

The International Consultative Group on Food Irradiation (ICGFI) was created in 1983, now supported by 45 member countries, and provides publications on the safety of irradiated food, the effectiveness of food irradiation, commercialization of the process, legislative aspects, control of irradiation facilities, and acceptance of the information on food irradiation(Diehl, 2002).

As ionizing radiation passes through food, it creates a trail of chemical transformations by primary and secondary radiolysis effects. The extent of chemical reactions induced by irradiation in food components depends on following variables: irradiation treatment conditions (absorbed dose, dose rate, facility type), presence or absence of oxygen, temperature as well as composition of food. The main reported radiolytic products are certain hydrocarbons and 2-alkylcylobutanones produced from the major fatty acids in food, and some cholesterol oxides and furans ((EFSA), 2011).

Application to Food Preservation

All irradiated foods are supposed to have a label (G. H. Zhou, 2010). The irradiation technology was promoted by the FAO in the Codex Alimentarius in 2003 and has been well accepted in 50 countries. Irradiation technology is used worldwide to sterilize medical devices and pharmaceuticals, preserve artefacts, process cosmetics, packaging and food, and enable material improvements in consumer and manufactured goods ((EFSA), 2011).

The following types of ionizing radiations are covered by international standards of the Joint FAO/WHO Codex Alimentarius Commission and are therefore internationally recognized for the treatment of foods and permissible under Directive 1992/2/EC concerning foods and food ingredients treated with ionizing radiation:

1. Gamma rays with energies of 1. 17 and 1. 33 MeV8 as emitted by the radionuclide cobalt-60 (Co-60) or gamma rays of 0. 66 MeV as emitted by caesium-137 (Cs-137);
2. Electrons (electron beams, E-beams) generated from machine courses operated at or below an energy level of 10 MeV; or
3. X-rays generated from machine sources operated at or below an energy level of 5 MeV ((EFSA), 2011).

The irradiation technology is highly efficient of inactivating bacteria, and the product is essentially chemically unaltered and the appreciable thickness materials, which can be used after packaging. It is non-thermal, thus it wont change the freshness and nutritional quality of the meat and meat products, though color change may occur due to the inherent susceptibility of the myoglobin molecule to energy input and alterations in the chemical environment.(G. H. Zhou, 2010). The radiation treatment results in no loss of thiamine, which is one of the least stable vitamins (Graham, 1998).

Disinfestation of papayas and other exotic fruits (rambutan, lychee, star fruit, atemoya) by irradiation process in Hawaii for shipment to US mainland enabled Hawaiian exports to offer products with higher quality, instead of steam heating them for several hours (Diehl, 2002).

Degradation products of parathion formed by irradiation seem to protect against a decline of antioxidant capacity and reduce polyphenolic loss. Ionizing radiation was found to be useful in breaking down pesticides residues without inducing significant loss of polyphenols (Issam Ben Salem, 2013). Gamma irradiation was effective in delaying deterioration reactions, improving microbiological, chemical, and color quality of vacuum-packed squid rings stored at 4-5 °C (Yeannes, 2012).

Safety

World Health Organization encourages the use of food irradiation, which is described as ‘ a technique for preserving and improving the safety of food’ (WHO, 1988).

However, the high radiation doses up to 25 kGy produced a statistically significant (p <0. 05) effect on the migration of commercial plasticisers [di-(2-ethylhexyl0 adipate (DEHA) and acetyl tributyl citrate (ATBC)) from polyvinyl chloride (PVC) fild into the specified aqueous food simulants (distilled water, 3% w/v acetic acid and 10% v/v ethonaol) (Panagiota D. Zygoura, 2011) . The ionizing treatment caused a decrease of 15-29% in the folic acid content in dry fermented sausages at the does of 4 kGy (Irene Gala Ì n, 2011).

While inoising radiation being an effective method to reduce pathogenic *E. coli* O157: H7 in meat and poultry products (E. Mayer-Miebach and Schuchmann, 2005), *Bacillus cereus* LSPQ and *Salmonella* Typhi ATCC 19430 are radiotolerant bacteria (Samia Ayari, 2009).

A recent research studied the effect of irradiation by dufferent irradiation types (gamma and electron beam), irradiation doses (1, 3, 7 and 10 kGy) and does rates (5kGy s-1 for electron beam and 0, 4 1. 85 kGy h-1 for gamma) on fifteen retail packaging materials. The results confirmed that irradiation-induced changes do occur in substances with the potential to migrate and that the safety of the finished packaging material following irradiation showed be assessed (M. Driffielda, 2014).

Other study showed gamma-radiation did not affect the kinetics of plasticizer migration. On the contrary, electron-beam radiation produced shorter equilibration times for all food-simulating solvents tested at 40 °C. The values are far below the European Union restriction (1mg Kg-1 body weight) for ATBC and PVC. Thus PVC cling film may be used in food irradiation application in contact with aqueous foodstuffs (P. D. Zygoura, May 2011).

Some studies indicate that at least some alkylcyclobutanones can induce DNA damage in vivo. No in vivo genotoxicity studies are available; however, the Panel considers a genotoxic hazard in humans unlikely. The only new contrary evidence was leukoenohalomyelopathy in cats, which have been fed mainly, or exclusively with highly irradiated feed (> 25kGy). The finding has only been reported with cats, dogs consumed the same pet food did not show the disease in one report. A clear mechanistic explanation in terms if risk assessment has not been established yet ((EFSA), 2011).

Suitability

Due to the opposition from some very influential anti-irradiation activist groups an the uncertain about the acceptance of irradiated commodities by consumers, for many years, only spices and seasonings are still being irradiated worldwide on a significant scale. The irradiation of meat and meat products in USA requires prior approval not only by FDA, but also by US Department of Agriculture’s Food Safety and Inspection Service (USDA/FSIS) (Diehl, 2002).

Conclusion

The ionizing radiation works by passing through food, creating a trail of chemical transformations by primary and secondary radiolysis effects. The irradiation technology can be used on fruits, vegetables, meat products, and spices. It is highly efficient of inactivating bacteria, disinfestation with minimum influence of nutritional factors of food to achieve longer shelf life and better food quality. However, some studies showed migration of some packaging material with aqueous foodstuff after irradiation. The development and permeation of ionizing irradiation become very slow due to vocal anti-irradiation activist groups and uncertain about the acceptance of irradiated commodities by consumers.

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