REVIEW ARTICLE

Electron Beam Irradiation - An environmentally safe method of fungal decontamination and food preservation: A review

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ABSTRACT

Electron Beam Irradiation (EBI) is an effective and environmentally safe method ofsterilization and fungal decontamination of a variety of food commodities. This irradiation allows decontamination of many food and agricultural commodities, which usually suffer from fungal contamination and mycotoxin interference during post-harvest processes. Since EBI uses less energy thanconventional techniques, it may replace dry sterilization techniques in future.

Key words: Electron BeamIrradiation, agricultural produce, food commodities.

INTRODUCTION

Providing safe and adequate food supplies for all has been a challenge since time immemorial for all Governments. The Food and Agriculture Organization (FAO) has estimated the annual loss of the world's food supply to be about 25% due to microbial contamination, improper handling and storage. The European Union (EU) and several other countries have imposed stringent laws on the quality and safety of imported materials. This has encouraged the introduction of non-conventional alternatives for food preservation andhave opened up possibilities of commercializing food irradiation on a large scale (Sridhar and Bhat, 2008).

Radiation is one of the latest methods in food preservation.Over 42 countries in the world including USA, UK, Canada and France have given clearance for radiation processing of food. The Government of India has permitted the use of Gamma radiation technology in preservation of food items such as potato, onion, rice, semolina wheat flour, mango, raisins, dried dates, ginger, garlic, shallots (small onions) as well as meat and meat products including chicken (Balakrishnan, 2015).

The objective of this review is to highlight the importance of Electron Beam Irradiation technology, to prevent fungal contamination and thus enhance the quality of food.

Radiation processing Technology

Three principal types of radiation source can be used in food irradiation according to the Codex Alimentarius General Standard (Food and Agriculture Organization, WHO, 1984). Radiation processing involves precise exposure of food and agricultural commodities to ionizing radiations such as gamma rays (cobalt-60 and caesium-137) or machine generated X-rays (5 Mev) and high-energy electrons (8-10 Mev). Ionizing radiation in Electron Beam Irradiation (EBI) technology is provided through electrons from a linear particle accelerator, while mainly by photons in X-rays.The amount provided by the source is known as dose and measured in kilo Grays (kGy) (1 kGy = 1,000 kJ). Radiation processing is broadly classified into three categories:

1. Low dose (<1 kGy), mainly used for sprout inhibition of vegetables, for disinfestation of storedgrains, dry fruits and spices and for delayed ripening in fruits.

2. Medium dose (1-10 kGy), for reducing microbial load of whole and powdered spices, and for elimination of spoilage microbes in fruits and sea food to extend shelf life.

3. High dose (10-45 kGy), necessary to make foods sterile, wherein no refrigeration is required. Some spices recommended for export has been given clearance for this dose range. This dose produces sterile foods in hospital diets for patients with compromised immune systems and for foods used by astronauts during space flight.

Packed foods or agricultural commodities are allowed to pass through a radiation chamber on conveyor belts in such a way that they will not come in direct contact with radioactive materials. Nutritionists are of the opinion that radiation processing produces no greater nutritional loss than other food processing methods like cooking or canning. Nutrient losses can be minimized by irradiation of foods in anoxic conditions or while freezing.

Gamma irradiation (Co-60) is a well-established technology while Electron Beam Irradiation technology is relatively new.

The available accelerators for radiation processing with varying beam power of 10-200 kW include: LINAC, RHODOTRONS, CYCLOTRONS, MICROTRONS and DYNAMITRONS. (Sridhar and Bhat, 2008; Kalyani and Manjula, 2014).

The energy from electrons or X-rays has to target and inactivate fungal nucleic acids. This damage occurs directly as a result of electron and photon interactions with DNA and RNA and indirectly through the radiolytic products of water, which further react with nucleic acids. Microorganisms with large genomes are usually more susceptible to radiation than those of smaller genomes. When ionizing radiation reaches microbes, its high energy breaks chemical bonds in molecules that are vital for cell growth and integrity, and this results in microbial death. EBI technology has been shown to be more effective on fungal spores as D-10 value (the minimal dose required to kill an organism) is usually higher in gamma irradiation. Being a cold process, radiation can be used to pasteurize and sterilize foods without causing changes in freshness and texture of food unlike heat. Further, unlike chemical fumigants, radiation does not leave any harmful toxic residues in food and is more effective and can be used to treat packaged commodities too (Sridhar and Bhat, 2008)

Current status of Irradiation technology

Food, feed and silage: Improper storage of consumed food grains, fruits and beverages worldwide include rice, wheat, barley, sorghum, rye, sugar (sugar cane and sugar beets), grapes, spices, cocoa, coffee, wine and beer, can become contaminated with Mycotoxins like like Aflatoxin and Patulin which are known for teratogenic, mutagenic and carcinogenic effects in livestock and humans. The efficacy of EBI treatment in combination with other methods to prevent the growth of molds will be of immense value. EBI may also serve as an effective means of decontamination and preservation of fresh sea foods.

Animal feed and fodder borne fungal contamination and aflatoxins produce by fungi in humid conditions in groundnuts and oilseed meal affect the livestock as well as human health through animal products (Bastianelli and Le-Bas, 2000). Mycotoxin contamination of fodder due to*Aspergillus flavus, A. ochraceus* and *A. parasiticus* which proliferate in fodder in tropical warm humid conditions, while *Penicillium expansum* and *P. verrucosum* predominate in temperate conditions (Chhabra and Singh, 2005).

Growing consumption of minimally processed vegetables for nutritional benefits has raised questions about their safety. Fungal diseases during post-harvest storage are well known. Rhizopus spp. are common and cause considerable loss of fruits and vegetables. Raw sprouted seeds consumed as nutritional supplement are prone to be contaminated by toxigenic molds as they are wet and nutritionally rich. A low-dose EBI on fresh-cut cantaloupe combined with modified atmospheric packaging promises to extend shelf life. Similarly, the impact of EBI on packaged fresh blueberries at greater than 1.0 kGy on the quality has been evaluated by Moreno *et al*. (2012).

Table 1: Effect of Gamma rays andEBI on the fungal contaminants- a few examples

Fungus	**Food**	**Dose**	**Effect**
Aspergillus flavus & Osmophilic molds	black pepper, turmeric, rosemary and coriander	4 kGy EBI	Eliminated or reduced to below detectable limit most of the contaminant microflora (Ito and Islam (1994)
Aflatoxins of the molds*Aspergillus flavus*, *Aspergillus parasiticus*and *Aspergillus nomius*	Peanut seeds	10 kGy. Gamma irradiation 20 kGy	complete inhibition of Fungi at irradiation dose 10kGy 83-100% inactivation of Aflatoxin B (Prado *et al*., 2003)
Fungus	Food	Dose	Effect
Spores of *Aspergillus* and *Penicillium and* Yeasts	Food Packaging material, yogurt cups, containers, bottles and seal caps	EBI 5-7 kGy	Inactivation of spores and vegetative cells (Mittendorfer *et al*., 2002).
Aflatoxin Initial microbial load including fungi	Coconut, Dry parsley leaf, parsley root, carrot, celery leaf and root, red beet and dry mushrooms	0- 5.0 kGy 5 kGy	Inactivation (Prado *et al*., 2003; and Rogovschi *et al*., 2009). 5 kGy was sufficient to reduce the initial microbial load by 10^5 organisms (Migdał and Maciszewski, 1995)
Initial microbial load	Soyabeans	Soft electrons up to 7.5 kGy	reduce the microbes in soybeans so high temperature sterilization 120^{o}C not required (Todoriki *et al*., 2007)

Harvested mushrooms also undergo deterioration by fungal contaminants during storage in spite of packing and refrigeration. EBI is a promising approach for the decontamination of raw materials for mushroom cultivation, and to prevent fungal growth during andafter production of mushrooms (Sridhar and Bhat, 2008).

CONCLUSION

EBI is an effective method for mold decontamination and sterilization. In future, it may replace conventional dry sterilization techniques, high dose EBI sterilization may allow energy saving compared to the conventional techniques.

REFERENCES

Balakrishnan S, Radiation Processing of Food, *Press Information Bureau, Government of India, Feature*. Retrieved on 02 Oct., 2015.

Bastianelli D and Le Bas C (2000) Evaluating the role of animal feed in food safety: perspectives for action. In: *Food Management1 in Developing Countries* (eds. Hanak, E., Boutrif, E., Fabre, P. and Pineiro, M.). CIRADFA

Chhabra A and Singh P (2005) Antinutritional factors and contaminants in animal feeds and their detoxification: a review.*Indian Journal of AnimalScience 75*: 101-112.

Ito H and Islam MS (1994) Effect of dose rate on inactivation of Microorganisms in spices by electron beams and gamma rays irradiation. *Radiation Physics and Chemistry, 43*: 545-550.

Kalyani B and Manjula K (2014) Food Irradiation - Technology and Application, *Int. J. of Curr. Microbiology and App. Sciences, 3(4)*: 549-555

Migdał W and Maciszewski W (1995) Application of "ELEKTRONIKA 10-10" electron linac for food irradiation, *Radiation Physics and Chemistry, 46*: 749-752.

Mittendorfer J, Bierbaumer HP, Gratzal F and Kellauer E (2002) Decontamination food packaging using electron beam – status and prospects, *Radiation Physics and Chemistry63*: 833-836.

Moreno MA, Castell-Perez ME, Gomes C, Da Silva PF and Moreira RG (2007) Quality of electron beam irradiation of blueberries (*Vaccinium corymbosum*L.) at medium dose levels (1.0–3.2 kGy). *LWT Food Scienceand Technology*, 40: 1123-1132.

Prado G, Pinheiro de Carvalho E, Silva Oliveira M, Cruz Madeira JG, Morais VD, Correa RF, Cardoso VN, ThaísVeloso Soares TV, da Silva JM, Pereira Gonçalves RC (2003) Effect of Gamma Irradiation on the Inactivation of Aflatoxin B1 and Fungal Flora In Peanut. *Brazilian Journal of Microbiology* 34 *(Suppl.1)*:138-140

Rogovschi VD, Aquino S, Nunes TCF, Gonçalez E, Corrêa B and Villavicencio ALCH (2009) Use of Electron Beam on Aflatoxins Degradation in Coconut Agar, *2009 International Nuclear Atlantic Conference - INAC 2009 Rio de Janeiro,RJ, Brazil, September27 to October 2, 2009 ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR – ABEN*

Sridhar KR and Bhat R (2008) Electron beam irradiation – An emerging technology for fungal decontamination of food and agricultural commodities. In: *Novel Techniques and Ideas in Mycology (eds. K.R. Sridhar, F. Bärlocher, & K.D.Hyde), Fungal Diversity Research Series20*: 271-303.

Todoriki S, Kikuchi OK, Nakaoka M, Miike M and Hayashi T (2002) Soft electron (low energy electron) processing of foods for microbial control. *Radiation Physics and Chemistry 63*: 349-351.