

Ionizing Irradiations in food industry

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The ionizing radiations are particles or waves containing enough energy to ionize the matter when coming in contact. Their mode of action in living cells involves either the direct destruction of nucleic acid or by creating free radicals that can attack the cellular components. This cellular destruction and inactivation can be used to reduce the microbial burden in food items to increase the shelf life and safety of food, meanwhile maintaining the quality of the product. Although this technology is accepted by more than 60 countries, some consumers are reluctant to buy such products thinking that radiations might have modified their food which can also induce changes in their body after consumption. The proper scientific communication regarding the safety of ionization irradiations can change consumer behavior, and it requires the collaboration of all stakeholders in the food production chain.

1. Definition

The ionizing irradiation is the process of applying ionizing energy to a material, such as food, to sterilize or preserve them by destroying microorganisms, parasites, insects, and other pests ^[1].

2. Introduction

Ionizing radiations can remove bound electrons from an atomic or molecular structure, leaving the structure to become electrically charged or ionized ^[2]. When these radiations are bombarded on living cells at specific doses, they can denature cellular components, either by direct destruction of nucleic acid or by breaking water molecules and generating reactive oxygen species and free radicals which can subsequently damage the cellular components (Figure 1).

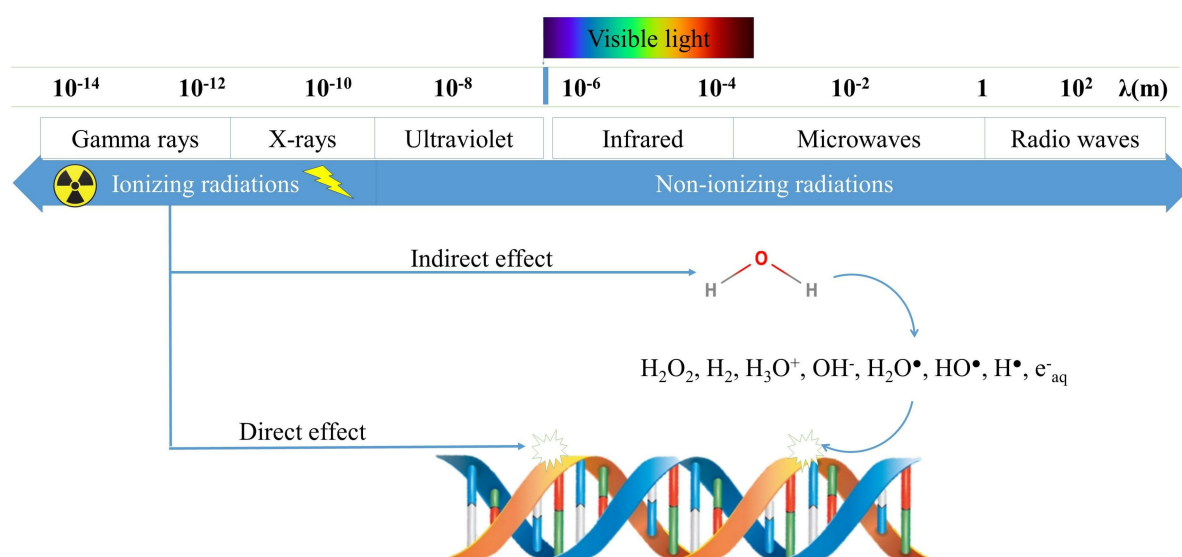


Figure 1. Electromagnetic spectrum and mode of action of ionizing radiations on nucleic acid in living cells

The major ionizing radiations used in food industries are: electromagnetic gamma (γ) rays obtained from radioactive forms of the elements cobalt (^{60}Co) or cesium (^{137}Cs), and the corpuscular beta rays (β) that are the electrically

formed electrons in a cathodic tube, which are taken by an electron accelerator to form a stream of high-speed electrons propelled to foods [3].

3. Regulatory and Enforcement Status of Application of Ionizing Irradiation

3.1. Regulatory Aspects

The ionization of food products is a process subject to regulatory control. Authorized products are either part of an approved list or the authorization has been given by the competent authority based on an application for authorization. The implementation of treatments requires sophisticated installations and/or equipment in a perfectly controlled environment [4]. Therefore, ionization treatment is not as simple and globally developed as heat treatments. Several texts provide a framework for their use. At the global level, the texts of the Codex Alimentarius (2003a and 2003b) are references, they concern the general code of use 2003a and the practices of use 2003b and have been adopted by more than 60 countries. This general framework is often supplemented by national and/or community regulations; for example, European directive 1999/3/EC provides a list of authorized products and their respective radiation doses [5].

Consumer information on food treatments is extremely important, especially for treatments that are not always universally accepted. For ionizing radiation, information concerning its application to the food and/or one of the ingredients of the food is mandatory. This may be in the form of label statements such as “product treated by ionizing radiation”, “product treated by ionizing energy”, “product treated by irradiation” or the affixing of the international symbol “radura”, which indicates the existence of such treatments (Figure 2). However, the use of the radura symbol is voluntary [6].



Figure 2. Radura symbol.

3.2. Applications of Authorized Ionizing Treatments

There are several ways to describe the agri-food applications of ionizing treatments; the most common is based on the dose applied [7]. Different levels of ionizing radiations are authorized for different food materials (Table 1).

Table 1. Use of different levels of irradiation dose for food preservation.

Dose (kGy)	Usage for Food Products
0.05–0.15	Anti-germination for potatoes, onions, garlic, shallots, etc.
0.15–3	Pesticide and insecticide properties (by the destruction of embryos and larvae, and sterilization of adults) for cereals, fruits, and pulses. In this dose range, some meat parasitic worms, e.g., <i>Trichinella</i> in pork, can be eliminated, and also the ripening of fresh fruits and vegetables is delayed.
2–10	Treatment of meat and meat products, ready meals, fish products (fish, shellfish, frog's legs), fresh fruit and vegetables, spices and herbs, and various ingredients (gums, additives) to improve and guarantee a hygienic quality by eliminating pathogenic microorganisms and/or extend their shelf life by reducing the microbial population of spoilage.
10–60	Food is sterilized and then can be stored for up to 2 years at room temperature in sealed plastic packaging

The terms radicidation and radurization are used to refer to these applications of less than 10 kGy doses^[8]. Radicidation (from Latin: *radiare*—radiate and *occidere*—kill) is the application to the food of a dose of ionization sufficient to reduce the specific number of viable pathogenic bacteria to a level such that they are not detectable by any known method. This term also applies to the destruction of specific parasites. Radurization (from Latin: *radiare*—radiate and *durare*—prolong) is the application of an ionization dose sufficient to preserve the quality of food by ensuring a substantial reduction in the number of spoilage bacteria.

Radappertization (by the name of Nicolas Appert, the inventor of thermal sterilization method of food products) is the application of high dose (10 to 60 kGy) of ionization to food in order to reduce the number and/or activity of living microorganisms so that none (except viruses) is detectable by any recognized method^[8]. Such radio-sanitized products can then be stored for up to 2 years at room temperature in sealed plastic packaging. It should nevertheless be noted that the search for commercial sterility or microbiological stability remains a very marginal application of ionization (Table 2).

Table 2. Ionization dose (in kGy) to ensure the radappertization of various foods.

Foods	Dose (kGy)	Temperature
Bacon	25.2	Room
Beef	41.2	−30 °C

Corned beef	26.9	−30 °C
Duck with orange sauce	21	−40 °C
Turkey	28	−40 °C
Ham	31.4	−30 °C
Pork	43.7	−30 °C
Pork sausages	25.5	−30 °C
Chicken	42.7	−30 °C
Mashed carrots and sweet potatoes	28	−40 °C
Madras rice	28	−40 °C

Adapted from Desmonts et al. [9].

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Keywords

ionizing radiations; e-beams; Gamma rays; food safety; shelf life; Biological hazards; Food quality



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