Gamma Rays' Effect on Food Allergen Protein

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Abstract

Many foods cause different kinds of allergies for so many people due to health problems. Recently, gamma rays have been used to minimize this problem by altering the protein allergen structure. The aim of this study is to represent the use of the gamma rays in allergen food treatment and to show what happened to food structures. It can be concluded that the use of the technique of irradiation by gamma rays may be an efficient solution for allergic foods.

Keywords: gamma radiation, food irradiation

1. Introduction

Many types of food induce different allergies and may lead to severe health problems.

Basically, preventing the allergic disorders requires to stop eating the food promoter of the allergic reaction. The food irradiation by specific ionizing radiation is used to improve the safety and storability and is one of the most extensively studied technologies since the radiation discovery.

There are some attempts to use gamma rays to minimize this problem by changing the protein allergen structure like some research that show this effect in eggs and milk allergenic protein, in shrimps, and in other allergic foods. These researches showed that the gamma radiation could minimize the quantity of the allergen by altering the promoter protein structure; this step may depend on the radiation dose.

The aim of this work is to show how to employ radiobiology for peaceful purposes and to help allergic people to consume more healthy and safe food.

2. Food allergy

Food is essential for life, usually a source of pleasure, and is usually related to the cultural identity of each population. Over a lifetime, a person eats about two or three tons of food. Not surprisingly, therefore, that diet is implicated in a wide variety of symptoms leading to disorders in the lives of individuals who believe they have food allergies [1]. Also according to the same authors, the first description of food allergy was made by Hippocrates more than 2000 years ago, but only from the 1980s extensive studies have begun to shed light on the different aspects of food allergy. Meanwhile, numerous publications led us to attribute any symptom in human to a certain allergic reaction to a particular food.

Etymologically, the word ALLERGY derives from the word ALLOS, which in Greek means altered state/other, and ERGON, which means energy/reaction, and was first introduced in 1905 by Austrian pediatrician Clemens von Piquet (1874–1924) to designate a clinical manifestation [2]. Moreira [3] defined allergy as a chronic disease characterized by an increase in lymphocyte capacity B to synthesize immunoglobulin isotype IgE antigens that enter the body by inhalation, ingestion, or penetration of the skin leading to an immune hyperactivity, allergic inflammation, and with 20% loss of body weight, when tested in animals process.

Already Pereira et al. [4] defined food allergy as an adverse reaction to a food antigen-mediated immune mechanisms fundamentally. They also reported that it is a nutritional problem, which showed a considerable growth in the last few decades probably due to greater exposure of the population to a larger number of available food allergens, it has become a health problem worldwide because it is associated with a negative impact on quality of life.

In general, allergy is a hypersensitivity reaction initiated by immunological mechanisms. Antibodies or cells may mediate the allergy. In most cases, the antibody responsible for allergic reaction belongs to the IgE isotype and those individuals are referred to as "suffering from an IgE-mediated allergy." Not all IgE-associated allergic reactions occur in atopic individuals. In non IgE mediated allergy, the antibody can belong to the IgG isotype, i.e., serum sickness previously referred to as reaction type III [5].

According to the same author, allergens are antigens, which cause allergy. Many allergens to react with IgE and IgG are proteins, often with carbohydrate chains that under certain circumstances they have been referred to as allergens themselves. Rarely, chemicals of low molecular weight such as isocyanates and anhydrides, which act as haptens are referred to as allergens.

Adverse reactions to food (ARF) is the name used for any abnormal reaction to food or food additives, regardless of their cause. These can be classified into intolerance and food hypersensitivity. Food intolerance is the term for an abnormal physiological response to food or food additives, not from immune nature. These reactions may include: metabolic abnormalities responses to pharmacological substances contained in foods, toxic reactions, among others. Food hypersensitivity and food allergy (FA) is the term used for the ARF, involving immunological mechanisms resulting in great variability of clinical manifestations. The mechanism involving immunoglobulin E (IgE) is the most commonly involved, which is characterized by rapid installation and clinical manifestations such as urticaria, bronchoconstriction, and possibly anaphylaxis. When no immune responses measured by IgE are involved, the clinical manifestations are established later (hours or days), making the diagnosis of FA [6].

When the ARF are caused by immunological mechanisms are said to FA, whereas when caused by toxic, pharmacological, metabolic, or idiosyncratic reactions to chemicals are said food intolerances [3, 6]. For this reason everything has mistakenly been considered allergies and intolerances as synonyms, and many of these adverse effects are blamed for promoting allergic processes [4, 7] and what are the main food allergens are nature protein [4].

Food allergy can begin in childhood and usually arises when the family has a history of atopic diseases (such as allergic rhinitis or allergic asthma). The first hint of allergic predisposition may be a rash as eczema (atopic dermatitis). Such rash may or may not be accompanied by gastrointestinal symptoms, such as nausea, vomiting, and diarrhea, and may or may not be caused by a food allergy [8].

According to the same author, children with allergies to certain foods probably will contract other atopic diseases as they grow as allergic asthma and seasonal allergic rhinitis. However, in adults and children over 10 years, it is very unlikely that food is responsible for respiratory symptoms, despite skin tests (skin) being positive. People who are allergic to foods may react violently to eat a minimal amount of the substance in question, can be covered with a rash all over the body, feel the throat ignite until it closes, and have breathing difficulties. A sudden drop in blood pressure can cause dizziness and collapse. This emergency, life-threatening problem is called anaphylaxis. Some people just suffer from anaphylaxis when exercising immediately after eating the food to which they are allergic.

And in recent decades, there has been an increase of allergic problems promoted by food in children and young people [4, 9]. This contributes negatively to the quality of life for the population and becomes a public health problem that affects the whole world [3, 4, 10, 11]. There is no specific treatment for food allergies, instead is necessary to stop eating foods that trigger.

Type I allergy is characterized by immunoglobulin E (IgE), which mediates hypersensitivity afflicting more than one fourth of the world population [1].

About 2.5% of the adult population suffers from some type of allergy and certainly unknown. Between 100 to 125 people die each year in the US because of an allergic reaction to foodborne [4, 12].

Anaphylaxis is the most severe allergic conditions seen by allergists and may quickly lead to death of healthy individuals and according to Lopes [13], ingestion of food allergens is a major trigger of anaphylactic reactions. Among the most allergenic foods for children are cow's milk and egg white, and for adults are crustaceans [13, 14].

3. Gamma radiation use in food

Radiation is a form of energy. It is in the form of atomic particle or electromagnetic energy such as alpha particles, electrons, positrons, protons, neutrons, etc., which can be produced in particle accelerators or reactors and alpha particles; electrons and positrons are also spontaneously emitted from the nuclei of radioactive atoms [15].

The sources of Cobalt 60 (Co^{60}) ($T_{1/2}$ = 5.263 years), using Co^{60} source, whose gamma rays have greater penetration power more than that from electron beams, the objectives of irradiating food can be achieved [16, 17]. The gamma rays are applied in large thickness or bulk foods, while the electron beam used in superficial irradiation [18].

According to the Codex Alimentarius [19], the following radiation sources are allowed:

(a) Gamma rays radionucleotides as Cobalt 60 (Co^{60}), and Cesium 137 (Ce^{137});

(b) X-rays generated by machines operating with power up to 5 MV;

(c) Electrons generated by machines operating at 10 MV or below.

Cardoso [20] says that unfortunately the great benefits of nuclear energy are little known. According to the author, every day, new nuclear techniques are developed in various fields of human activity, making it possible to perform tasks impossible to be carried out by conventional means. The research, industry, health, pharmaceutical, and particularly agriculture are the most benefited areas.

According to Nouailhetas [21], the use of ionizing radiation for the benefit of man, related to human health became evident. Throughout history, these effects have been identified and described mainly from situations in which man is found exposed acutely, either by accident or during medical use. Effects that may result from exposure to radiation in natural conditions have been little studied and poorly understood. Recently, studies have been conducted in order to better understand the role of these radiations by the life has been developed and is expected to issue new concepts about the biological effects of ionizing radiation.

When interacting with matter, different types of radiation can produce various effects that can be simply a color sensation, a perceived sensation of heat, and an image obtained by radiography. Radiation is called ionizing when it produces ions, radicals, and free electrons in irradiated matter. Ionization occurs when radiation has energy enough to break chemical bonds or expel electrons of atoms after collisions.

Due to the global needs of the food security and the problems, arising from inadequate storage and inadequate processing, contemporary agribusiness runs in constant development of new methods of preservation of agricultural products. Irradiation is a method of preservation on both levels: raw materials in nature and adjunct industrial processes [22].

The use of ionizing radiation in all lines of research such as agriculture, health, and industry generates much controversy due to mainly several nuclear accidents worldwide. Therefore, radiation for the population already may be a risk and harm to human health. People should know the difference between contaminated material with radioactive elements and materials processed by irradiation. Irradiators used for food processing are well secured. All safety rules and procedures are followed, which reduce the risks of using these devices in food irradiation process serving for disinfection, sterilization, control of insects and increase the shelf life of foods, delay in fruit ripening, inhibit sprouting, etc., without causing substantial damage to food. It is important to convince consumers that irradiated food does not become radioactive and toxic waste and can be consumed immediately after irradiation process [23].

According to the same author, irradiation is an effective technique in food preservation because it reduces natural losses caused by physiological processes such as sprouting, ripening and aging, and eliminating or reducing microorganisms, parasites, and pests without causing any damage to food, making them also safer for the consumer. The process consists of submitting them already packaged or in kind to a controlled amount of radiation for a given time and set goals. Irradiation can prevent the multiplication of microorganisms such as bacteria and fungi that cause deterioration or losses in products not only by altering the molecular structure but also by inhibiting the maturation of some fruits and vegetables by changes in the physiological processes of the plant tissue.

For Landgraf [24], there is no doubt that the main objective of the use of ionizing radiation in food is to make them safe by reducing the population of pathogenic microorganisms and deteriorating to undetectable levels, and thus increasing the life of products and ensuring their safety. This technology can also be used for other purposes such as to inhibit sprouting of onions and potatoes, insect infestation control, quarantine treatment, and change of allergenic foods, among other applications.

The irradiation has the following advantages over treatment with chemicals, heat treatment or a combination of both. It is a continuous and very efficient process that ensures complete disinfection of products. It leaves no residue in fruits and tends to slow the ripening of climacteric fruit without deteriorating storage time [25].

Importing and exporting countries have shown interest in irradiation technology, conducting research for this application due to increased international trade in food and the growing regulatory requirements of consumer markets [26].

The effects of irradiation on food depend on the food type, the kind of radiation, and its dose. The irradiated products can be transported, stored, and consumed immediately after treatment. In 1983, a working group from the United Nations established standards and set the dose limits; they recommended 10 kGy as the upper limit in food irradiation [27, 28].

The absorption of electromagnetic radiation by biological tissues that constitute the food is a function of the electronic excitability of the constituent molecules. In the case of gamma radiation, the electronic excitation produced is sufficient to eject electrons from orbitals, resulting in their molecular ionization. One of the most important free radicals induced by radiation is the formation of the hydroxyl radical (HO─) that is involved in the initiation and propagation reactions [29].

Food irradiation was supported by FAO/WHO, being that the FDA, in 1963, considering the irradiation of food a safe process, as well as an important tool for preventing poisoning and food infections, approving its use for a variety of foods [13, 30, 31].

For all food submitted to food irradiation, the Radura symbol can be used to identify the process (**Figure 1**), which should be placed on irradiated food packages in many countries of the world. The Radura symbol originated from and was copyrighted by an irradiation

Figure 1. The Radura symbol.

food processing facility located in Wageningen, Netherlands in the 1960s. Then, President Jan Leemhorst of the company called Gammaster recommended its use as an international label to be placed on irradiated food as long as manufacturers implemented appropriate quality parameters. The Radura symbol is listed in the Codex Alimentarius Standard on Labelling of Prepackaged Food. The FDA requires that foods that have been irradiated bear the "Radura" logo along with the statement "Treated with radiation" or "Treated by irradiation." [31].

4. Irradiation of allergenic proteins

Irradiation may cause irreversible changes in the molecule by breaking covalent and conformational changes. Therefore, it is an attractive option to cause the breakdown of the possible allergenic structures naturally present in various foods [32–35].

Gutierrez et al. [36] found that irradiating a cheese dish, which was in the maturation of casein proteolysis yields compounds of low molecular weight and those with increased irradiation doses showed decreased percentage of non-protein nitrogen.

Harder [37] introduced the use of gamma radiation to minimize the effects of allergenic ovomucoid laying hen eggs protein and noted the potential of this technology for this purpose. According to Ma et al. [38], the yolk protein is more susceptible to breakage than proteins of white egg. The chemical change of the radiation in the egg and yolk powder, irradiated in the presence of oxygen, induces degradative changes of the lipid components: a lipid hydroperoxides accumulation and the destruction of carotenoids. For the food industry, this is as important as the deterioration of functional proteins such as egg withe powder foam and the emulsifying ability of the yolk.

Jankiewicz et al. [39] studied the stability of the immunochemical allergen in celery roots, including gamma radiation (10 kGy) and concluded that the allergenicity was only slightly reduced at this dose. Similarly, in studies with cashew nuts, Su et al. and Venkatachalam et al. [40, 41] used doses up to 25 kGy where the major allergens showed stability. In contrast, Byun et al. [42] found effects of decreasing allergenicity of potentially allergenic foods as increasing dose of gamma radiation used, aiming beta-lactoglobulin protein in cow's milk, hen egg albumin, and shrimp tropomyosin using doses up to 10 kGy as shown in (**Figure 2**).

Sinanoglu et al. [43] completely inactivated the allergen shrimp tropomyosin by irradiating them at a dose of 4.5 kGy confirming the results of Zhenxing et al. [44] but found that at doses lower than 5 kGy allergenicity increases. Leszczynska et al. [45] used doses up to 12.8 kGy in wheat flour gliadin irradiation and noted small increase in ω-gliadin as the dose of radiation increases.

Although similar amino acid irradiation cannot be directly extrapolated to peptides or proteins, in any event, the contribution is observed that more complex amino acids and peptides provide valuable insights in the study of more complex proteins. A lesser extent of free amino acids and peptides is also present in food and meat (approximately 2%), and therefore, they are treated as separate food components and not merely as "building blocks" of proteins. The soluble fraction of the flesh, the sarcoplasm consists of approximately 25–30% of the total protein content. It consists of enzymes (glycolytic, etc.), myoglobin, amino acids, nucleotides (ATP, ADP, NAD, FAD, etc.), carbohydrates (glucose intermediates), lactic acid, etc.

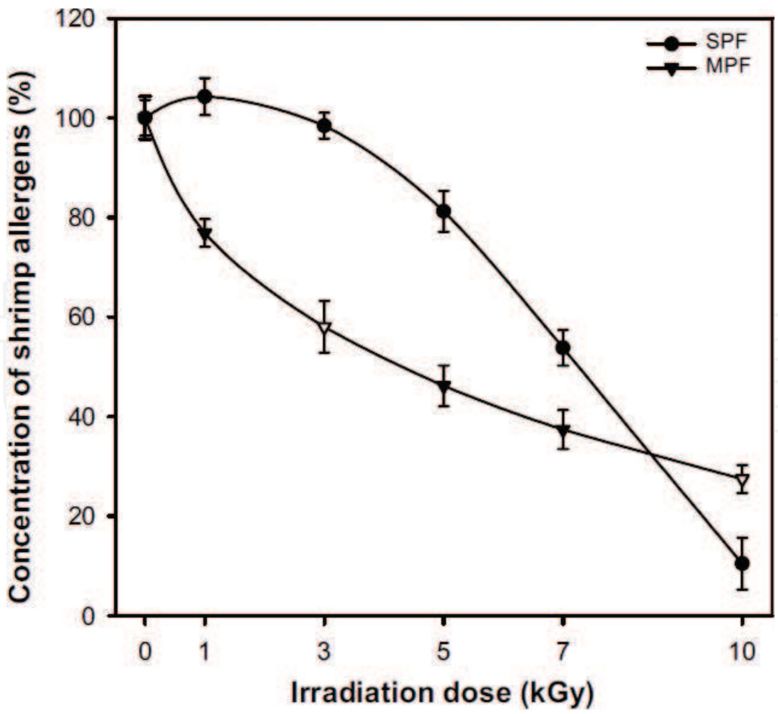

Figure 2. Concentration of allergens in gamma-irradiated shrimp extracts detected by shrimp-hypersensitive patients' IgE. The concentration was measured by CI-ELISA formatted with shrimp tropomyosin as standard allergen. SPF and MPF indicate sarcoplasmic protein fraction and myofibrillar protein fraction, respectively [42].

In view of limited number of detailed studies that have been conducted, only few can cause widespread attempts over protein-OH reaction. The fraction of highest reactivity is located exactly on the aromatic and heterocyclic amino acid in the protein. Therefore, more than 3% of OH radicals are involved in the separation of the C─H bond. Approximate calculations regarding the reactivity of the protein can be applied using constant proportions to amino acid constituents. The distribution of attack, the entire route can depend on the conformation of the protein. Deeply groups as ─SS─ are expected to be less accessible to the OH radical. The experimental determination of k value for OH radical reaction, i.e., alcohol dehydrogenase, catalase, lysozyme ribonuclease, tripisin, trypsinogen, etc., is too high, on the order of 1011 m^{-1} s^{-1}, mainly for its broad size, which increases the frequent meeting and multiplication of reactive sites. The radiation interaction may lead to protein deamidation, breakage of peptides, and disulfide bond, in addition to aromatic residues, heterocyclic amino acids, and metmyoglobin reduction, and the extent and rate of these reactions depend on the conditions and the proteins in this system. These reactions are endless for the variety of radiological products found in irradiated foods. In freezing systems, the OH radical contribution will greatly decrease and only a small fraction of the OH radical inducing products will be present in radappertization food. However, recognition of those products is desirable [46].

In general, there are few researches that have focused on the use of gamma radiation to reduce the allergenicity in food taking into account the protein kind or extrapolating this to the amino acid level. There is a real necessity for additional studies to define the suitable conditions to submit the food for the optimum gamma ray treatment.

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