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STUDIES REGARDING THE SAFETY AND CONTROL OF IRRADIATED FOOD

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Abstract: *Food irradiation is a preservation technique that uses ionizing radiation and has minimum influence on food properties. Food safety studies shown that it doesn't generate noxious compounds in the food structure. Food irradiation can ensure safer foodstuff (by inactivating pathogen microorganisms) and higher quantities of foodstuff (by increasing the validity period). The detection of irradiated food is an activity in the benefit of the consumer that regards for the collective security of foodstuff. The paper is bringing out a physical method for the detection of irradiated food, Electron Spin Resonance (ESR) Spectroscopy. This method is sophisticated and it requires qualified personnel for an adequate application.*

Key words: *preservation technique, ionizing radiation, collective security, ESR spectroscopy.*

1. Introduction

Food irradiation is the process of treating food with ionizing radiation of well known and controlled energetic levels [1].

The generic notion "irradiation" appeared later in the scientific literature (by the 1940s) and it brought a conceptually misleading association of the term with the nuclear field. This association is especially strong in some languages, in which the term "food irradiation" and "radioactive food" are almost undistinguishable terms [4].

Some authors consider that in the actual context, for describing this technique, the French term "ionization" should be adopted, that is already used by French-speaking countries that have or are developing regulations in this field. Other proposal, stated by E. Wierbicki is to call irradiated food "picowaved", in correlation with the very short wavelength of ionizing radiation and taking into consideration the present acceptance of the term "microwaves". Another term, used in the United States is "electronic pasteurization", whereby the inactivation of pathogenic bacteria is described [4].

When ionizing radiation penetrates through a food product, all the amount of energy or a part of it is absorbed by that medium. This energy, proportional to the product's mass is called the dose of absorbed energy (the dose). The unit of measurement for the dose is 1 Gray (Gy) that is equal to 1 Joule/kg. In the case of food radiation processing, the dose is measured in kGy (1,000 Gy) [1].

Ionizing radiations are beams that have sufficient energetic levels to push out electrons from atoms and molecules,

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converting them into specific particles, with electric charge, named ions [2].

In the field of food irradiation there are four radiation sources: gamma (γ) rays, from the radio nuclides $^{60}Co^{*}$ and $^{137}Cs^{*}$, x-rays and electrons generated from machine sources. At present, the most frequently used source for commercial irradiation is $^{60}Co^{*}$ [1].

Although named a "new technology", food irradiation is anything but new. Studies written by Josephson (1983) and Diehl (1990) state that the idea of using ionizing energy for the treatment of food has already been expressed starting from the late 1800s [4].

Radioactive radiations are not uniform. If the radiations emitted by a radioactive source are passed through a magnetic field, they are deflected differently. Radioactive substances develop three types of radiation namely α, β and γ [1].

Radioactive substances may contaminate the environment, the drinking water, food and therefore having adverse effects on the human or animal organisms [5].

2. Objectives

Although food irradiation has been and still is controversial subject, scientific information presented in this paper may contribute to the documentation of the fact that the technique is safe for the consumer [3].

By using this food preservation technique, you obtain microbiologically safer food products that have their functional properties unaltered [3].

It is important that consumers be well informed, therefore in the specific area of this technique, there have been developed methods for the control and identification of food treated by ionizing radiation. Labeling is also stipulated, but producers tend to avoid this aspect, because of the negative image that this processing technique has. The control techniques of irradiated food are sophisticated and need qualified personnel. More than that, in Romania there is only a facility (the IRASM center) that carries out this sort of activity [3].

3. Materials and Methods

This paper aims to present the benefits and the risks of processing food by ionizing radiation, but also to describe the methods for consumer information, although the technique has been proved to be safe. Consumers have to be aware of anything that they buy and eat, because of the high incidence of food borne illness as nowadays.

The detection method described in this paper is *Electron Spin Resonance (ESR) Spectroscopy,* a physical method that detects species with unpaired electrons, for example free radicals. Ionizing radiation produces free radicals in food and since ESR spectroscopy detects free radicals, it can be used to determine whether certain foods were irradiated [1].

All three ESR methods for the detection of irradiated food, that contain cellulose, bone or crystalline sugar are easy to apply, nondestructive and the apparition of the ESR signals that are specific to irradiated food is proof that the sample was treated with ionizing radiation [3].

However, for a reliable detection, the ESR spectrometry has to be very well understood. The ESR equipments are relatively expensive, if a national laboratory analysis chain is intended to be organized [3].

The personnel that should perform this kind of analysis would have to be very well qualified, because of the difficult interpretation of the signals generated by the ESR equipment's software.

3.1. Results interpretation of ESR analysis method

3.1.1. Samples that contain cellulose

For irradiated samples, a pair of lines appears, along with the specific signal. The detection limits and stability are parameters that are influenced by the content of crystalline cellulose and the water content of the samples [7].

Therefore, the positive identification of cellulose radicals is a proof that the sample was irradiated, and the absence of this signal doesn't indicate the fact that the sample hadn't been treated with ionizing radiation [7].

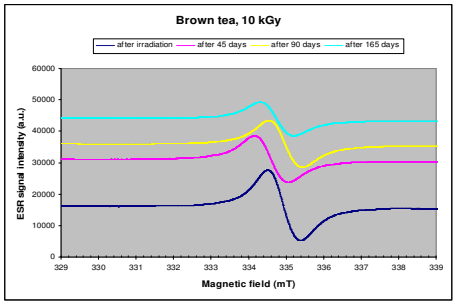

Fig. 1. *ESR spectra of irradiated brown tea*

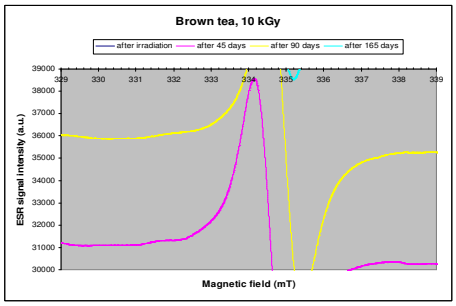

Fig. 2. *Detailed ESR spectra of Fig. 1*

As can be seen in Figures 1 and 2, the brown tea sample didn't show the specific signal of irradiation, not even when treated at the highest dose of 10 kilo - Gray (kGy).

3.1.2. Samples of bone

Because the specific signal of irradiation is due to the hydroxyl-apatite, the main constituent of the bone, the method is expected to be extended to all sorts of meat and fish that contain bone [6].

The detection limits depend on the bone's degree of mineralization, and this is generally lower in the case of small size animals [6].

The detection of the bone samples that were irradiated is possible even at low doses of irradiation, so this is available for all commercial applications [6].

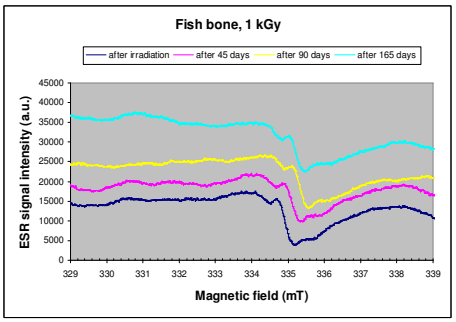

Fig. 3. *ESR spectra of irradiated bone*

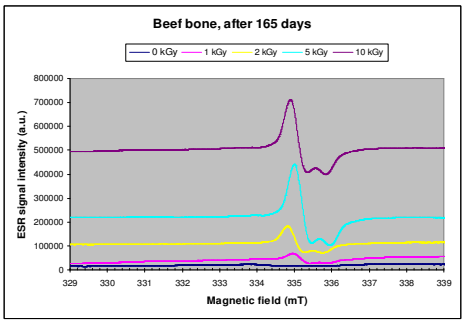

Fig. 4. *ESR spectra of bone, after 165 days*

As can be seen in Figure 3, the sample of fish bone treated with 1 kGy shows a well represented specific ESR signal of irradiated food. The specific signals of irradiated bone samples are very long lasting (Figure 4).

3.1.3. Samples containing crystalline sugar

Irradiated samples that contain crystalline sugar show typical multi-component ESR spectra that reflect the presence of radio induced radicals [8].

But, because of the differences between monosaccharides and disaccharides and because of the changes in the saccharide composition, different ESR spectra may appear [8].

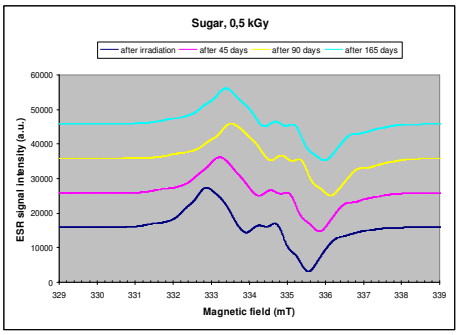

Fig. 5. *ESR spectra of irradiated sugar*

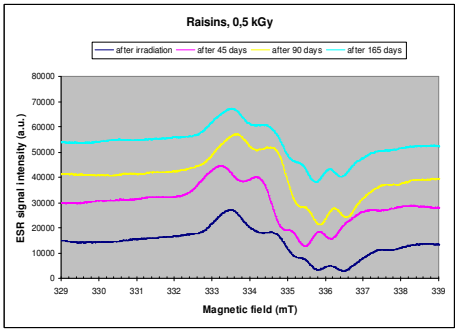

Fig. 6. *ESR spectra of sugar containing sample*

In the case of samples containing crystalline sugar, the multi-component ESR spectra are very well represented even at the lowest dose of 0.5 kGy (Figures 5 and 6).

While the process of radical development in the case of irradiated samples is a common one, the process of identifying specific radicals that are responsible for the characteristic signals, has not yet been totally discovered. Still, the association between radiation treatment and the signals illustrated in the above presented figures has been demonstrated in some studies [3].

The ESR specific spectra gives proof that the samples were irradiated, as the absence of the specific ESR signal is not an evident proof that the samples has not been irradiated [3].

4. Results and Discussion

4.1. The safety of irradiated food

Every food processing technology has to add a benefit to the food product, but most important it must not alter food properties or its structure.

The effects of treating food with ionizing radiation have been observed in the structure of all the food components (carbohydrates, proteins and fats), but these proved to be very little represented. In a complex matrix, as the food is, the constituent components carry out a degree of mutual protection, so the individual degradation of the specified components is diminished [4].

So, it is very important to understand that the tests carried out in the laboratory that were focused upon pure solutions, are not very adequate when we refer to the food product.

Radio-lythical changes in food structure, when the ionizing radiation interacts with the food products, are very little represented, these are not more pronounced than in the case of classical processing of food (cooking) [4].

Clinical studies on humans, although they didn't highlight any adverse effect, don't offer a satisfying data base, on the grounds of which the general extension of the irradiation process be adopted, for any food product on account on its being safe [4].

Studies have shown that 2-alkylcyclobutanones (2-ACBs), compounds

that are specific to the irradiation of fatty products, have cytotoxic effects, as well as a capacity to deteriorate DNA [4].

Although it is almost impossible to evaluate a food processing technique as being 100% safe, it seems that irradiated food products don't represent a risk for the consumer, when they are consumed as a part of a balanced diet [4].

Radiation processing of foodstuff was demonstrated to be safe and efficient, reducing or even eliminating a great number of biological risks [4].

4.2. Control methods for irradiated food

The methods for the detection of irradiated food are based on the physical, chemical and microbiological changes that, although minimal, are induced in the food structure, during the irradiation process.

Apart from the method described in the preceding chapters, there are many other detection methods for irradiated food: viscosity measurement, electrical impedance measurement, the detection of 2-alkylcyclobutanones, gas evolution, the DNA "Comet Assay", immunologic detection of modified DNA bases, Direct Epifluorescent Filter Technique, combined with Aerobic Plate Count (DEFT/APC), and others [4].

It is worth noticing the great number of detection methods for irradiated food, but the great majority of these tests is relatively sophisticated and need highly qualified personnel.

4.3. Market surveillance

The first patents in the field of food irradiation are 100 years old (Great Britain and USA, 1905), but the negative view of nuclear radiations in the past 60 years leads to the fact that this technology be received with a lot of fear from the public opinion and strong rejection from non-governmental organizations [1].

The initiator of the study and standardization of the detection and control of irradiated food is the European Union. The Directive 1999/2/EC states that every Member State has to survey the internal market regarding the conformation to the communitarian regulations on the subject of food irradiation. According to the first Report of the EC regarding food irradiation (September 2000 - December 2001), in the European Union, there were analyzed over 6.500 food samples, out of which about 1.5% were detected as being irradiated and not labeled [1].

Because of the great variety of food products and their different characteristics, a standard method of detection for irradiated food hasn't been developed yet. The detection can be done only at qualitative level (irradiated/non-irradiated), but not at a quantitative level (the irradiation dose) [1].

Nowadays, in Romania, the official control of irradiated food is not applicable [1].

5. Conclusions

As a Member State in the European Union, Romania should abide by the regulations that refer to food safety and that should be an overriding priority for national authorities. Regrettably, economical interests are above all important issues that can make a difference. For example, the monitoring of some aspects regarding the degree of healthiness and hygiene of food products could finally lead to a better general state for the global population.

Although food irradiation proved to be a safe process, its application even further benefiting food safety by inactivating microbiological risks (the first discovered food risks), labeling and market surveillance are still a problem in Romania and in other countries.

The problem of food safety is more and more acute nowadays, because of the development of the free market. Food products originate from a lot of places, from many producers, so it's very hard to have control upon what eventually enters the food market and that's also valid in the case of irradiated foodstuff.

Food irradiation can be a solution for food preservation and processing in the future, but the technological aspects and influences upon food have to be clearly brought forth to the public opinion.

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