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The use of ionising radiation in the food industry as a mechanism for ensuring food quality and safety under Algerian law

Dr. Rekai Ghenima

Lecturer Class A, Faculty of Law and Political Science, University of Blida 2, Law and Real Estate Laboratory, Algeria, Email: g.rekai@univ-blida2.dz

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Abstract

The treatment of foodstuffs using ionising radiation technology is a modern method employed in the food industry to eliminate or reduce certain microorganisms, insects and parasites, prevent germination and extend the shelf life of food products, all while preserving their properties within the limits permitted by practical and technical standards. This technique can replace chemical preservatives and fumigation. This requires the establishment of regulations governing irradiation facilities, compliance with legally required doses and the mandatory inclusion of information for the labelling of irradiated foods. These foods must also be subject to supervision by the competent authorities.

Keywords: Irradiation facility, food irradiation, consumer safety, required doses, prior control.

Introduction:

The availability of food that is safe and free from biological contaminants, such as bacteria and insects, as well as contaminants resulting from the excessive use of pesticides and chemicals, is essential for life on Earth to continue. However, countries are facing shortages in providing sufficient quantities of healthy food for their populations due to the continuous increase in food losses caused by the destruction and spoilage of food by insects and other pests.

Health authorities worldwide suffer from diseases resulting from consuming food contaminated with microorganisms such as Salmonella[1], which pose a real threat to public health. Meanwhile, pathogenic parasites continue to increase despite awareness of the need to apply health requirements and good practices at all stages of food processing, using preservation methods and chemical treatment.

Furthermore, producers seek to manufacture food economically in large quantities, using additives to extend storage periods, as well as enhancers to make the food more attractive in terms of its colour, flavour and taste, within the recommended limits for determining the minimum...

Therefore, anyone involved in placing foodstuffs on the market for consumption must ensure these products are safe and do not harm consumers' health and safety[2].

Since its establishment in 1957, the International Atomic Energy Agency (IAEA) has worked to promote the safe and peaceful use of nuclear technologies in various scientific, technological and economic fields, including food and agriculture, while recognising the need for nuclear technologies and their applications to play a clear and multifaceted role in sustainable development processes[3].

Ionising radiation treatment technology was introduced as a complementary technique to existing technologies. It is also considered the optimal technique for food sterilisation, providing an alternative to chemical fumigation and physical methods.

Regulations require certain contaminated foodstuffs to undergo appropriate treatment to reduce the level of contamination before they are made available for consumption, provided the treatment method is scientifically and technically acceptable. Such foodstuffs cannot be stored with other foodstuffs intended for direct human consumption or use as food ingredients unless they have undergone treatment first.

Furthermore, foodstuffs containing mycotoxins cannot be treated using chemical methods[4].

The importance of food irradiation lies in its direct relationship with protecting consumer health and ensuring food safety. It also plays a role in reducing food losses and improving storage, transportation and handling conditions. However, its use also gives rise to a number of legal and technical requirements, particularly with regard to radiation sources and doses, facility supervision, and labelling and information requirements. The aim is to strike a balance between benefiting from irradiation technology and protecting consumers.

The following research question therefore arises: To what extent does the treatment of food by ionising radiation enhance food safety and protect consumer health?

To answer this question, I have divided the subject into two sections. The first section is entitled 'The Conceptual Framework of Irradiated Foods', while the second is entitled 'The Legal and Technical Requirements for Subjecting Food to Ionising Radiation'.

Section One: The Conceptual Framework of Irradiated Foods

At first glance, the term 'radiation' may evoke a sense of danger. However, this scientific process ensures the safety of food for every consumer. This technology uses radiation to eliminate food contaminants and produce high-quality food products that are free from microorganisms and insects that are harmful to human health.

This technology has been established by the legislator under Presidential Decree No. 05/118 concerning the ionisation of foodstuffs[5]. In this section, I will first address the concept of irradiated foods, followed by the types of irradiation approved by the relevant authorities and permitted by law.

First: The Concept of Irradiated Foods

Irradiation has emerged as an appropriate scientific method for addressing food safety challenges and reducing risks that may affect food quality and suitability for consumption. Accordingly, it is considered a modern technology that reduces food spoilage caused by the microorganisms responsible for deterioration. It also helps to minimise food losses and maintain product quality and safety during storage, transportation and distribution[6]. In certain cases, it can also eliminate the need for continuous refrigeration, helping to maintain freshness and the natural properties and nutritional value of food.

Therefore, it is necessary to define food (1), explain the meaning of irradiation (2), and then address irradiated foods (3).

1. Definition of foodstuff

Foodstuff is defined in Article 3(1) of Law No. 09-03 concerning Consumer Protection and the Suppression of Fraud as follows: 'Any processed, partially processed, or raw substance intended for human or animal consumption, including beverages and chewing gum, and all substances used in the manufacture, preparation, and processing of food, excluding substances used solely as medicines, cosmetic products, or tobacco products.'

It is also defined in Article 2(1) of Presidential Decree No. 05-118 of 11 April 2005 concerning the ionisation of foodstuffs as follows: 'Foodstuffs' shall mean 'any raw substance or substance processed into a finished or semi-finished product intended for human consumption, as well as any other substance involved in the manufacture, transformation or processing of a 'foodstuff'. Cosmetic products, tobacco, and medicines are excluded.'

These two definitions make it clear that the legislator has adopted a broad concept of 'foodstuff', taking into account its nature, the stages of its production, transformation and processing, and its intended purpose. The two definitions complement each other: the definition in Law No. 09-03 establishes the general framework for the concept of foodstuffs in the context of consumer protection and the prevention of fraud. In contrast, the definition in Presidential Decree No. 05-118 is a specific application of this concept in the context of food irradiation.

2. Definition of Food Safety

In Article 3 of Law No. 09-03 concerning Consumer Protection and the Suppression of Fraud, the legislator defines food safety as follows: 'The complete absence of, or the presence at acceptable and harmless levels in a foodstuff of, contaminants, adulterated substances, natural toxins, or any other substance that may render the product harmful to health, either acutely or chronically.' Food safety therefore means the absence of harm to human health resulting from food consumption.

According to the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), food safety is defined as follows: 'All the conditions and standards necessary throughout the processes of food production, manufacturing, preparation, processing and distribution, which are required to ensure that food is safe, wholesome and suitable for human consumption[7].'

3. The meaning of irradiated foods

Scientific and technological advances in the food industry have given rise to modern methods that aim to ensure food safety, extend shelf life and reduce risks to consumer health. One of the most prominent of these methods is ionising radiation technology. This technique involves exposing foodstuffs to specified doses of ionising radiation in accordance with certain technical and regulatory conditions, with the aim of eliminating or limiting the activity of microorganisms and pests. This improves the health and safety of food products without making them radioactive. Therefore, the scientific and legal meaning of irradiated foods must be examined.

A. Radiation

It is commonly referred to as 'cold pasteurisation'. It refers to energy that can penetrate the objects it encounters, either wholly or partially, affecting them according to the amount of energy absorbed.

B. Scientific definition of ionising radiation

The World Health Organization (WHO) defines it as a type of energy released by certain atoms and transmitted in the form of electromagnetic waves (gamma rays or X-rays) or particles (beta or alpha particles, and neutrons). The spontaneous disintegration of atoms in this way is called radioactivity, and the excess energy emitted during disintegration constitutes a form of ionising radiation. Unstable elements that disintegrate and emit ionising radiation are called radio nuclides.

C. Jurisprudential definition of ionising radiation

Legal scholars have defined it as follows: 'The deliberate exposure of a food product to gamma radiation emitted by a radioactive source, X-rays or a beam of accelerated electrons.' The irradiation of the product is subject to the full control of those responsible for carrying out the process[8].'

D. Legislative definition of ionising radiation

It is defined in Article 2 of Presidential Decree No. 05/118 as follows: 'Any electromagnetic or particulate radiation that may cause the material exposed to it to become ionised, either directly or indirectly.'

This definition is almost identical to that adopted in Article 4 of Law No. 19/05 of 17 July 2019 concerning nuclear activities. 'The transfer of energy in the form of particles or electromagnetic waves capable of producing ions in matter, either directly or indirectly.'

E. Definition of irradiated foods

Irradiated foods are defined as foods that have been deliberately treated with specific types of radiant energy to produce desirable effects such as preventing germination, delaying ripening, eliminating disease-causing bacteria transmitted through food and extending shelf life.

Food irradiation is a physical process that uses ionising radiation from radioactive isotopes such as cobalt-60 or caesium-137, or from accelerators that produce controlled levels of gamma rays, X-rays or electrons. This process ensures food safety by sterilising food and eliminating microorganisms, parasites, insects and other pests.

D. The legislator defines irradiated foods as follows in the aforementioned Presidential Decree No. 05/118[9]: 'Any foodstuff that has undergone treatment using ionising radiation, excluding foods exposed to radiation for inspection purposes.'

This definition clearly adopts both functional and technical criteria. On the one hand, food is classified as irradiated if it has undergone treatment using ionising radiation. On the other hand, the scope of this concept is defined by excluding exposure to radiation for measurement and monitoring purposes[10].

H. Radioactive foods are also excluded: foodstuffs that have become contaminated with radioactive substances accidentally, for example from nuclear weapons tests or nuclear reactor accidents. This type of contamination is unrelated to irradiated foods, which have been deliberately treated for preservation purposes.

E. Definition of irradiated foods

Irradiated foods are foodstuffs that have been deliberately treated with specific types of radiant energy to produce desirable properties such as preventing sprouting, delaying ripening, eliminating disease-causing bacteria transmitted through food and extending shelf life.

The process of food irradiation uses ionising radiation from radioactive isotopes of cobalt-60 or caesium-137, or from accelerators that produce controlled levels of gamma rays, X-rays or electrons. This ensures food safety and sterilises food by eliminating microorganisms, parasites, insects and other pests[11].

The legislator defines irradiated foods as follows in the aforementioned Presidential Decree No. 05-118: 'Any foodstuff that has undergone treatment by means of ionising radiation, excluding foodstuffs exposed to radiation for monitoring purposes.'

This definition is both functional and technical. On the one hand, food is classified as irradiated if it has undergone treatment by means of ionising radiation. On the other hand, the scope of this concept is defined by excluding exposure to radiation for measurement and monitoring purposes.

Foods with radioactive activity are also excluded, namely foodstuffs that have become contaminated with radioactive substances accidentally, for example from nuclear weapons tests or nuclear reactor accidents. This type of contamination is unrelated to irradiated foods that have been deliberately treated for preservation purposes[12].

Thus, it is evident that ionising radiation enhances the safety of various foodstuffs, whether of animal or plant origin. The process of food preservation by irradiation involves exposing food, whether packaged or unpackaged, to a calculated quantity of ionising radiation (gamma rays or X-rays) under precise and controlled conditions[13]. This process is highly accurate and monitored according to a predetermined programme over a specified period of time to achieve a particular objective, such as preventing sprouting in vegetable crops, killing insects in grains or eliminating microorganisms in meat and fish.

Food irradiation, also known as ionisation, involves treating foodstuffs with high-energy radiation. This exposure causes reactions and modifications to the molecular structure of food cells and microorganisms. However, the maximum permitted energy levels do not allow interaction with the nuclei of the food; consequently, irradiated food cannot become radioactive

itself[14]. In other words, irradiation involves exposing food products to a specified and authorised dose of high-energy, massless ionising radiation for a particular period of time inside a sealed irradiation unit. Packaged food is conveyed on an automated conveyor belt into a chamber with thick concrete walls, where it is exposed to radiation according to its type, ensuring the appropriate dose is absorbed.

Therefore, irradiated food cannot become radioactive, since the types and doses of radiation used for food ionisation have been carefully tested to ensure they do not increase the food's natural radioactivity[15].

Thus, irradiation is considered one of the most recent methods of food preservation and is referred to as cold sterilisation or radiation sterilisation. It requires a high level of expertise and technical proficiency due to its risks and substantial costs.

Third: types of irradiation and legally approved doses

The type of irradiation varies according to the nature and characteristics of the radiation source used. The effectiveness of the treatment also depends on compliance with the legally specified radiation doses for each type of food. It is therefore necessary to identify the types of irradiation and the legally approved doses, as these constitute some of the most important safeguards governing the use of this technology in the food sector.

1. Types of irradiation under Decree No. 05/118 concerning the ionisation of foodstuffs

The types of radiation and their sources authorised for use in food preservation and treatment must be safe. The sources and their energy levels have also been specified. Pursuant to Article 5 of Decree No. 05/118, treatment using ionising radiation is authorised only when emitted by sources of cobalt-60 (^{60}Co) or caesium-137 (^{137}Cs), or by electron-beam-generating devices with an energy of no more than 10 megaelectronvolts (10 MeV) or X-ray-generating devices with an energy of no more than 5 megaelectronvolts.

These types of radiation and their sources are approved by the World Health Organization (WHO), the Food and Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA).

2. Determination of Legally Approved Doses

The dose is considered one of the most important elements governing the irradiation process. Irradiation must not be treated as a uniform process applicable to all foodstuffs, since the required dose varies according to the nature of the product and the purpose of the treatment. The objective of irradiation may be to reduce microorganisms, eliminate certain insects, control certain parasites, inhibit sprouting, or extend shelf life. Accordingly, the use of an inappropriate dose may result in failure to achieve the intended objective or may affect food quality[16].

Although the maximum permissible radiation dose for foodstuffs is determined by the International Council for Radiation Protection, the Commissariat for Atomic Energy in Algeria is responsible for supervising the monitoring of the permissible limit[17]. This body was regulated by Presidential Decree No. 96/436 of 1 December 1996, as amended by Presidential Decree No. 23/398 of 7 November 2023, concerning the establishment, organization, and operation of the Commissariat for Atomic Energy[18].

Accordingly, the operator of an irradiation facility must ensure that the treated material has received at least the minimum effective dose. This dose must fall within the recommended and appropriate range for each type of material and intended purpose[19]. The applicable absorbed doses for each category of foodstuff shall be determined by a joint order of the ministers responsible for trade and agriculture[20].

Furthermore, every operator of an irradiation facility must maintain a register indicating information relating to each batch of treated foodstuffs, in particular the nature and quantity of the irradiated foodstuffs, the batch number and its recipient, the date of the irradiation process, the type of packaging used during treatment and the results of dose measurement checks carried out. This register must also include precise identification of the minimum and maximum limits of the absorbed dose and the type of radiation, as well as any incident occurring during the irradiation process.

The unit of absorbed dose is the gray (Gy), representing the average energy transferred by ionising radiation to a mass of material. One gray is equal to one joule per kilogram of irradiated material. The Codex Alimentarius Commission of the World Health Organization and the Food and Agriculture Organization currently recommend a dose that does not exceed 10,000 grays, commonly expressed as 10 kilograys (kGy). This corresponds to a very small amount of energy, equivalent to the heat required to raise the temperature of one litre of substance by 24°C. Despite this small amount of energy, food undergoes minimal changes during irradiation and is considered suitable for human consumption.

The Joint Expert Committee of the Food and Agriculture Organization, the International Atomic Energy Agency and the World Health Organization is responsible for evaluating the safety of irradiated foods. During meetings held in 1969, 1976 and 1980, the Committee assessed the suitability of such foods for human consumption. In 1980, the Expert Committee concluded that treating any foodstuff with radiation at an average dose not exceeding 10 kGy did not pose any toxicological risks. Consequently, additional toxicological testing of the product was no longer considered necessary[21].

Section Two: Legal and Technical Requirements for Subjecting Food to Ionising Radiation

The irradiation process must always be carried out within an approved facility (first). Foodstuffs must also be inspected (Second), packaged in accordance with the required specifications and food quality standards (Third), labelled in accordance with the prescribed method (Fourth), and consumers must be informed about irradiated foods (Fifth).

First: Facilities for Food Irradiation

Food irradiation is carried out in a specially designed, fully secure facility known as an irradiation unit or facility. These facilities must be registered in order to obtain accreditation and authorisation from the competent authorities to treat foodstuffs using ionising radiation[22].

Every facility must comply with radiation protection requirements and hold a licence issued by the Commissariat for Atomic Energy in accordance with applicable procedures.

The application must include a set of requirements designed to provide prior protection for workers. It must be accompanied by a radiation protection competence certificate or a radioactive materials handling qualification certificate, issued to the persons responsible for handling ionising radiation sources[23].

The facility operator must also ensure that all irradiation-related operations are carried out in accordance with a quality assurance programme that has been approved by the relevant department of the Ministry of Trade and the Commissariat for Atomic Energy.

The quality assurance programme must allow verification of the following:

- That the facility and its equipment are designed, manufactured and operated in accordance with operational safety requirements.

- That irradiation treatment is carried out under optimal technical and scientific conditions to ensure health and prevent harm or interference with physiological functions, while preserving the nutritional properties of the irradiated foodstuffs.

The facility and its equipment must comply with applicable technical and safety standards, and the irradiation process must be carried out under the supervision of competent bodies capable of monitoring radiation sources and the doses used.

The operator must also ensure that irradiated and non-irradiated materials are physically separated and that the necessary measures are implemented to ensure the packaging is equipped with a dose indicator that distinguishes between the two types of material by visual inspection.

Second: supervision of the food irradiation process within the facility.

Given its multiple functions, food irradiation technology is considered an effective and safe method, particularly in protecting the environment, and an alternative to the use of harmful chemicals[24]. It also plays a vital role in improving food hygiene and reducing the incidence of diseases resulting from consuming contaminated food by eliminating or reducing the number of pathogenic microorganisms and parasites present in food. Therefore, treatment methods must not damage the essential quality of the product or result in the formation of other harmful residues. These methods must comply with Algerian standards, or with applicable international standards in their absence.

To ensure safety, the legislator has subjected irradiated foods to monitoring for radioactive isotopes in cases where the legally required dose is exceeded, as this may lead to radioactive contamination. This applies in particular to imported irradiated food products, which are inspected before being placed on the domestic market for purchase by consumers.

Accordingly, supervision covers both locally irradiated foods and imported irradiated foods.

1. Prior inspection of foodstuffs irradiated locally within the facility.

The legislator requires that foodstuffs intended for treatment using ionising radiation are safe and suitable for consumption. Compliance with this requirement is verified through certification by bodies with expertise in this field[25]. These bodies inspect the quality of irradiated foodstuffs and carry out radiation protection inspections within the facility[26].

2. Inspection of imported irradiated food products

When importing a food product, the importer must request a certificate from the supplier confirming that radionuclide analyses have been carried out on each consignment. This certificate must be issued by the competent authority in the country of origin and confirm the radiation concentration levels in the imported products[27].

The marketing and consumption of imported foodstuffs are therefore subject to results demonstrating that contamination levels do not exceed the maximum permissible limits established by the relevant ministerial order.

The Algerian Atomic Energy Commission is responsible for conducting radionuclide analyses and determining radioactive contamination levels within 48 hours. Samples are collected and taken in accordance with the applicable procedures and techniques for each type of material[28].

Third: packaging of irradiated foodstuffs.

Packaging foodstuffs involves placing a food product in a container or wrapping that comes into direct contact with the product[29]. When it comes to irradiating food, the aim is to preserve its safety and protect it from external factors that may cause contamination or spoilage by placing the foodstuff in a suitable container or wrapper before or after irradiation.

Packaging used for foodstuffs intended for irradiation must be suitable for the treatment method. To prevent contamination or insect infestation following irradiation, food products must be packaged in materials that effectively protect against recontamination and reinfestation, as well as any other damage that may occur during storage and transportation.

Article 51 of Executive Decree No. 17-140 of 11 April 2017 stipulates that: 'The materials constituting food packaging must not be a source of contamination. Components of packaging intended to come into contact with food must comply with the applicable regulations concerning materials that come into contact with food."

Packaging must also comply with the importing country's specifications.

Consequently, packaging food in a suitable container helps to preserve the microbiological condition achieved after irradiation.

Fourth: labelling of irradiated food

Labelling refers to all written information, indications, signs, images, representations and symbols associated with a product. This information can be found on any packaging, document, sign, label, sticker or accompanying card that indicates the nature of the product. This information is important for identifying products and providing all the necessary details for their proper use, particularly in the case of food products[30].

In the case of goods closely associated with health, such as food products, providing consumers with information and supplying them with relevant data is increasingly important. Knowledge of the ingredients used in food composition is particularly important for consumers with allergies to specific compounds[31].

When a foodstuff has been treated with ionising radiation, the label must contain information about the foodstuff while complying with mandatory labelling requirements, particularly those set out in Article 12(15) of Executive Decree No. 13-378.

The label must display the international symbol 'Radura', which is a distinctive green circular logo consisting of simple green petals within a broken circle. This must be accompanied by one of the prescribed statements indicating that the product has been ionised or irradiated following approval by the competent authorities responsible for authorising the use of irradiation treatment.

The label must indicate that the product has been treated by ionisation or irradiation, thereby identifying the application of one of these radiation treatments. The location where the treatment took place must also be stated, appearing directly next to the name of the food.

All such information must be legible, visible and indelible. If a product treated by irradiation is used as an ingredient in another foodstuff, this must be indicated in the list of ingredients[32].

Fifth: raising consumer awareness of irradiated foods

Although the benefits and safety of irradiated foods have been scientifically proven, consumers are unaware of this information, which leads them to refuse to purchase irradiated foods. A lack of knowledge about food irradiation and how it works can generate the misconception that irradiated foods are radioactive. Specialists in the food irradiation industry can play a decisive role in raising consumer awareness of the benefits of irradiation.

Irradiation has been identified as the most logical method for addressing food safety issues arising from various contaminants and chemicals worldwide. Thus, it is a modern, effective technology that can be used safely to reduce food losses caused by microbial spoilage. It also facilitates safe storage[33].

Furthermore, the growing interest in reducing contamination levels in the long term during production makes food irradiation an essential technology and an alternative to traditional food preservation methods. The three organisations initially demonstrated that food irradiation can help to reduce the increasing incidence of foodborne diseases and contribute to their prevention.

To achieve harmonisation, it is undoubtedly recommended that irradiated foods comply with international standards. However, the scientific basis of these standards means they are mandatory. Moreover, under the SPS Agreement[34] (Agreement on the Application of Sanitary and Phytosanitary Measures), any food product that does not comply with these standards is presumed to constitute an obstacle to international trade. Consequently, any evidence to the contrary must be scientifically justified.

Accordingly, food irradiation has attracted considerable attention as a technology capable of replacing chemical preservatives and fumigation. In recent years, its safety has been endorsed by the World Health Organization (WHO), the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA) and the World Trade Organization (WTO).

Conclusion:

Scientific and technological developments in the food industry have led to modern methods and techniques that do more than just improve the characteristics of food products. They also play an important role in preventing risks to consumer health and safety. One such technique is the treatment of food products using ionising radiation. This technique is important because it can

reduce certain biological hazards, insects and microorganisms, while extending the shelf life of food and maintaining its nutritional and sensory properties within technically established limits.

Ionisation involves exposing foodstuffs to specific doses of ionising radiation in precisely controlled technical and scientific conditions. This process must be legally authorised and monitored, and the necessary authorisation for the facility must be obtained.

The main findings of this study:

- The use of ionising radiation in the food sector is a modern and effective technology that can contribute to preserving food quality and safety. This is achieved by reducing microorganisms, insects and other spoilage agents, as well as extending the shelf life of food products.

- The radiation dose is essential for ensuring the safety of the ionisation process, as achieving the technological purpose of irradiation requires compliance with the prescribed limits and doses. Excessive use of radiation or use outside the specified conditions may conflict with safety requirements.

- Food ionisation cannot replace fundamental hygiene and food safety rules; rather, it is a complementary method within an integrated system for preventing food-related risks.

- The labelling of ionised foods is a key safeguard for consumers, enabling them to identify the treatment to which the product has been subjected, and safeguarding their right to information and free choice.

Recommendations that can be made in this study:

- The legal framework governing the ionisation of foodstuffs must be updated and developed to ensure continuous alignment with modern scientific and technological developments in this field.

- Technical regulatory provisions concerning permitted radiation doses, the methods for determining them and their monitoring must be strengthened to ensure the technological objective is achieved without compromising consumer safety and security.

- Oversight of food irradiation facilities must be strengthened and the conformity of equipment and radiation sources with applicable legal and technical standards must be periodically verified.

- Regulatory bodies must be equipped with modern scientific and technical tools to enable them to verify the safety of ionised foods and assess compliance with legal requirements.

- Control over the labelling of ionised foods must be tightened to ensure that information indicating whether a product has been subjected to radiation is clear, legible and indelible, thereby preventing consumers from being misled. The Radura symbol indicating that the food has been irradiated or ionised should be placed alongside the food's name to assure consumers of its safety and quality.

- Scientific research must be encouraged and supported to keep pace with developments in modern radiation technologies. The aim is to achieve high quality that meets consumers' growing expectations and prevent diseases resulting from food contamination.

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