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Web-Based Tools to Increase Public Understanding of Nuclear Technology and Food Irradiation

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***Abstract*—**Food irradiation is a processing and preservation technique to eliminate insects and parasites and reduce disease-causing microorganisms. Moreover, the process helps to inhibit sprouting and delay ripening, extending fresh fruits and vegetables shelf-life. Nevertheless, most Brazilian consumers seem to misunderstand the difference between irradiated food and radioactive food and the general public has major concerns about the negative health effects and environmental contamination. Society´s judgment and decision making are directly linked to perceived benefits and risks. The web-based project entitled 'Scientific information about food irradiation: Internet as a tool to approach science and society' was created by the Nuclear and Energetic Research Institute (IPEN), in order to offer an interdisciplinary approach to science education, integrating economic, ethical, social and political aspects of food irradiation. This project takes into account that, misinformation and unfounded preconceived ideas impact heavily on the acceptance of irradiated food and purchase intention by the Brazilian consumer. Taking advantage of the potential value of the Internet to enhance communication and education among general public, a research study was carried out regarding the possibilities and trends of Information and Communication Technologies among the Brazilian population. The content includes concepts, definitions and Frequently Asked Questions (FAQ) about processes, safety, advantages, limitations and the possibilities of food irradiation, including health issues, as well as its impacts on the environment. The project counts on eight self-instructional interactive web courses, situating scientific content in relevant social contexts in order to encourage self-learning and further reflections. Communication is a must to improve public understanding of science. The use of information technology for quality scientific divulgation shall contribute greatly to provide information throughout the country, spreading information to as many people as possible, minimizing geographic distances and stimulating communication and development.

***Keywords*—**Food irradiation, multimedia learning tools, nuclear science, society and education.

I. Introduction

SCIENTIFIC divulgation is a must and a challenge. In the Information Society, where the Internet is the most popular information source, most often social networks seem to associate radiation to nuclear weapons and major accidents. This web-based educational initiative aims to provide trustworthy information, improving public understanding of nuclear technology, demystifying paradigms and combating misinformation and prejudices about the beneficial uses of nuclear technology in our daily lives.

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The International Agency for Atomic Energy for the United Nations (IAEA) asks for actions and larger efforts regarding public education and communication about food irradiation. As a matter of fact, population-food supply is one of the major Brazilian issues. Problems of a growing population, urbanization, lack of resources to deal with pre- and post-harvest losses in food, problems of environmental and food hygiene adversely affect quality and safety of food supplies. Moreover, food safety is a basic human requirement. It implies the absence or acceptable and safe levels of contaminants, adulterants, naturally occurring toxins or any other substance that may make food injurious to health on an acute or chronic basis. The quality and safety of food have to be ensured throughout the food production, processing, storage and distribution chain. Food irradiation is a technique related to important Brazilian issues, such as: human health, agriculture applications, food safety, radiological protection, environmental issues, nutritional education, food waste, economic losses and international commerce.

Taking advantage of the growing impact of the Internet, this project aims at the development of a web-based system that shall contribute largely for democratization of scientific education. The project counts on a multidisciplinary team approaching experts from different fields, such as: radiation technology, radiological protection, human health and nuclear techniques in agriculture, among others. A multi-disciplinary approach to science education shall offer a wider perspective on the opportunities, as well as the dilemmas that nuclear science present in our daily lives. The program covers different aspects of food irradiation, including its impact on social, environmental, economic and political aspects, enabling the public to formulate a critical understanding of the interaction between science, society and nuclear technology.

II. Specific Aims and Expected Results

The web-based multimedia courses have been developed according to modern educational concepts and instructional strategies, which not only replace instructor absence, but also enable users to see and review the content with great quantitative and qualitative achievement. One of the most interesting ways to understand nuclear energy is the possibility to relate it to life itself. Therefore, in order to enrich the public's educational experience, encouraging a deeper learning, all topics are related to everyday life covering: human health, agriculture applications, food production, food supply, food safety, radiological protection, environmental issues, nutritional education, food waste, economic losses and international commerce. All content will be easily accessed by

any conventional Internet point and mobile apps, for Android Smartphones and tablets will be created.

Information and Communication Technologies (ICTs) impact positively on science education, engaging society in issues pertaining to the impact of nuclear science on social, technological, economic and political contexts.

- Social gains: The growing impact of ICTs contributes to transform education, offering inclusive and democratic learning opportunities. It is expected that this opportunity for learning nuclear science through diverse perspectives, shall contribute to develop critical thinking, enabling abilities and confidence to examine media information and prepare people to participate as active citizens in the world around them. Education through ICTs allows the inclusion and participation of disadvantaged groups in the democratic Information Society.
- Educational gains: Learning goals extend far beyond academic gains. This initiative tries to reach society, promoting dynamic engagement with consumers´ who, due to lack of knowledge and understanding about the difference between food irradiation and radioactive food, fear the harmful effects of ionizing radiation to the health of humans.
- Economic gains: Food irradiation is related to agriculture possibilities and food production. It is also a process that contributes to food safety reducing pathogenic microorganisms and parasites that cause diseases to human health. It helps to delay sprouting and ripening of fresh fruits and vegetables, contributing to food supply issues. It helps to extend food shelf-life, reducing food waste. It brings benefits to the national economy, bringing knowledge and skills (related to food-importing and exporting restrictions and international commerce) that are essential to the economic growth and effective competition within the global market.

III. Problem Statement

Some studies conducted in Brazil to measure public acceptance of food irradiation show that most often the public does not know the difference between food irradiation and radioactive food. Food irradiation is a process that contributes to reduce pathogenic microorganisms and parasites that cause diseases to human health. Besides the health benefits to the consumer, food irradiation could also bring benefits to the national economy: food irradiation helps to delay sprouting and ripening of fresh fruits and vegetables, extending their shelf-life, avoiding losses and waste. However, beyond these benefits some subjective aspects must be considered: due to lack of knowledge about the benefits of irradiated food, people fear the harmful effects of ionizing radiation to the health of consumers.

A study published in Brazil in 2008 [1] clearly demonstrates that misinformation and preconceived ideas impact heavily on the acceptance of irradiated food. This experiment was designed to measure the level of public acceptance considering four different groups:

- Group 1. Received information and tasted food identified as irradiated.
- Group 2. Received information and tasted food without knowing whether or not food had been irradiated.
- Group 3. Received no information and tasted food identified as irradiated.
- Group 4. Received no information and tasted food without knowing whether or not it had been irradiated.

The third group showed markedly unfavorable results, confirming the negative impact of misinformation and prejudice.

Another survey entitled “Brazilian Consumer Views on Food Irradiation” was conducted in 2009. The information given to participants about the benefits of irradiated food impacted positively; however, participants generally still proved to be fearful about the risks and possible side effects. The research provided important data about factors which affect acceptance and purchase intention by the Brazilian consumer. In the published conclusions, the authors emphasize the importance of developing an educational program for Brazilian population, explaining the principles, purposes and benefits of food irradiation [2].

Looking at a wider context, author Ioannis S. Arvanitoyannis brings in his book some considerations about consumer behavior toward irradiated food in Brazil and worldwide: public acceptance of irradiation has been a significant challenge.

> "*Despite all this benefits, this technology remains underutilized not only in Brazil but in other countries. The main reason appears to be consumer concerns and doubts about the use of radiation in food processing.*" [3]

Building public confidence in the safe use of radiations for food processing includes the public´s knowledge about the level of protection of consumers’ health and interests. Therefore, aside from communication of scientific and technical information, this educational program includes legal issues for food irradiation, the responsibility of national public authorities [4], [5], as well as international standards and regulations [6]-[9]. Education and communication are essential to increase the dialogue between science and the general public.

IV. Means and Methods

In order to face this challenge, IPEN started the development of eight web-based courses to inform the general public. To successfully achieve the goals, the methodology for this project includes a comprehensive analysis of two main challenges: (i) literature review of the official publications of ICTs access possibilities in Brazil; and (ii) development of an effective instructional design for scientific divulgation and strategic definition of technological resources for scientific divulgation.

A. Literature Review of the Official Publications of ICTs Access Possibilities in Brazil

There was conducted a comprehensive study regarding the possibilities of access to the ICT throughout the country. This research work has enabled the collection of quantitative and

qualitative data that allowed us to define the best interfaces tools and resources for this Project [10].

According to the latest publication held by the Internet Steering Committee in Brazil, entitled "Research on the use of information and communication technologies in Brazilian households," despite the regional and socioeconomic inequalities, there was an important breakthrough in the use of ICTs in Brazilian households. According to data from the ICT Households surveys "*there are 94.2 million Internet users in the country, which corresponds to 55% of the population 10 years old or older. In 2008, this figure was only 34%.*" [10]. Table I depicts the ICT Households survey results regarding Internet access by region in Brazil. This research aims to "*support the company with official data on the socioeconomic impacts of ICTs, contributing to more effective and efficient public policies and the development of the Internet in Brazil*" [10].

TABLE I
HOUSEHOLDS WITH INTERNET ACCESS BY REGION PROPORTION AND ESTIMATE IN MILLIONS (2014) [10]

Households with internet access by region	Percentage (%)		Estimate (Millions)	
	Yes	No	Yes	No
Southeast	60	40	18.3	12.1
Northeast	37	62	6.6	11.0
South	51	49	5.2	5.0
Center-West	44	56	2.4	3.1
North	36	64	1.5	2.7

Among the 65,129,753 households that responded to the survey, in all Brazilian states, 92% of respondents reported having mobile phone for Internet access, while 50% reported having computers at home. Among the 32,881,928 households that own a computer, 56% reported having desktop computer, 60% have a portable switch and 33% have tablets. Some 39% have more than one computer. When categorized in class, reported having computer: 98% of households in the class; 82% of households in Class B; 48% of families in the C class and 14% of the D class families. As for the connection speed, the vast majority has broadband access; only 2% have dial-up and 25% also has mobile broadband (3G). 17% claims to have connection between 256 Kbps and 1 Mbps; 13% between 1 Mbps and 2 Mbps; 9% between 2 Mbps and 4 Mbps; 8% between 4 Mbps and 8 Mbps. 23% of households with computers have connection speeds up to 8 Mbps. 66% of families have Wi-Fi. The research also includes data on the proportion of Internet users by activities in the search for information. Some 47% of respondents reported using the Internet for the purpose of academic research and information; 38% seek information on encyclopedia site; 33% study on the Internet on their own and 11% seek distance courses. Regarding the device used to access individual, 76% of users claim to use the phone. Fig. 1 brings the proportion of households with internet access by presence of Wi-Fi. Given all these data, the team was able to design the system intelligence and the development of distance courses.

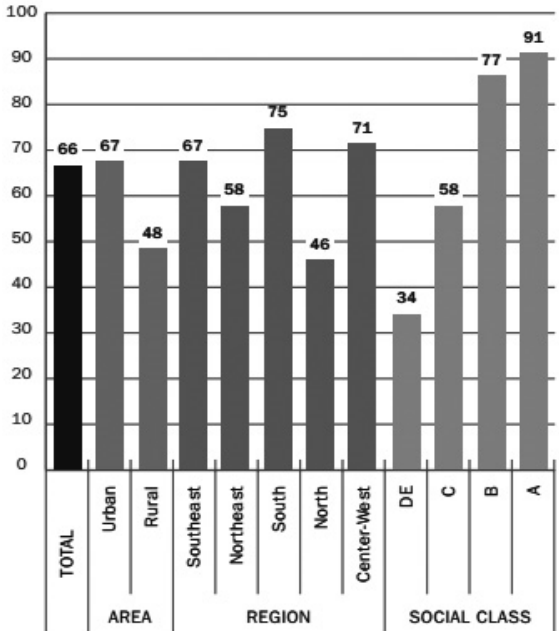

Fig. 1 Percentage of total households with Internet access in 2014 [10]

B. Instructional Design for Scientific Divulgation

The next challenge involved providing public accessible scientific information throughout Brazil, expanding the dialogue among different segments of society. The information about the current situation of ICT in Brazil, the way people work with the resources available, the most present technologies, as well as the main challenges and trends were essential to guide the planning of this project development. The interactive web based material focus on self-instructional content, so that the process is 100% automated. The web-based system development strategies included two essential steps: to create a website and to create short courses. Creating a website involved the development of an original and creative design, according to modern concepts, to please the different segments of our society, regarding sex, age, geographic location and sociocultural aspects. This project counts on different possibilities for activities according to the various contents, such as FAQ, interactive short courses and a repository of supplementary support references material designed to clarify and enhance public understanding of core in food irradiation issues. All interactive short courses development should consider modern educational concepts and count on last generation Internet resources which replace instructor absence and enable students to see and review the content with quantitative and qualitative achievement. The content includes concepts, definitions and theory (Fig. 2), in addition to many interactive activities and exercises (Fig. 3). Moreover, the project counts on responsive instruction design tools and can be easily accessed either from computers or mobile technologies, from any conventional point internet at home, at work, on the way home or any other location. In this sense, the instructional project includes not only the adaptability to mobile media, but also a responsive system. The system is able to identify the type of screen used by the

visitor. According to the equipment and resolution of the screens, the layout automatically adjusts for best viewing and better use of educational resources designed for the transmission of each content, as seen in Fig. 4.

Fig. 2 Informing the general public: concepts about food irradiation

Fig. 3 Interactive exercises to check public´s previous knowledge

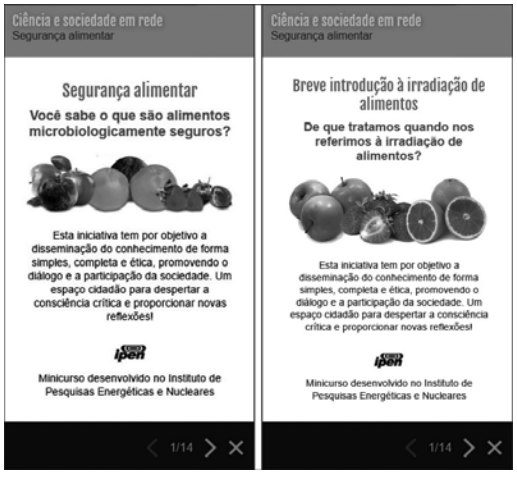

Fig. 4 Responsive web design for mobile devices

The project involves the creation of computerized models that comprise the various aspects of food irradiation in daily life, as described below.

1. *Fundamentals of food irradiation.* Introduction to the various aspects involved in food irradiation, such as fundamental concepts, food safety, regulatory bodies and specific purposes, as well as assumptions, advantages and limitations when compared to other available techniques.
2. *Biological aspects involved in food irradiation.* Introduction to the concepts of food contamination and the potential toxicity of microorganisms (such as fungi, bacteria, viruses and mycotoxins), as well as the risk of disease transmission associated, and includes discussions about the potential value of nuclear energy to contribute to food safety and its impacts on human health.
3. *A brief history of food irradiation.* This short course goes through a condensed version of important comparative studies, experiments, researches and results from the 40s to the present day.
4. *Laws and regulations for food irradiation.* This course presents international rules and recommendations (OMS, AIEA) and national guidelines for foods irradiation in Brazil, discussing Law No. 7,394 (October 29, 1985); Decree No. 72718 (August 29, 1973) and Resolution - RDC No. 21 (January 26, 2001).
5. *Sensory analysis of irradiated food.* This topic involves public acceptance of irradiated food, sensory analysis results (texture, color, flavor and overall impression), nutritional aspects and impacts on the internal Brazilian market and economy related impacts.
6. *Food irradiation and radiation protection.* Introduction to nuclear techniques and equipment used in food irradiation, as well as quality control, optimization and monitoring techniques to ensure radiological protection and safety, concerning workers, public and environment.
7. *Nuclear techniques and agriculture.* This course presents food irradiation as a phytosanitary measure and prevention of quarantine pests. Also, the course discusses nuclear applications in agriculture to control insect plagues, reduction of production losses and its impacts on national economy.
8. *Public acceptance of irradiated food in Brazil and worldwide.* This course discusses food irradiation approval in other countries, approved irradiated foods including fruits, vegetables, meat, poultry, fish, seafood, roots and tubers and public acceptance around the world. In addition, the course provides access to surveys results, articles and scientific papers about food irradiation, past experiences, present challenges and future trends.

These eight topics were designed to meet the global interests of our plural society, providing a more comprehensive and solid information, linking technology and everyday life in order to improve public understanding of nuclear science. Making use of the latest technological resources, each short course presents the essential of the main concepts and their practical applications.

Scientific divulgation to the general public is not an easy task, for scientific knowledge for the outsider public involves transforming scientific language into accessible information. This work demands diversifying instructional methods concerning the best teaching practices and learning techniques. Therefore, specific objectives will be defined for the development of each topic, considering the characteristics

and specificities of each subject issues, specialist jargons and academic language, identifying the best didactic and pedagogical educational multimedia solutions in order to help citizens to access scientific information.

V. Final Considerations

The web-based system for public communication of food irradiation issues is still in its initial phase. For the moment two web courses were created in order to explain the general content to a public with any previous knowledge. From this point on, the researchers intend to produce specific content focusing other issues of general interest, such as processes and techniques, safety, nutrition and health issues. All content can be easily accessed from any conventional Internet point, with good performance even via not high speed connection. ICTs shall impact positively on science education, engaging society in issues pertaining to the impact of nuclear science on social, technological, economic and political contexts.

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