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Dissemination of information in nuclear sciences and public acceptance of irradiated foods in Basic Education

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Abstract: Technological advances, such as food irradiation, aim to improve environment sustainability, human health, and the well-being of society. Food irradiation is a well-established and effective technology for preserving and disinfecting food, keeping food quality and nutritional properties. The lack of adequate information about nuclear sciences can lead to resistance, compromising acceptability. Prejudices and misinformation lead society to associate nuclear techniques with harmful effects on human health and on the environment. The recent reformulation of the Brazilian National Common Core Curriculum favor interdisciplinarity and provides opportunities for the inclusion of nuclear sciences in schools. Themes that are crucial to national development, such as Science and Technology, as well as Food and Nutrition Education, are now mandatory subjects in schools. Considering the vast content available on the Internet, with channels of direct communication with young people, this study aimed to analyze the prior knowledge about nuclear sciences, especially food irradiation, among Elementary School students at a well-known private school in São Paulo. The research with groups of students allows communicators to identify current gaps and specific needs for the development of future actions to combat disinformation. The results bring a paradoxical perception of elementary school students, whose prior knowledge is fragmented and decontextualized. However, the research demonstrates that students are receptive to new learning, and tend to support national technological advances, including nuclear sciences. Also, the offer of quality information, in a formal learning environment, can instigate critical thinking, reformulate opinions and contribute to the acceptability of peaceful applications of nuclear technology.

Keywords: Nuclear technology, food irradiation, public communication.

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Disseminação da informação em ciências nucleares e aceitação pública dos alimentos irradiados no Ensino Básico

Resumo: Os avanços tecnológicos, como o uso de alimentos irradiados, visam melhorar a sustentabilidade, a saúde e o bem-estar da sociedade. A irradiação de alimentos é uma tecnologia consolidada e eficaz para conservação e desinfecção de alimentos, preservando a qualidade e as propriedades nutricionais. A falta de informação adequada sobre as ciências nucleares pode levar à resistência na sua aceitabilidade. Preconceitos e desinformação levam a sociedade a associar as técnicas nucleares aos efeitos negativos para a saúde e o meio ambiente. A recente reforma da Base Nacional Comum Curricular privilegia a interdisciplinaridade e oportuniza a inserção das ciências nucleares nas escolas. Temas cruciais para o desenvolvimento nacional, como Ciência e Tecnologia, assim como Educação Alimentar e Nutricional, passam a ser temas obrigatórios nas escolas. Considerando o vasto conteúdo disponível na Internet, com canais de comunicação direta com os jovens, este estudo teve por objetivo analisar o conhecimento prévio sobre ciências nucleares, em especial a irradiação de alimentos, entre alunos do Ensino Fundamental II, de uma renomada escola particular de São Paulo. A pesquisa junto grupos de alunos permite identificar atuais lacunas e necessidades específicas para a elaboração de ações futuras para o combate à desinformação. Os resultados apresentam uma percepção paradoxal dos alunos do fundamental II, cujo conhecimento prévio é fragmentado e descontextualizado. Entretanto, a pesquisa demonstra que os alunos são receptivos a novos aprendizados, tendem a apoiar o avanço tecnológico nacional, incluindo as ciências nucleares, e a oferta de informação de qualidade, em um ambiente formal de aprendizagem, pode instigar o pensamento crítico, reformular opiniões e contribuir para a aceitabilidade das aplicações pacíficas da tecnologia nuclear.

Palavras-chave: Tecnologia nuclear, irradiação de alimentos, comunicação pública.

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1. INTRODUCTION

Advances in nuclear technology bring benefits to society and improve its quality of life in different areas: food, agriculture, industry, health and environmental sustainability, among others. In the medical field, nuclear sciences bring undeniable contributions, especially in imaging exams, diagnostics and treatments. Nuclear power generation is another well-known application, even though it is still a controversial issue in Brazil and worldwide [1]. Nuclear technology seems to be a mystery among a large part of the population, due to unfounded myths and fears, including those spread by the media. Other than medicine and nuclear power generation, nuclear technology offers many benefits, completely unknown to a large part of the population, such as food irradiation.

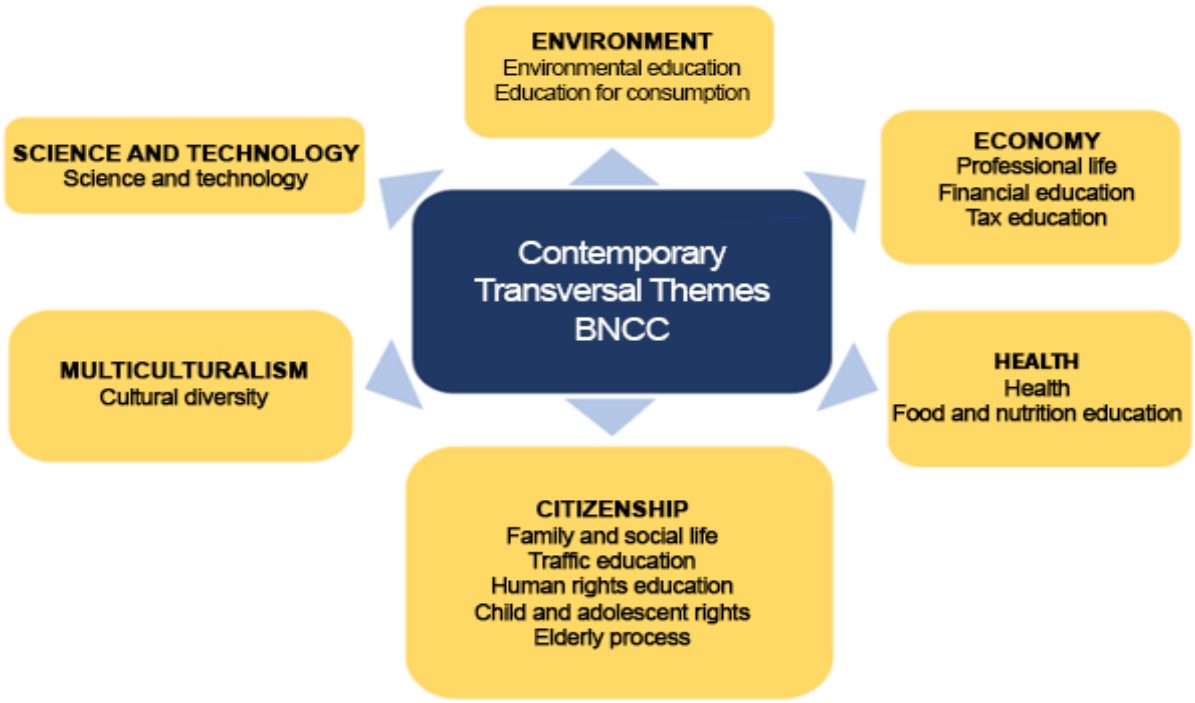
Food irradiation is a well-established and effective technology for preserving and disinfecting food, ensuring quality and preserving organoleptic and nutritional properties. It is used in several areas, including agriculture and the food industry, to increase shelf life and improve safety [2 - 3]. It is approved by international organizations such as the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), the Codex Alimentarius and the Scientific Committee on Food of the European Commission. In Brazil, it is regulated by the National Health Surveillance Agency (ANVISA) and the Ministry of Agriculture and Food Supply (MAPA).

Food irradiation responds to crucial national demands, such as public health, food safety and combating waste. Even so, the lack of adequate information about nuclear sciences shall lead to resistance and distrust. Public's perception of risk differs from experts´ risk perception [4 - 5].

It is crucial for national development to disseminate information about irradiated food and to educate new generations. Since the 2017 the Common National Curriculum Base in

Brazil (BNCC) has been completely reformulated and nuclear sciences and their applications have gained space in Elementary and High School Education. In 2019, the inclusion of Contemporary Transversal Themes (TCTs) also became mandatory. As seen in FIGURE 1, TCTs enable the work of nuclear sciences in 3 macro-themes: Science and Technology, Environment and Health (Food and Nutrition Education). [6 – 7].

Figure 1 – Contemporary Transversal Themes for Elementary and High School Education



Source: Brazilian Ministry of Education, 2018. Authors' own translation [7]

Nevertheless, despite the advances in the formal curriculum, teachers are most often unaware of the matter and still not prepared to deeply discuss the theme [8].

This article presents the prior knowledge about nuclear sciences, especially food irradiation, among elementary school students. Its main objective is to identify current gaps and future possibilities for educational actions so that new generations can build a fair view of nuclear sciences and their peaceful applications.

2. MATERIALS AND METHODS

This article presents qualitative exploratory research conducted through a face-to-face questionnaire to identify the perception and knowledge related to nuclear sciences, especially the acceptability of food irradiation, among elementary school students. The survey was conducted in a well-known private school in São Paulo city. The respondents were 48 students between the 6th and 9th grades, aged between 11 and 14 years, as seen in TABLE I.

Table I: Respondents from Elementary School

School education	Average age	Participants	Gender Male	Female
6th grade	11,3	18	9	9
7th grade	12,1	13	9	4
8th grade	12,9	7	4	3
9th grade	14	10	5	5
Total	12,6	48	27	21

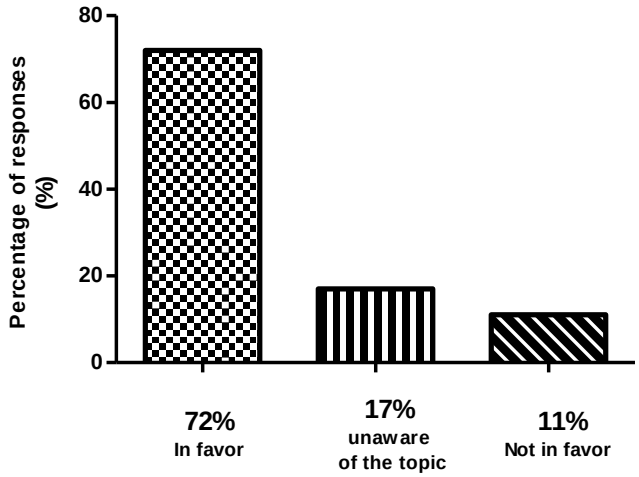
Source: Authors' compilation

The research was carried out in two phases: (1) to verify prior knowledge among the students and (2) to verify the influence of the information provided by the IPEN researcher on the perceptions and decisions of adolescents.

3. RESULTS

The survey was carried out through a face-to-face questionnaire, for researchers were interested in spontaneous responses. The first question aims to check the acceptability of the development of nuclear technology in Brazil, and 72% of the students claim favor the development and technological advances in Brazil, as seen in FIGURE 2.

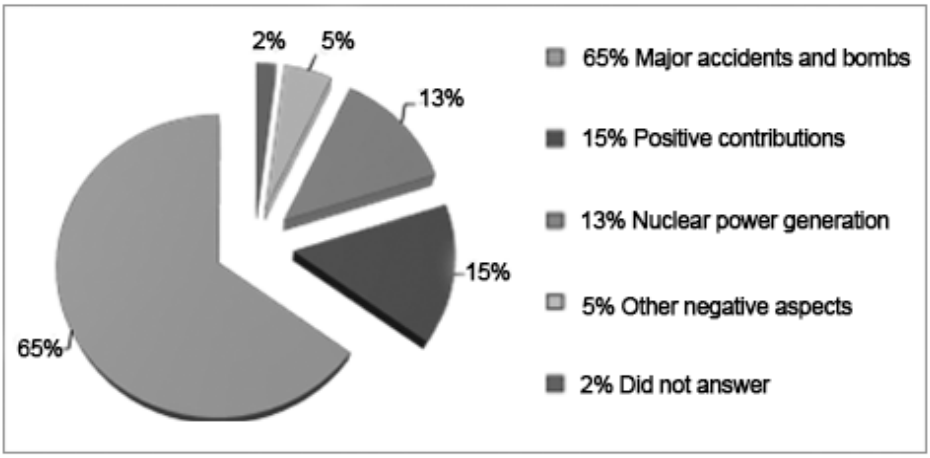
Figure 2: Students' responses regarding the development of nuclear technology in Brazil



Source: Authors' compilation

However, when asked about their first thoughts when they think of radiation, 65% of respondents mentioned major accidents and mass destruction weapons, as seen in FIGURE 3. Beneficial applications of nuclear technology were found in only 15% of the answers. Nuclear power generation was mentioned by 13% of the students, without specifying whether it would be considered a good or bad practice in Brazil.

Figure 3: First thoughts that come to mind when they think of radiation



Source: Authors' compilation

When asked how radiation applies to their daily lives, more than 38% of the answers (in different grades of Elementary School) mentioned non-ionizing radiation, including sunlight, cell phones, microwaves, among others. Moreover, the answers from 7th grade

students regarding the application of radiation in the medical and hospital environment (30%) and the answers from 9th grade regarding applications related to food (40%) stood out in the results, as seen in TABLE II.

Table II - Radiation in daily life

Questions	Answers						
Where can we find radiation in our daily lives?	Sun/UV rays/air	TV, mobile phones, microwaves	Chernobyl	Did not answers	Hospitals and businesses	Food	Our bodies
6th grade	61%	6%	6%	22%	6%	0%	0%
7th grade	8%	31%	0%	23%	31%	8%	0%
8th grade	0%	38%	0%	38%	13%	0%	13%
9th grade	30%	20%	0%	0%	10%	40%	0%

Source: Authors' compilation

Table III presents the results for the question: "Have you ever eaten irradiated food?". 54.2% of the students answered yes, associating it with processed foods, such as “salty snacks” (processed snacks) and foods prepared in the microwave; 18.8% of the students answered no and 27.1% did not know if they had tried or did not know what irradiated food was.

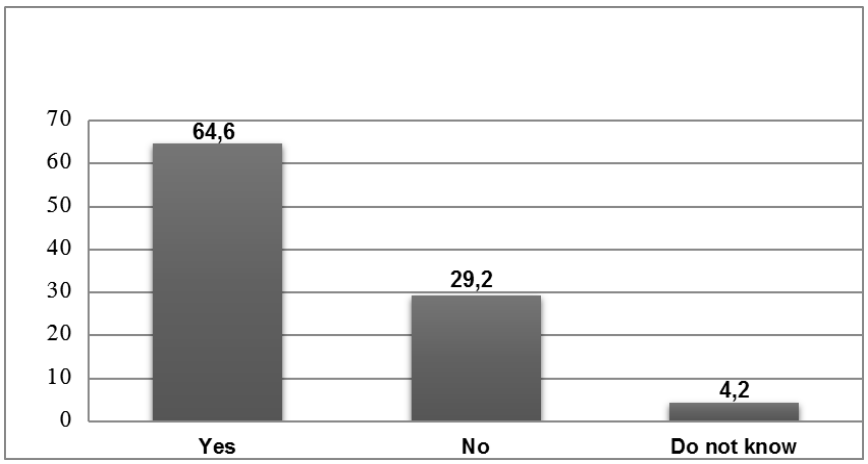
Table III – Adolescents´ answers about “eating irradiated food”

Question	**Answer**	**Percentage**
Have you ever eaten irradiated food?	Yes	54,2%
	No	18,8%
	Did not know	27,1%

Source: Authors' compilation

Regarding the Radura symbol, 31.3% of the students claimed to know it, while 8.3% had already seen it but did not know its meaning; and 58.3% had never seen it. The students were informed that the Radura symbol is used internationally to identify irradiated food products. When asked if they would buy food containing this symbol, 29.2% claimed they would not buy, because that food contains radiation and it would cause harmful effects to human health; 4.2% did not know whether they would choose it or not; and 64.6% answered that they would buy it, associating the Radura symbol to a food safety seal and health benefits.

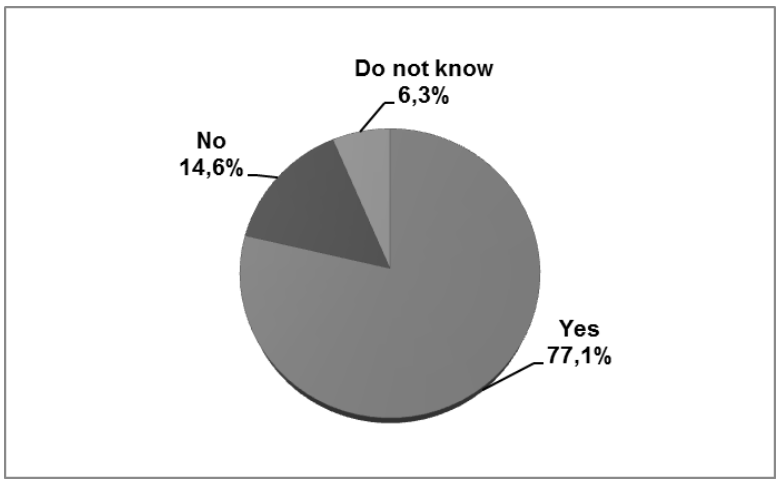
Figure 4 - Purchase intention of food products with the Radura symbol.



Source: Authors' compilation

Before answering the last question, students received a short text with information about the technique of irradiating food for extend shelf-life, eliminate insects and reduce disease-causing microorganisms. The difference between irradiated and contaminated foods was also explained to the students. After the explanation, students responded to the second stage of the survey, about their intentions to buy irradiated foods and recommend irradiated food to their families and communities. After being informed, 77.1% of the students associated irradiation with healthy eating; 14.6% would not buy them because they are dangerous; and 6.3% did not know how to respond.

Figure 5- Responses of participants regarding purchase intention of irradiated foods



Source: Authors' compilation

4. DISCUSSIONS

According to the Diagnosis of Science Dissemination in Latin America (2017), Brazil Ranks 2nd in Latin America for actions to popularize Science and Technology, and its main actors are institutions (25%) and research centers (12.2%). This report highlights the need for surveys to identify needs and topics of interest to the public, in order to develop effective communications strategies. [9]

The authors of the present article have been conducting surveys with Basic School teachers since 2017. The results of these surveys show that, although most respondents favor the development of the Brazilian Nuclear Program, educators are still confronted with fears and prejudices. Their first thoughts regarding nuclear technology are major accidents, mass destruction weapons, contamination and harmful effects for human health and the environment. Teachers barely know about food irradiation´s contributions for food safety, combating waste and environmental sustainability. [8]

This recent survey with the adolescent public is justified in the so-called "Knowledge Society" where school curriculum has just been reformulated, there are public policies to popularize science and thousands of actions on the Internet designed for the young population. According to the Diagnosis of Science Dissemination in Latin America (2017), regarding scientific communication strategies, 94.3% of science communication actions are designed for the Internet. Moreover, the main target audience for these actions are adolescents between 13 and 18 years old (42.9%). [9]

Nevertheless, these online communication efforts seem to provide partial and fragmented information, since adolescents are also exposed to fake news, confusing people´s risk perception, and leading to a fragmented construction of knowledge. Indeed, our young respondents presented, as well, paradoxical responses: the students favor the development of nuclear technology, although their first thoughts refer to accidents and weapons. The discussions of this survey shall help nuclear science disseminators in successful future actions.

In the last decade, pedagogical practices have prioritized meaningful learning. "Scientific Literacy" means articulating science with the learner's daily life. Therefore, one of the most effective ways to popularize science is to relate it to specific habits of the target-public [6]. Adolescents associate radiation with processed foods and snacks. In fact, ramen, snacks and spicy cookies are part of the universe of the young public. Communicators may and should explore it, since all these foods contain irradiated ingredients and have this information on the packaging, as required by ANVISA [10].

In the new Brazilian education guidelines, BNCC includes, as a benchmark, a global citizenship education, enabling each student to act as a change agent in his family and his community[bncc]. Indeed, one of the objectives of popularizing science among young people is to multiply information. In this sense, the presentation of the RADURA symbol has a double function in our research: (1) to check prior knowledge: many students know the RADURA symbol, but do not know its meaning; and (2) to introduce this symbol to potential multipliers, who shall tell friends and family that this symbol exists and should be synonymous of food safety and quality.

The Diagnosis of Science Dissemination in Latin America (2017) states that decisions for defining actions are most of the time (43.1%), based on the areas of expertise and interests of science and technology communicators [9]. Regarding the nuclear sector, public educational policies in Brazil favor innovative initiatives and the scientific community must be part of the process, disseminating relevant information in effective and accessible ways. [7]

Regarding communication on food irradiation, the object of this article, there are many possibilities for developing didactic content based on TCTs in different macro-areas:

Science and Technology: nuclear technology is part of the new BNCC, especially Energy Generation, applications in medicine and industrial applications of ionizing radiation. It is textually required in High School. Food irradiation can be introduced since Elementary School, with food and nutrition education. Since nuclear technology is an interdisciplinary

area, it is possible to produce didactic material linking the contents with the biology, physics and chemistry curriculum [11].

Food and nutrition education: food irradiation contributes to food safety preventing Foodborne Diseases, outbreaks and food poisoning, in addition to reducing food waste. With doses of less than 1 kGy, it is possible to inhibit the sprouting of foods commonly found on Brazilian tables. With doses of less than 5 kGy, it is possible to effectively reduce contamination by microorganisms in raw meat, chicken and fish. These are examples of objectives that meet current food paradigms, such as healthy nutrition and the reduction of chemicals in food [12].

Environment: Food irradiation also contributes to the treatment and reuse of agro-industry-waste, enabling oil extraction or the production of enriched flour. The use of unconsumed parts of food, such as peels or seeds (such as oil extraction or production of enriched flour) contributes to expanding food supply and food safety. Reducing agro-industrial waste is an environmental issue in Brazil and worldwide [13].

5. CONCLUSIONS

Risk perception by the general public differs from experts´ risk perception. Despite many efforts to disseminate information, important concepts of nuclear science and its applications remain superficial, leading to the perpetuation of prejudices and misinformation. Society seems to associate nuclear techniques with negative effects on human health or environmental contamination [1; 5; 8].

An important document about Latin America [9] demonstrates efforts to popularize information among young people, especially through the Internet, where adolescents come across a large amount of content from various sources. In fact, this research, conducted with Elementary School students, shows that adolescents are receptive to new learning, but their prior

knowledge is partial and fragmented, generating paradoxical responses. The initial responses reflect common sense information from the media and the Internet. However, after a little information, provided in a formal learning environment (school) by a reliable source (institute researcher), not only do students favor technological development, but their acceptability of food irradiation increases, as well as their intention to consume irradiated foods.

Schools are responsible for providing quality information, to develop skills and competencies for a fair understanding of nuclear technologies [6 -7]. However, most educators are not prepared to discuss the topic, which is most often introduced in a superficial way to meet the minimum content required [8]. This article shows that young people are receptive to new information, public policies favor the popularization of knowledge, and educational guidelines provide never-before-seen possibilities for introducing nuclear sciences in schools. It is necessary to invest in adequate communication to educators and teachers from elementary and high schools.

It is essential to invest in the knowledge of new generations, our future decision-makers. It is important to reach these "citizen students", to develop critical thinking, and to promote discussions of nuclear sciences related to social issues. This article demonstrates that students are receptive to new learning and supportive of nuclear research, recognizing its importance for knowledge, technological progress and the development of the country.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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