



# Food Irradiation: A Solution for the Conservation and Safety of Perishable Foods in Naval Environments by the Brazilian Navy

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**Abstract:** The article discusses the application of food irradiation as a solution for food preservation and safety in naval settings, focusing on the missions of the Brazilian Navy's submarines. Food irradiation, recognized in 37 countries, effectively eliminates parasites, fungi, and bacteria, extending the shelf life of foods without compromising their nutritional and sensory qualities. The research used an electronic questionnaire to assess the knowledge and acceptance of food irradiation among military and civilian personnel of the Navy. Results indicate that before receiving information, 54% of participants were unaware of the technology, and 28% had a negative view of nuclear energy. After exposure to informative materials, 82% of participants expressed willingness to consume irradiated foods, up from 54% previously. The study highlights the importance of education and scientific dissemination for the acceptance of the technology and suggests expanding the study to a larger sample within the Navy. The findings suggest the potential use of food irradiation in Navy ships and submarines, contributing to the health and well-being of crew members.

**Keywords:** Food irradiation, Naval logistics, Submarine supplies, Ship supplies.



# Irradiação de Alimentos: Uma solução para a Conservação e Segurança de Alimentos Perecíveis em Ambientes Navais pela Marinha do Brasil

**Resumo:** O artigo discute a aplicação da irradiação de alimentos como uma solução para a preservação e segurança alimentar em ambientes navais, com foco nas missões de submarinos da Marinha do Brasil. A técnica de irradiação, reconhecida em 37 países, é eficaz na eliminação de parasitas, fungos e bactérias, aumentando a vida útil dos alimentos sem comprometer sua qualidade nutricional e sensorial. A pesquisa utilizou um questionário eletrônico para avaliar o conhecimento e a aceitação da irradiação de alimentos entre militares e civis da Marinha. Os resultados mostram que antes de receberem informações, 54% dos participantes desconheciam a tecnologia, e 28% tinham uma visão negativa sobre energia nuclear. Após a exposição a materiais informativos, 82% dos participantes expressaram disposição para consumir alimentos irradiados, comparado a 54% anteriormente. A pesquisa destaca a importância da educação e divulgação científica para a aceitação da tecnologia e sugere a ampliação do estudo para uma amostra maior dentro da Marinha. As conclusões apontam para o uso potencial da irradiação de alimentos em navios e submarinos da Marinha, contribuindo para a saúde e o bem-estar dos tripulantes.

**Palavras-chave:** Irradiação de Alimentos, Logística Naval, Suprimentos para Submarinos, Suprimentos para Navios.

## 1. INTRODUCTION

Approximately one-third of the global food production is lost before reaching consumers, according to data from Embrapa [1]. The United Nations (UN) emphasizes that reducing these losses is crucial for balancing food supply and demand. In this context, treatments such as food irradiation gain importance and are recognized by health surveillance authorities in 37 countries. Twenty-four of these countries already incorporate irradiation into commercial practices, highlighting its effectiveness and global acceptance.

In food preservation, irradiation has proven to be an efficient tool for significantly extending the shelf life of products, minimizing losses, ensuring food safety, and enhancing the availability of these items for consumers.

According to Embrapa [1], the irradiation technique plays a crucial role in eliminating or inactivating insect larvae, parasites, fungi, and bacteria present in food, thereby reducing the risk of disease transmission. Additionally, this method allows for the inhibition or delay of physiological processes such as sprouting and ripening. Given that early food deterioration is often attributed to the actions of insects, microorganisms, and degrading enzymes, irradiation emerges as an effective treatment to substantially extend the life of products.

As stated by [2] food irradiation is a fundamental technique for the preservation and pest control of food products, involving the exposure of food to controlled doses of radiation from sources such as Cobalt-60, Cesium-137, X-rays, and accelerated electrons. It is crucial to note that irradiation leaves no residues in the food and does not release radioactive materials into the environment. The entire process is rigorously monitored to ensure food quality while preserving its sensory and nutritional characteristics. A notable advantage of this technology is its post-packaging application, significantly reducing the risk of recontamination during transportation, storage, and commercialization phases. In Table

1 below, concerning food irradiation, low doses are considered up to 1 kGy; medium doses range from 1 to 10 kGy, and high doses exceed 10 kGy.

**Table 1:** Doses suficientes para alcançar as finalidades almejadas

Purpose	Absorbed Dose	Food
Sprouting Inhibition	0,03 a 0,12 kGy	Onion, garlic, potato
Ripening Delay	0,03 a 0,12 kGy	Carrot, banana, strawberry
Insect Disinfestation	0,2 a 0,8 kGy	Peach, apple, mango
Parasite Disinfestation	0,1 a 3 kGy	Oysters, shellfish, salmon
Microbial Load Reduction	1 a 5 kGy	Meat, chicken, fish
Fungal Reduction	1 a 10 kGy	Coffee, flour, corn

Source: Levy, Sordi e Villavicencio (2020)

Despite the undeniable benefits of food irradiation, research indicates that a large portion of the population has little to no information on the subject according to [2], [3], [4]. Prejudices and unfounded fears influence the risk perception among decision-makers across various segments of society, including producers, industry, commerce, and the consuming public [5]. Research also indicates a willingness to change habits and attitudes after access to information through informative actions.

This article aims to propose, based on recent studies, food irradiation as a solution for food preservation and safety in naval settings, as well as to present partial results of a survey on knowledge and acceptance of food irradiation among members of the Brazilian Navy.

## 2. MATERIALS AND METHODS

This work follows a qualitative descriptive research design using an electronic questionnaire as a tool for assessing the knowledge of food irradiation among the military

and civilian workers of the Brazilian Navy. The methodology employed in conducting this research is grounded in the works of [2], [3], [4].

### 3. RESULTS AND DISCUSSIONS

Submarine missions often involve extended periods without access to ports or external supply sources. The vessel's autonomy directly depends on its ability to maintain a sustainable food reserve for the entire crew during these prolonged operations. Ensuring the proper preservation of food becomes a strategic priority.

The effective operation of submarines, especially during long-duration and isolated missions, necessitates a careful approach to food logistics. Onboard food conservation is a critical issue directly impacting the crew's ability to maintain adequate nutritional status and, consequently, their operational performance and overall well-being.

Life aboard a submarine presents unique challenges, such as lack of natural light, constraints within confined spaces, limited fresh air supply, critical attention during combat, among others. The quality and variety of fresh foods available onboard directly impact the physical and mental health of the crew. A balanced diet is essential to sustain the physical and cognitive demands of submariners, contributing to their operational performance, resilience to adverse conditions, and critical decision-making. To confirm these qualitative insights regarding military personnel embarking or having already embarked on Brazilian Navy ships, a survey was conducted through an electronic questionnaire based on previous research on the irradiation of food.

In [4], an analysis of the acceptance of irradiated foods was conducted, with a focus on education as a fundamental element in this context. The research involved the application of questionnaires to students, a systematic review of specialized literature, analysis of international research on the acceptance of irradiated foods, and verification of nuclear

energy-related educational content in different countries. The thesis emphasizes the importance of integrating education about nuclear energy and its applications, such as food irradiation, into Natural Sciences, Physics, and Chemistry disciplines, aiming to promote contextualized knowledge integrated into students' lives.

The study conducted by [3] aimed to assess consumers' prior knowledge regarding food irradiation, highlighting the lack of information and existing misconceptions on the subject. Through a face-to-face survey with 100 participants, including educators and members of the general society, the authors identified that most respondents associated ionizing radiation with negative aspects such as wars, contamination, and diseases. Given this scenario, the study sought to develop scientific dissemination strategies to demystify prejudices and inform consumers about the benefits and safety of food irradiation, aiming to promote public acceptance of this technology.

The research conducted by [5] aimed to evaluate the knowledge and acceptance of irradiated foods among consumers at the CEAGESP food bank, as well as investigate the effectiveness of educational interventions in disseminating the benefits of food irradiation. The survey used structured quantitative questionnaires as data collection instruments, administered to food bank employees. After the educational intervention, which included information through text, video, visual sensory analysis, and graphic material, there was a significant increase in the participants' intention to purchase irradiated foods. The results indicated that information and active knowledge dissemination were effective in promoting consumer acceptance of this technology. Additionally, the study highlighted the importance of producing informative materials in Portuguese for different populations to enhance understanding and acceptance of food irradiation.

In an article also led by [2], a comprehensive review of food irradiation in Brazil was conducted, addressing historical, regulatory, and technological aspects, as well as current challenges and future possibilities. The work analyzed legislation, norms, and resolutions

related to food irradiation, highlighting the evolution of regulatory practices over decades. Additionally, the benefits of food irradiation compared to the use of agrochemicals were discussed, emphasizing the need for information and communication to promote public acceptance of this technology.

The present study, carried out in accordance with the mentioned researches, comprised a virtual questionnaire, divided into three parts: the first part is the socioeconomic and demographic characterization of participants; in the second part, prior knowledge about food irradiation among Brazilian Navy workers was assessed, and finally, in the third part, new questions were asked to assess acceptance and demystification of food irradiation among Brazilian Navy workers. After completing the second part of the questionnaire, respondents gained access to informative pamphlets and explanatory videos, which were expected to significantly contribute to increase understanding knowledge about irradiated foods.

A total of 50 respondents aged between 28 and 58 years old participated of this online survey: among them, 38 officers, 9 enlisted personnel, and 3 civilian employees. Regarding gender, there was a male predominance, with 47 men and only 3 women. Regarding education, there was observed an interesting distribution: while 62% attended private schools during elementary education, this proportion decreased to 44% in high school. Regarding educational attainment, it was found that 8% had incomplete higher education, 68% had completed higher education, and 24% had a master's or doctoral degree. Finally, in terms of location, 18 participants were from the state of São Paulo, 28 from Rio de Janeiro, two from the Federal District, one from Pará, and one from Amazonas. This diversity in the sample composition provides a comprehensive insight into the socio-economic and demographic characteristics of the participants, enriching the analysis of the research results.

The sample composition was considered scattered, not effectively reflecting the socio-economic and demographic characteristics of military personnel and civilian workers of the Brazilian Navy, which is a vast institution located in all capitals and port



cities across immense Brazil. For a more accurate and representative research on the subject, it is suggested that a survey conducted by the institution itself in order to enrich the analysis and research results across the country.

After analyzing the responses from Part II and Part III of the virtual questionnaire, we noticed significant changes in the participants' perceptions regarding food irradiation technology. Before receiving information, 28% of the respondents expressed a negative view of nuclear energy, a number that decreased to 12% after accessing the information. Additionally, 98% of the participants demonstrated concern about the foods they consume. Before the survey, 54% of the respondents claimed to have no knowledge about food irradiation technology, which was reflected in the belief that irradiation produces toxins in foods after the process. However, after receiving clarification, through the informative pamphlets and explanatory videos, 82% of the participants expressed willingness to consume irradiated foods, a number that was 54% before accessing the information. This positive result is encouraging, considering that little information was conveyed only through pamphlets and a YouTube lecture. Regarding the information provided, 74% of the participants preferred to watch the interview [6], 16% preferred to read the pamphlets, 4% claimed to have done both options for information, and 6% (3 participants) stated that they did not choose either option. Still, regarding the information provided, 74% responded that the explanations provided in one way or another were enlightening, and 90% of research participants consider the information received through the research to be relevant.

It is important to highlight that during the research, participants were shown an illustration containing everyday foods, such as cookies, pasta and savory snacks. They all contain irradiated ingredients, but the public is not aware of this fact. Therefore, regarding the question of whether or not respondents had consumed any food presented in that illustration, the survey brings the following results:

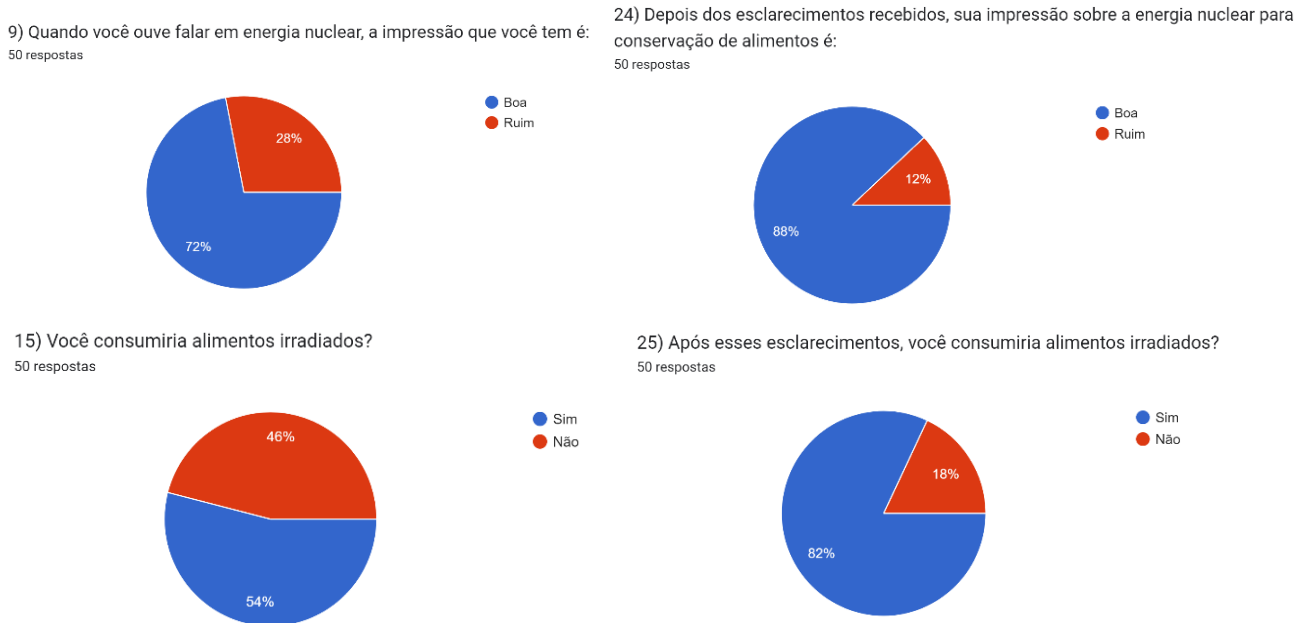


- 64% affirmed that they had eaten those foods, but did not know that they had been irradiated or contained ingredients treated by irradiation.
- 30% of the respondents had consumed some of the illustrated products already knowing that they were irradiated foods or contained some ingredient treated by irradiation.

Furthermore, the majority of respondents (88%), stated that they were not familiar with the Radura symbol, which identifies products treated by irradiation. In the last question of the questionnaire, 16 participants indicated interest and provided email addresses intending to receive more content about food irradiation.

An initial hypothesis was that the technique of food irradiation would be unfamiliar to most respondents, however, after reviewing the provided informative material, there would be a positive acceptance from the surveyed audience. Such as in previous studies [2], [3], [4], [5], this initial hypothesis, has been confirmed. As a result, it is of interest to the researchers to expand this research among a larger number of participants from the Brazilian Navy. This expansion could be achieved through a formal questionnaire requested by the institution, encouraging the voluntary participation of Navy personnel and civilian employees. In Figure 1 there are some pie charts obtained in Google Forms with the results of some relevant questions.

**Figure 1** – Graphs about answers directly from Google Forms



Source: Elaborated by the authors

The research findings indicate that 98% of participants expressed concern about the food they consume, and 94% stated that consuming fruits and vegetables during voyages exceeding 15 days is important. These results underscore the significance of this technology for use in Brazilian Navy ships and submarines, thereby contributing to the health and morale of sailors.

## 4. CONCLUSIONS

The research findings indicate a significant shift in participants' perceptions regarding food irradiation, with a notable decrease in negative views about nuclear energy and a substantial increase in willingness to consume irradiated foods after receiving information. The results also highlight a high level of concern among participants regarding the quality of the foods they consume, along with recognition of the importance of consuming fresh produce during extended voyages. These observations underscore the

relevance of food irradiation technology for use by the Brazilian Navy, offering potential benefits for the health and well-being of naval personnel.

Furthermore, the preference for accessing information through an interview on the YouTube platform underscores the effectiveness of engaging multimedia formats for educational purposes. These findings inform the conclusion of the study, suggesting the need for a more comprehensive investigation to explore the topic of food irradiation among a larger sample of Brazilian Navy personnel, potentially through a formal survey administered by the institution, encouraging voluntary participation. The conclusions drawn from this analysis of the research results provide valuable insights for future research and educational initiatives aimed at increasing awareness and acceptance of food irradiation technology among Brazilian Navy personnel and civilian employees. Finally, it is suggested that holding in-person seminars or workshops at conferences could further increase the acceptance of food irradiation.

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