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Review Article

Impact of the Food Nutritional Value on The Public Health

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Abstract:

The Meat is a valuable element of the human diet as it contains essential elements such as protein, vitamins, and minerals. However, these foods are also vulnerable to the microbial pathogens and the spoilage, posing significant risks to the human health. Ionizing radiation is used in food irradiation to maintain the safety and quality of the food items, specifically the beef.

For decades, the food irradiation has been used to reduce microbial contamination and extend the storage period. The procedure entails subjecting the food item to a regulated amount of ionizing radiation, usually accomplished by applying gamma rays, electron beams, or X-rays.. The radiation disrupts the DNA and other cellular components of microbes, making them unable to reproduce and causing their death. The procedure also breaks down some of the molecules in the food product, which can affect its nutritional quality and sensory properties.

Keywords: beef, human health, food irradiation, DNA gamma rays

Introduction:

Despite its potential benefits, food irradiation remains controversial, with concerns about its safety, efficacy, and impact on the nutritional quality and sensory properties of food products. Some critics argued that the food irradiation could create the harmful compounds or destroy the essential nutrients. In contrast, others questioned the need for the irradiation, considering other food safety measures, such as the good manufacturing practices and the food testing. The Consumer acceptance of the irradiated food products also needs to be addressed, with some people expressing concerns about their safety and acceptability (1,2,3,4,5 and 6). This comprehensive research aims to critically evaluate the existing literature on food irradiation and its repercussions on the quality and safety of the beef. The proof of irradiation effectiveness at lowering microbial contamination and prolonging the shelf life of the beef is explored along with its potential impact on the physical and chemical characteristics, nutrient content, and sensory properties. This paper will also address the regulatory framework for food irradiation, including labeling requirements and government oversight, as well as identify areas for further research and policy development (7,8,9,10,11 and 12).

Sources and Principles of the Food Irradiation:

The Ionizing radiation, such as the gamma rays, the X-rays, or the high-energy electrons, is used to irradiate the food. The ionizing radiation wavelength is shown in Figure 1a. The food irradiation is generally

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determined by the absorbed dose expressed in Gray (Gy) or kilo Gray (kGy), with 1 Gray being equivalent to 1 J/kg of product. The technique is considered a safe and effective way to decrease or eliminate the hazardous microbes, prolong the shelf life, as well as enhance the quality and safety of the food products (79,80,81,82,83 and 84). The principles of the food irradiation are determined by the ability to disrupt the genetic material of microorganisms, preventing them from reproducing or causing illness. The irradiation affects the microorganisms' genetic material (DNA or RNA) directly and indirectly. Direct irradiation can break the bonds between base pairs in the genetic material, killing the cell's reproduction ability. Then, on the other hand, damage to water molecules creates free radicals and reactive oxygen species, which damage genetic material indirectly. Irradiation also helps to break down certain enzymes and proteins in the food that can contribute to spoilage, thereby increasing the shelf life (13,14,15,16,17 and 18). The US, Canada, as well as several European and Asian nations, allow the food irradiation using Cobalt-60, cesium-137, and electron-beam accelerators. Cobalt-60, the most prevalent source of ionizing radiation for the food irradiation, is a radioactive isotope that emits gamma rays capable of penetrating deep into the food products to destroy the harmful microorganisms. Cesium-137 is another source of the ionizing radiation, although it is less commonly used than cobalt-60. In addition, the electron-beam accelerators are used for the food irradiation. These devices generate high-energy electrons that can penetrate the food products to eliminate the harmful microorganisms and extend the beef shelf life (19,20,21,22,23 and 24). Irradiating the foods has several benefits, including multifunctional applications as well as guaranteed safety and security. The spectrum produced is effective against bacterial spores across a broad range of concentrations. Given that processing does not involve heat, it is safe for the food, does not significantly reduce nutrient levels, leaves no chemical residues, and is simple to control during use., to effectively lengthen the lifespan of the irradiated food products, the following the principles must be observed, Radurization uses low doses of 0.1–1 kGy (85,86,87,88,89 and 90). This amount inhibits respiration, delays ripening, disinfects pests, and inactivates the Trichinella parasite. Radicidation is referred to as a moderate dose. This radiation uses a quantity of approximately 1–10 kGy, which has the effect of reducing spoilage and microbial pathogens including Salmonella sp. And Listeria monocytogenes. This dosage is typically found in the frozen foods and its application is identical to that of pasteurization, except irradiation does not rely on thermal energy (91,92,93,94,95 and 96). Radapertization uses extremely high doses which are above or equal to 10 kGy, ranging between 30 and 50 kGy. This dose is typically used in the sterilization process because its effect can kill all microorganisms in the foodstuffs up to the level of spores. Generally, the food irradiation sources and principles are based on the ability of ionizing radiation to disrupt the genetic material of microorganisms, enzymes, and proteins in the food products, culminating in improved safety and quality. The use of irradiation is regulated by national and international authorities to ensure its safety and effectiveness (25,26,27,28,29 and 30).

The Effects of Irradiation on the beef:

The Microbial Safety:

The Microbial safety is a critical aspect of the beef production and the consumption, as these products can be a source of the various harmful microorganisms that can cause the foodborne illness. The beef products are potentially contaminated with various pathogens, such as Salmonella, Escherichia coli, Campylobacter, and Listeria monocytogenes, leading to severe illness or death in vulnerable populations (31,32,33,34,35 and 36). Contamination might occur at the production, processing, or distribution stage, including on the farm, during transport, in slaughterhouses or processing facilities, and in retail outlets or at home. The Improper handling and storage of the beef products can also increase the risk of contamination (97,98,99,100,101 and 102). The Foodborne illness outbreaks related to the beef have been reported globally, with various types of products being implicated, including the ground beef, the chicken, the pork, and the processed beef. These outbreaks have led to the significant public health and the economic consequences, the highlighting the importance of the effective interventions to reduce the risk of contamination (37,38,39,40,41 and 42). The Irradiation has been studied extensively for its efficacy in reducing microbial contamination of the beef. By exposing the food to the ionizing radiation, the latter reduces or eliminates the harmful microorganisms that can cause foodborne illness. Previous research showed that irradiation could effectively reduce the levels of the pathogens such as Salmonella and Escherichia coli as well as levels of spoilage organisms, leading to improved microbial safety and a reduced risk of the foodborne illness (103,104,105,106,107 and 108). The effectiveness of various types of the ionizing radiation on the beef, including the gamma rays and the e-beams, has been studied, gamma ray irradiation is more effective than e-beam irradiation is at inhibiting microbial growth in the beef.The UV light effectively eliminates Salmonella spp., Pseudomonas, Micrococcus, and Staphylococcus on the beef. The shelf life of the beef products is extended by eliminating these contaminant bacteria (109,110,111,112,113 and 114). Gamma irradiation at low doses can improve the microbiological safety, ensure safety, and extend the chicken meat's shelf life without affecting the quality .The 3 kGy gamma-irradiated beef reduced the growth of the mesophilic bacteria, coliforms, and Staphylococcus aureus (115,116,117,118,119 and 120). Food and Drug Administration (FDA) determined that a 3.5 kGy gamma ray irradiation dose effectively eliminates the pathogenic microbes from the fresh beef. The Irradiation had the effect of slowing the growth of the bacterial cells and deactivating their metabolism (157,158,159,160,161 and 162). The Bacteria are inherently resistant to the effects of the irradiation and, in the lag phase or inactive state, will be more resistant. In contrast, those in the growth phase will be more vulnerable (43,44,45,46,47 and 48).

Chemical Properties:

The chemical properties of the irradiated beef refer to the changes that occur to the chemical constituents and the compositions of the food due to exposure to the ionizing radiation. The Irradiation can cause both desirable and undesirable effects on the chemical characteristics of beef, depending on the dose and the specific compounds in the food (49,50,51,52,53 and 54). One of the most significant changes often observed in irradiated beef products is the formation of the free radicals. They become reactive molecules that damage cellular components and cause oxidative stress. This leads

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to the lipid oxidation, which causes off-flavors and odors, as well as a decline in nutritional quality due to the loss of essential fatty acids and other nutrients (121,122,123,124,125 and 126). However, the irradiation at lower doses also aids lipid oxidation by reducing the levels of peroxides and other reactive species. This procedure also affects the protein content of the beef, leading to alterations in the composition of the amino acids, protein structure, and digestibility. These changes have potentially positive and negative effects, mostly on the nutritional value of the food, that are contingent upon the particular proteins involved and the dose of radiation used (127,128,129,130,131 and 132). The positive effects of irradiation include the fact that irradiation can cause the formation of reactive species, such as the free radicals, which can cause the formation of covalent bonds between the amino acids in protein molecules (163,164,165,166,167,168,169 and 170). This cross-linking can change the structure of a protein molecule and make it resistant to enzymatic digestion, which causes a decrease in the protein digestibility (55,56,57,58,59 and 60). The Irradiation can also cause the denaturation of the protein molecules. The Denaturation involves opening the protein structure, which can facilitate the interactions between the amino acids and increase the accessibility of the digestive enzymes to protein molecules, and it can also improve the protein digestibility (133,134,135,136,137 and 138). However, the irradiation can also cause adverse effects; namely, the excessive irradiation can cause a breakdown of or changes in the amino acid compounds in the protein molecules, which causes a decrease in the overall amino acid content and, consequently, decreases the protein digestibility.The electron-beam irradiation at less than 3 kGy did not affect changes in the quality of the smoked duck flesh (the amino acids, the fatty acids, and the volatiles) during the storage (61,62,63,64,65 and 66). Aside from these chemical changes, the irradiation also affects the vitamin content of the beef products, with some vitamins being more sensitive than others. For example, the irradiation leads to a loss of the vitamin C, while other vitamins, such as the vitamin A and E, are relatively stable. The Irradiation has been shown to alter the beef oxidation–reduction ability, accelerating the lipid oxidation, the protein breakdown, and the flavor and the odor changes (67,68,69,70,71 and 72). When combined with certain antioxidants, such as the flavonoids, the irradiation can help prolong the induction period of the lipid oxidation., storing the irradiated beef at 5–10 C for one week almost did not change the pH, the texture, the total volatile base nitrogen (TVBN), or the microbe number (145,146,147,148,149 and 150). Meanwhile, A higher dose of the UV irradiation increased 2-thiobarbituric acid (TBA) content, decreased the water-holding capacity (WHC), and the decreased beef color intensity and tenderness (139,140,141,142,143 and 144). The 2.5 and 5 kGy gamma irradiation reduced the nitrite content in the chicken sausages and prevented the oxidation when combined with the antioxidants. The titratable acidity and the acid value in the beef samples can be reduced by the irradiation (73,74,75,76,77 and 78). The beef contamination may occur at the production, the processing, or the distribution stage, including on the farm, during the transport, in the slaughterhouses or the processing facilities, and in the retail outlets or at the home (151,152,153,154,155 and 156).

Conclusion:

The Improper handling and the storage of the beef products can also increase the risk of the beef contamination. The Foodborne diseases outbreaks related to the beef have been reported globally, with the various types of the meat products being implicated, including the ground beef, the chicken meat, the pork, and the processed beef.

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