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Review Article

Irradiation of the Meat Products can Prolong the Shelf life of the Meat ?

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Abstract

The meat irradiation is a tried and true method that used to improve the food quality and the food safety of the meat. By the application of this method, the growth of the bacteria, the viruses, and the parasites is successfully inhibited. By using the postponing spoiling and inhibiting the growth of the microorganisms, it also extends the meat shelf life and improves the food quality of the meat. The right dosage is applied; the meat radiation has no action on the meat colour, the meat taste, or the meat texture. Its effect on the chemical and the nutritional properties of the meat is more complicated, though, as it may change the meat vitamins, the meat fatty acids, the meat amino acids, and produce the free radicals that oxidise the meat fat. The effect of these modifications is dependent on a number of factors, such as the kind of the meat, the meat storage conditions, and the meat radiation exposure. The Meat physical characteristics, such as meat softness, the meat texture, and the meat dose dependent ability to retain the water, can also be affected by the radiation. The Low doses of the meat radiation may enhance the meat texture and the meat softness, while excessive doses cause the meat protein denaturation, which adversely affects the meat characters. The regulatory and the public perception elements of the meat irradiation are also examined in this study. Although the meat radiation is permitted and regulated in many nations, its use is debatable and causes anxiety in the public. The meat irradiation is a dependable method of improving the food safety and the food quality of the meat; nevertheless, it is important to take into account the action it may have on the chemical, the physical, and the nutritional characteristics of the meat product when selecting the right dosage and application. The long term action of the radiation on the meat product and allay the consumer worries, further studies are required.

Keywords: meat irradiation; quality; safety; meat

Introduction

The Meat is a valuable element of the human diet as it contains essential elements such as the protein, the vitamins, and the minerals. The meat is also vulnerable to the microbial pathogens and spoilage, posing significant risks to the human health. The Ionizing radiation is used in the meat irradiation to maintain the food safety and quality of the meat [1-8]. For several decades, the meat irradiation has been used to lower the microbial contamination and extend the storage period. The procedure entails subjecting the meat item to a regulated amount of the ionizing radiation, usually accomplished by applying the gamma rays, the electron beams, or the X-rays. The radiation disrupts the DNA and other cellular components of the microorganisms, making them unable to reproduce and causing their death. The procedure also the breaks down some of the molecules in the meat product, which can affect its nutritional quality and sensory properties [46-54].

Despite its potential benefits, the meat irradiation remains controversial, with concerns about its food safety, efficacy, and effect on the nutritional quality and sensory properties of meat products [55-63]. Some critics argued that the meat irradiation could create the harmful compounds or destroy the essential nutrients. In contrast, others questioned the need for the irradiation, considering other meat safety measures, such as the good manufacturing practices and the meat testing. The Consumer acceptance of the irradiated meat products also needs to be addressed, with some people expressing concerns about their food safety and the acceptability [73-81].

This comprehensive research aims to critically evaluate the existing literature on the meat irradiation and its repercussions on the food quality and food safety of the meat. The proof of the irradiation effectiveness at lowering the microbial contamination and prolonging the shelf life of the meats is explored along with its potential effect on the physical and the chemical characteristics, the nutrient content, and the sensory properties [92-100]. This paper will also address the regulatory framework for the meat irradiation, including labeling requirements and government oversight, as well as identify areas for further research and policy development [101-108].

The Sources and the Principles of the meat Irradiation

The Ionizing radiation, such as the gamma rays, X-rays, or the high-energy electrons, is used to irradiate the meat. The meat irradiation is 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 method is considered a safe and effective way to decrease or eliminate the hazardous microorganisms, prolong the shelf life, as well as enhance the food quality and food safety of the meat products. The principles of the meat irradiation are determined by the ability to disrupt the genetic material of the microorganisms, preventing them from reproducing or causing the illness. The irradiation affects the microorganisms' genetic material (the DNA or the RNA) directly and indirectly. The Direct irradiation can break the bonds between the base pairs in the genetic material, killing the cell's reproduction ability. The damage to the water molecules creates the free radicals and the reactive oxygen species, which damage the genetic material indirectly [134-140]. The Irradiation also helps to break down certain enzymes and the proteins in the meat that can contribute to the spoilage, and increasing the shelf life [141-146]. USA, Canada, as well as several European and the Asian nations, allow the meat irradiation by using the Cobalt-60, the cesium-137, and the electron-beam accelerators. The Cobalt-60, the most prevalent source of the ionizing radiation for the meat irradiation, is a radioactive isotope that emits gamma rays capable of penetrating deep into the meat 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 meat irradiation. These devices generate high-energy electrons that can penetrate the meat products to eliminate the harmful microorganisms and extend the shelf life [154-160]. The Irradiating the meats has several benefits, including multifunctional applications as well as guaranteed food safety and food security. The spectrum produced is effective against the bacterial spores across a broad range of the concentrations. The processing does not involve the heat, it is safe for the meat, does not significantly lower the nutrient levels, leaves no chemical residues, and is simple to control during the use [37-45]. To effectively lengthen the lifespan of the irradiated meat products, the following principles must be observed as the Radurization uses low doses of 0.1–1 kGy. This amount inhibits respiration, delays ripening, disinfects pests, and inactivates the Trichinella parasite. The Radicidation is referred to as a moderate dose. This radiation uses a quantity of approximately 1–10 kGy, which has the action of reducing the spoilage and the microbial pathogens including the Salmonella sp. and the Listeria monocytogenes. This dosage is typically found in the frozen meats and its application is identical to that of pasteurization, except the irradiation does not rely on the thermal energy. The 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 action can kill all microorganisms in the meat up to the level of spores [161,162,163,164 and 165]. The meat irradiation sources and the principles are based on the ability of the ionizing radiation to disrupt the genetic material of the microorganisms, the enzymes, and the proteins in the meat products, culminating in improved the food safety and the food quality. The use of the irradiation is regulated by the national and the international authorities to ensure its food safety and effectiveness [166-171].

The action of the Irradiation on the Meat

The Microbial food Safety

The Microbial food safety is a critical aspect of the meat production and the consumption, as these products can be a source of the various harmful microorganisms that can cause the food-borne diseases. The Meat products are potentially contaminated with various pathogens, such as the Salmonella, the Escherichia coli, the Campylobacter, and the Listeria monocytogenes, leading to severe illness or the death in vulnerable populations [9-16].

Contamination might occur at the production, the processing, or the distribution stage, including on the farm, during transport, in the slaughterhouses or the processing facilities, and in the retail outlets or at the home. The Improper handling and the storage of the meat products can also increase the risk of contamination. The Food-borne diseases outbreaks related to the meat have been reported globally, with the various types of products being implicated, including the ground beef, the chicken, the pork, and the processed meats. These outbreaks have led to significant public health and economic consequences, highlighting the importance of effective interventions to lower the risk of the contamination [109-117].

The Irradiation has been studied extensively for its efficacy in reducing the microbial contamination of the meat. The Exposing of the meat to the ionizing radiation, the latter lower or eliminates the harmful microorganisms that can cause the food-borne diseases. Previous research showed that the irradiation could effectively lower the levels of the pathogens such as the Salmonella and the Escherichia coli as well as the levels of the spoilage organisms, leading to improve the microbial food safety and lower the risk of the food-borne diseases. The effectiveness of various types of the ionizing radiation on the meat, including the gamma rays and the e-beams, has been studied [82-91]. The gamma ray irradiation is more effective than e-beam irradiation is at inhibiting the microbial growth in the meat. The UV light effectively eliminates the Salmonella spp., the Pseudomonas, the Micrococcus, and the Staphylococcus on the meat. The shelf life of the meat products is extended by eliminating these contaminating bacteria. The Gamma irradiation at low doses can improve the microbiological food safety, ensure safety, and extend the chicken meat's shelf life without affecting the food quality. Three kGy gamma irradiated beef lower the growth of the mesophilic bacteria, the coliforms, and the Staphylococcus aureus. The meat and Drug Administration (FDA) determined that a 3.5 kGy gamma ray irradiation dose effectively eliminates the pathogenic microorganisms from the fresh meat. The meat Irradiation had the action of slowing the growth of the bacterial cells and deactivating their metabolism. The Bacteria are inherently resistant to the action 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 [64-72].

The Chemical Properties

The chemical properties of the irradiated meat refer to the changes that occur to the chemical constituents and compositions of the meat due to exposure to the ionizing radiation. The Irradiation can cause both desirable and undesirable action on the chemical characteristics of the meat, depending on the dose and the specific compounds in the meat. One of the most significant changes often observed in the irradiated meat products is the formation of the free radicals. They become reactive molecules that damage cellular components and cause the oxidative stress. This leads to the lipid oxidation, which causes off flavors and odors, as well as a decline in the nutritional quality due to the loss of the essential fatty acids and other nutrients. The irradiation at the lower doses also aids the lipid oxidation by reducing the levels of peroxides and other reactive species. This procedure also affects the protein content of the meat, leading to alterations in the composition of the amino acids, protein structure, and the digestibility [126-133]. These changes have potentially positive and negative action, mostly on the nutritional value of the meat, that are contingent upon the particular proteins involved and the dose of the radiation used. The positive action of the irradiation include the

fact that the irradiation can cause the formation of the reactive species, such as the free radicals, which can cause the formation of the covalent bonds between the amino acids in the protein molecules. This cross-linking can change the structure of a protein molecule and make it resistant to the enzymatic digestion, which causes a decrease in the protein digestibility [27-36]. 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 the protein molecules, and it can also improve the protein digestibility. The irradiation can also cause adverse action; namely, the excessive irradiation can cause a breakdown of or the change 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 [118-125].

Aside from these chemical changes, the irradiation also affects the vitamin content of the meat products, with some vitamins being more sensitive than others. 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 meat's oxidation–reduction ability, accelerating the lipid oxidation, the protein breakdown, and the flavor and the odor changes [147-153].

When combined with certain antioxidants, such as the flavonoids, the irradiation can help prolong the induction period of the lipid oxidation. The storage of the irradiated meat at 5–10 C for one week almost did not change the meat pH, the meat texture, the total volatile base nitrogen, or the microbe number. The higher dose of the UV irradiation increased 2-thiobarbituric acid content, decreased water-holding capacity, and decreased the beef color intensity and the tenderness. The Two point five and 5 kGy gamma irradiation lower 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 meat samples can be lowered by the irradiation [17-26]

Conclusion

One promising method that might enhance the food safety and the food quality of the meat is the meat irradiation. According to recent study, the irradiation can preserve the nutritional value of the meat products, decrease the microbial contamination, and increase shelf life. To overcome this issue, more study is necessary as the sensory characteristics can be adversely affected. It is also significant to remember that the labelling regulations for the irradiated meat products exist, and that the irradiation in the meat processing is governed by both the national and the international bodies. The Government organisations play a crucial role in guaranteeing the security and the quality of the customers.

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