# Impact of Irradiation on Food Quality

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***Abstract***- *The spoilage of food products proves to be the biggest menace faced by the food industries and therefore, there is an immense need of improvised food preservation techniques.Amongst the different emerging methods, use of irradiation has shown promising results in the food preservation techniques and this method does not compromise with the taste, odour, texture, flavour, nutritional quality and safety of the food product. Both ionising and non-ionising radiations have been employed in the preservation methodology and ionising radiations have shown better efficiency than the latter one. The article highlights the activity of various types of radiations and also highlights the effects of the radiations of the macromolecules of food. The article also gives an insight onto the types of food products on which radiation is employed and also gives information on the regulatory affairs pertaining to the technique.*

***Keywords***- Food preservation, Food quality, Food safety, Irradiation.

## I. INTRODUCTION

Food spoilage has been the biggest menace in the food industry and hence, various food preservation techniques have been developed to combat with this menace. Man has developed numerous preservation methods since time immemorial [1]. Radiation from solar energy has been used to preserve different food materials since ancient times. Drying using solar energy had been used to store fruits, vegetables and even meat for a long period of time. The main was to remove water content from the food which would inhibit microbial growth as microbes need water for their metabolism and other vital functions [2]High quality food products are the basic demand of consumers and hence, food industries always employ better and improvised preservation methods that provide safety against microbial contamination and increase the shelf life of the food products [3]. The various food preservation techniques include drying, freezing, pickling, canning, fermentation, pasteurisation, cooling, irradiation and addition of preservatives [4].

Irradiation is the process that makes use of high-energy radiation (wavelength< 200nm) or high-speed electron beams to ionise the molecules and break chemical bonds in the food components. Irradiation has bactericidal effects-the biomolecules of the bacteria get damaged when exposed to irradiation. Moreover, certain irreversible modifications take place in the DNA and RNA molecules of the bacteria, which inhibit their growth and metabolism, thereby preventing contamination in food without leaving any residue in the irradiated food [5]. The main sources of irradiation are $^{60}$Co and $^{137}$Cs. The amount of radiation that is absorbed by a material is measured in gray and is denoted as Gy. 1 Gy is defined as the absorption of 1J of energy by 1 Kg of food [6].

The main reasons for employing irradiation techniques are listed below [7,8]:

- To destroy, inactivate and prevent the growth and metabolism of organisms that cause degradation and spoilage of the food products like meat, seafood, poultry products, fruits and vegetables, thereby extending their shelf life.
- To eliminate and destroy microorganisms like *Salmonella*sp. And *Escherichia coli*, that cause food-borne diseases in foods like meat, seafood, poultry products, fruits and vegetables.
- To sterilize foods like poultry, spices and seasonings, which can be easily stored without refrigeration.This uses 20-93 kGy of radiation.
- To delay the fruit ripening and senescence which uses 0.12-0.75 kGy ofirradiation and inhibit sprouting in foods like potatoes, onions and garlic, in order to increase their longevity. It uses 0.15-0.2 kGy of irradiation.
- To destroy insects and control the contamination by pests in the fruits, vegetables and other food items like grains and cereals. The amount of radiation used usually ranges from 0.15-0.50 kGy.
- To pasteurise food items like seafood, poultry and meat at 1-2 kGy of radiation.

## II. TYPES OF IRRADIATION

There are two types of radiations: Ionising and Non-ionising radiation.

*A. IONISING RADIATION*: These are radiations with very high energy with the ability to displace electrons from molecules and convert them to ions. These are transmitted

by high energy particles like electrons, protons, neutrons and alpha. The food industry employs electron-beam radiation and electromagnetic radiation (gamma- and X-rays) for irradiation of food particles [9].

B. *NON-IONISING RADIATION*: These radiations have relatively lower energy and cannot perform ionisation. These radiations hence, are not ableto remove electrons or break molecular bonds. They are presently not used for food preservation. Examples include microwave and ultraviolet radiation [10].

## III. COMMON RADIATIONS USED BY THE FOOD INDUSTRY

A. *GAMMA RADIATION*: The wavelength of gamma radiation is below 10-12 m and the frequency are above 1019 Hz. It is produced from the nucleus of radioactive elements like $^{60}$Co and $^{137}$Cs. Irradiation using gamma rays generates lower amount of heat, requires lesser energy, and causes lesser changes in food components. However, not all insects and pests can be killed using gamma rays [2,11].

B. *MICROWAVE RADIATION*: Microwave radiation has numerous industrial applications and is used as an alternative for sterilisation [12,13]. However, microwave radiation does not have sufficient energy to generate fee radicals and to cause ionisation [14]. Microwaves generate high amount of heat and creates electric field which kills the microbial cell by promoting alteration in the structure of proteins in the cell [13,15].Hence, microwaves can be used for decontaminating the utensils and sterilisation of other components [16].

C. *ULTRAVIOLET RADIATION*: The wavelength of UV radiations lies between 100-400 nm [17,18] and have high antimicrobial activity [19]. The UV light can be applied either in continuous or pulsed mode and the pulsed mode has been found to be for efficient for inactivation of microbiological metabolism [20]. UV radiation has greater germicidal action and has been increasingly used as a nonchemical disinfection [21]. Moreover, it does not produce any by-products, does not leave any chemical residues, and is cost-effective and simple technique [22].

## IV. EFFECTS OF IRRADIATION ON MAJOR FOOD COMPONENTS

Radiation may induce a few changes or modifications in the various constituents of food and these modifications are dependent upon certain factors like the constituent present in food, duration of the exposure to the radiation, amount of radiation used, temperature and atmospheric oxygen levels [23]. The effects on major constituents of food are described as [24]:

A. *EFFECT ON PROTEINS*: The pectinase activity in many food products decreased when exposed to 20 kGy of radiation [25]. The protein content in hazelnuts aggregated and denatured when they were exposed to 10 kGy of gamma radiation [26]. However, it was found that proteins chemically reacted lesser when irradiation was used for sterilisation than when heat was used [27].

B. *EFFECT ON CARBOHYDRATES*: The formic acid, aldehydes and hydrogen peroxide in the starches of rice, wheat, maize and potato produce radiolytic products, when exposed to gamma radiation [28]. There are certain modificationsinduced by various radiations but it was found that thermal treatment produces more modifications than irradiation [29].

C. *EFFECT ON LIPIDS*: Oxidation of lipids increase as free radicals are formed due to various radiations [30]. Phytosterols have similar structure to cholesterol and are naturally present in various cereals, fruits, seeds and vegetables. These get oxidised to oxyphytosterols, when they get exposed to radiation [31,32]. Chemical modifications due to irradiation depend on the fat content, presence of antioxidants, type of fatty acids present and storage conditions like light, temperature, etc. [33].

## V. FOODS PRESERVED BY IRRADIATION:

A. *CEREALS*: Irradiation is used as a pest control and it leaves no residues and odes not compromise with the nutritive value of the cereals [34]. The young adults of insects are seriously affected by lower doses of radiation [35].

B. *FRUITS AND VEGETABLES*: The maximum amount of radiation that can be applied to fruits and vegetables should be between 1-2 kGy, depending upon the type of fruit or vegetable [36].

C. *SPICES*: Irradiation is an efficient method to preserve spices and condiments to due to its antimicrobial activity [37]. Ionising radiation has more lethal effects on bacteria than thermal sterilisation and radiations are safer to the spices and its constituents [38].

D. *MEAT AND SEA FOODS*: Irradiation is mainly used to remove the pathogens and parasites from meat and sea foods [39]. Irradiation of around 3 kGy is found to be lethal to pathogenic, non-spore-forming bacteria [40,41]. However, irradiation can affect the odour, colour and taste of the food.

## VI. REGULATORY AFFAIRS

The FDA instructs that the international irradiation symbol must be present in the label of food products that have been irradiated. The Radura symbol is the symbol for irradiation and the label must contain words such as "Treated by irradiation". The safety of irradiated food products has been particularly assessed by FDA an it has approved the use of radiation in food products. The safety has further been endorsed by Centre for Disease Control (CDC) and World Health Organisation (WHO) [8].

## VII. CONCLUSION

Irradiation has shown promising results in the food preservation domain. The antimicrobial and germicidal activity proves lethal to various microorganisms, parasites, pests and insects. The ionising radiations are mostly used for irradiation processes as they have more effectiveness than the non-ionising radiations. When irradiation is used in a controlled limit, it has lesser effects on the nutritional quality of food. More than 60 countries have approved the use of irradiation as a method of preservation as it dos not compromise with the taste, odour and texture of the food. The regulatory bodies continuously monitor the process of irradiation and check for its efficacy and safety in the food products. However, lack of knowledge amongst the consumers has limited its use and hence, there is a need of awareness amongst the people in order to enjoy the benefits of this methodology. There is also a need of continuous research in irradiation methods so that the limitations associated with it can be easily combated and the safety and efficacy of the technique is enhanced.

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