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Food Irradiation: An Assurance for Food Security in Africa

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SUMMARY

Food irradiation is an effective technology for food processing and preservation globally but its adoption in Africa is still poor. Radiation treatment can be applied to agricultural produce and animal food products to get extended shelf life with improved microbiological safety and quality. The benefits, usefulness safety and problems of the technology are discussed in this review.

INTRODUCTION

Inadequate postharvest practices in handling and storage of agricultural produces as well as adverse climatic conditions cause heavy losses in Africa. With progressive increase in food production, a need for effective storage methods and facilities is of great importance otherwise these losses will continue to escalate. Foods progressively undergo deterioration or spoilage from the time they are harvested unless they are preserved (Dijkxhoorn *et al.*, 2021). Food spoilage occurs when microbiological, chemical or physical changes take place which is often accompanied by production of toxic substances while in other cases it results in losses of nutritional value thereby making the food product unacceptable to the consumers. With the continuous increase in the world's population, a massive problem of upholding ample safe and nutritious food supplies always exists. Therefore, it is crucial to acquire different knowledge on how to convert the unstable harvested produces to a stable form through processing and preservation methods with minimum loss of nutritive value. Food irradiation is one of the common food preservation technologies which can be used to address some of these problems.

Food Irradiation

Food irradiation is the controlled and regulated application of ionizing radiation energy to agricultural products, food, and its constituents in order to improve hygiene, safety, prolong storage, delivery time and also increase shelf life (Bisht *et. al.*, 2021). It is a non-thermal, energy-efficient, non-chemical and physical method of food preservation in which the food is exposed to various ionizing and non-ionizing radiations It can be applied on a variety of foodstuffs from dried products such as seasonings and spices to high moisture foods like poultry and meat and on frozen or refrigerated products without thawing them as well as on foodstuffs at room temperature (Prakash, 2020). The first patent for food irradiation was given in 1905 to J. Appleby and A. J. Banks in England (Toby, 2002). Food irradiation has being recognized and permitted by the World Health Organization (WHO), and is currently being used in over 40 countries and approximately 500,000 tons of food items are irradiated yearly all over the world (Akinloye *et al.*, 2015). The Food and Drug Administration (FDA) has approved a variety of foods for irradiation which include the following: Molluscan shellfish e,g, clams, mussels, Beef and Pork, Crustaceans (e.g., lobster, shrimp, and crab). Fresh Fruits and Vegetables, Poultry, Seeds for Sprouting (e.g., for alfalfa sprouts), Shell Eggs, Spices and Seasonings

Importance of food irradiation

Years of research have irrefutably shown that food irradiation have innumerable beneficial applications such as

- Reduction of postharvest losses of foods
- Prevention of Foodborne Disease
- Preservation of food
- Control of Insects
- Delay of Sprouting and Ripening
- Sterilization
- increase exports

Types of irradiation techniques and mode of action

Basically, there are two types of irradiations

Non-ionizing radiation

Non-ionizing radiation is a form of energy that is generated by a machine or an instrument which can move in a space in the form of electromagnetic waves with a definite wavelength. These radiations have little vigor that is enough to stimulate a molecule or atomic electron and are normally not dangerous so variations are not usually made (Pathak *et al.*, 2018). Common sources of non-ionizing radiations are, radio frequency extremely low frequency (ELF), infrared, microwaves and ultraviolet having lower energy electromagnetic waves. These radiations have a long wavelength (>100 nm) and low photon energy (<12.4 ev). They are the portion of the electromagnetic spectrum from 1 Hz to 3 × 1015 Hz (Syaza *et al.*, 2017). Ultraviolet radiations are the portion of electromagnetic radiations with wavelengths range of 100–400 nm. UV radiation with "C" band is very well known to reduce microbial contamination and as germicides they have the most lethal effect on microbes like viruses, bacteria, fungi etc At 265 nm, UV-C has a high efficiency at which microbes are killed by breaching their cell membranes and destroying their genetically engineered material (DNA or RNA), thereby eliminating their possibilities of thriving leading to cell death. Hence, these radiations neither prompt toxins nor affect the flavour, taste, pH, odour etc. of the product.

Ionizing Radiations

Ionizing radiation is with very short wavelengths and high intensity which is adequate to change atoms by removing an electron from them to form an ion, nonetheless not as high to split atoms, making exposed sources radioactive. X-rays, gamma rays, electron beams are some common examples of ionizing radiations (Khan *et al.*, 2019). Codex General Standard for Irradiated Foods has detailed the radiation sources suitable for food irradiation. There are three source of ionising radiation that can be used for treatment of food: Gamma rays produced from the radioisotopes cobalt-60 (60Co) and cesium-137 (137Cs), X-rays generated from machine sources operated at or below an energy level of 5 MeV and electron beams generated from machine sources operated at or below an energy level of 10 MeV19.

Safety of irradiated foods

Despite the positivity of the process, the development of food irradiation technology was stalled with the myth of food becoming radioactive, possibilities of generating toxic compounds and excessive denaturation or degradation of vital nutrients. A lot of studies both in vivo and in vitro have been conducted extensively to examine the concern about safety of food for human consumption and clear evidences have been provided that processing food with ionising radiation is safe and wholesome (Roberts, 2014).

Table 1: Ranges of Food Irradiation Doses

Level of application		
Low dose applications	Less than 1 kGy	• Inhibition of sprouting in potato and onion (0.03-0.15 kGy). • Delay in fruit ripening (0.25-0.75 kGy). 3. Insect disinfestation in stored grain, pulses and products (0.25-1 kGy). • Destruction of parasites in meat and meat products (0.25-1 kGy).
Medium dose applications	1 to 10 kGy	• Elimination of spoilage microbes in fresh fruits, meat, poultry and seafoods (1.5-3 kGy). • Elimination of food pathogens in meat, poultry and seafoods (3-7 kGy). • Hygienization of spices and herbs (10 kGy).
High dose applications	Above 10 kGy	• Sterilization of food for special requirements which are shelf-stable without refrigeration (25-70 kGy). • Elimination of viruses. • Food for astronauts in space

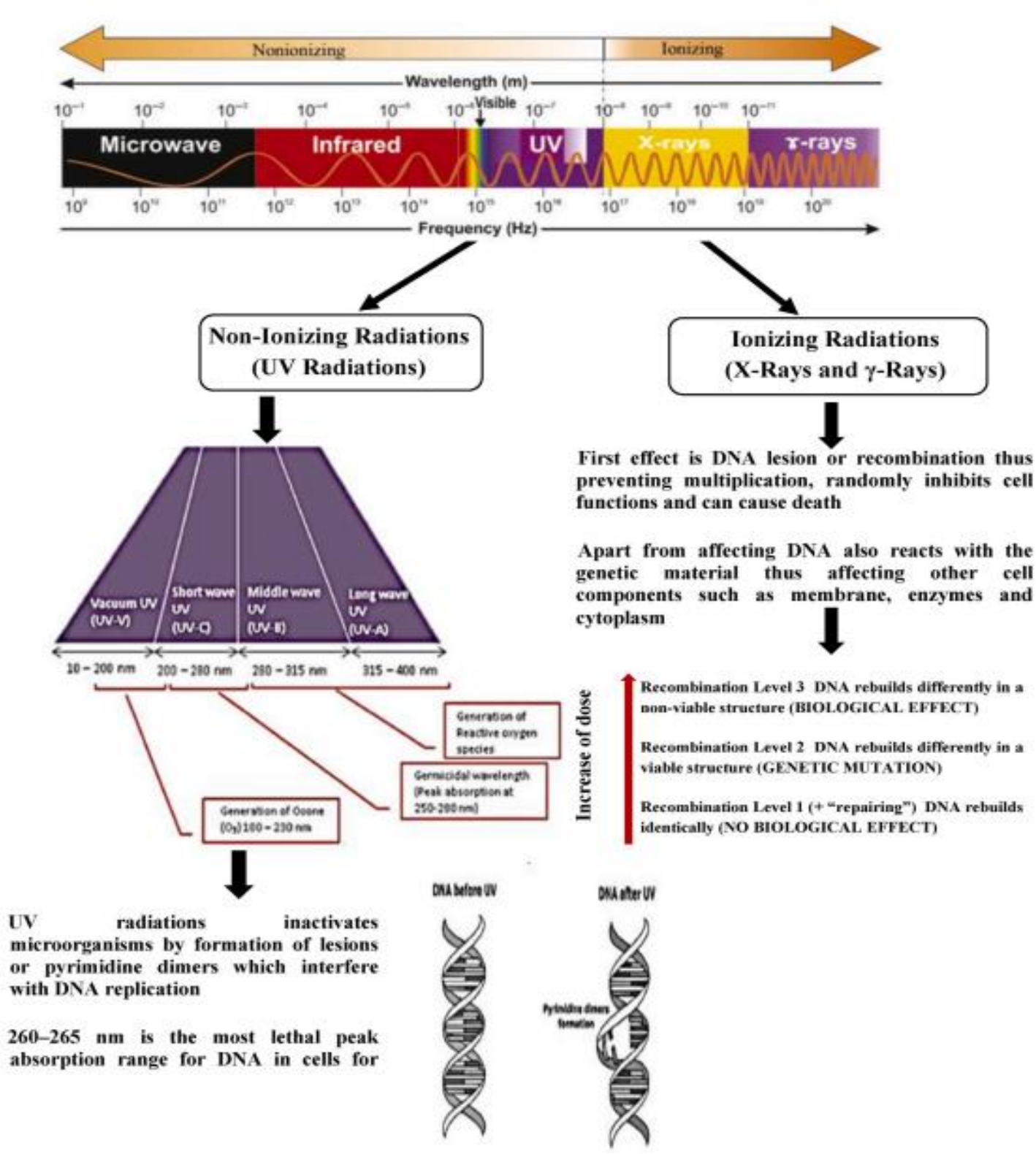

Fig 1: Effect of Ionizing and Non-Ionizing Radiations on Microbial Destruction (Bisht *et al.*, 2021)

Food and Agriculture Organisation (FAO), World Health Organisation (WHO), International Atomic Energy Agency (IAEA) and Codex Alimentarius Commission (CAC) have reviewed the studies on food irradiation for verification of the safety of irradiated food products. The Joint Expert Committee of the FAO, WHO and IAEA stated in its conclusions in 1980 that the irradiation of any food commodity up to an overall average dose of 10 kGy presents no toxicological hazard; hence, toxicological testing of foods so treated is no longer required. European Food Safety Authority and US Food and Drug Administration30 have also endorsed the safety and nutritional adequacy of irradiated foods (Singh and Singh, 2019).

Advantages:

- **Enhances Food Safety:** This innovation viably kills microbes that commonly cause foodborne sickness especially salmonella and E-coli.
- **Support prolonged Shelf Life:** Increase the shelf life of food products by obliterating the dormant organisms that lead to deterioration
- It ensures lower risk of importing or exporting hidden insect pests inside food products
- **Negligible Nutrient Loss: Many studies have shown that when compared with drying, freezing and other preservation techniques, it has the ability to preserve and retain** some nutrients.
- **They are mostly properly labeled w**ith a 'Radura' (which is the international symbol for irradiation) logo that allows consumers to select between buying or avoiding irradiated items.

- No recorded chemical Residue: The US Department of Agriculture, FDA and WHO have demonstrated that the technology may be used on food without causing any hazardous byproducts**.**
- They can control ripening of fruits and also inhibit sprouting times of roots and tubers

Disadvantages

- **Not all food can be irradiated: Eggs and dairy products cannot be irradiated because** the ionizing radiations create substantial changes in their organoleptic characteristics.
- **Does not guarantee total food safety:** Toxins and virus contained in food commodities cannot be eliminated by irradiation especially when administered below recommended doses
- The prices of irradiated food items are usually higher than non-irradiated products
- Inconsistent global standards are observed: Countries like New Zealand and Australia have strict standards that apply to only a few food groups. Labeling requirements are different all over the world, which also creates misperception about what is safe to eat and what is not.
- It is an expensive technique caused by upfront costs that are necessary to build a facility that uses this technology.
- It can change the nutritional profile of some foods: Although it doesn't change the nutritional profile of most items, but studies have recorded it can reduce the levels of some of the Vitamins like thiamin, Vitamin E, and Vitamin C and sometimes even eliminated through irradiation
- It can eliminate spoilage warning signals from foods.

CONCLUSION

Food irradiation is an important and toxically safe innovation in food preservation but it is still an underutilised technology due to the concerns to consume food treated with radiation. Consumers are gaining knowledge about the benefits of food irradiation and its potential to reduce the risk of food borne disease, but the process is not a replacement for proper food handling practices.

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