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Highs and Lows of Food Irradiation in Nigeria

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Abstract

In Nigeria, one of the less developed countries, it was estimated that about 25% of the total food produced annually is lose due to wastage and spoilage between harvest and consumption (post-harvest/storage) especially for the highly perishable food substances such as vegetable, fish, fruits and dietary stables like cassava, yam, maize, millet etc. and sorghums. Amazingly, increasing food production receives more attention than exertions to salvage food losses. Population-Food imbalance crises caused by food wastage and spoilage are common in most developing nations of the world including Nigeria. One of the common objectives of the Food and Agriculture Organization of the United Nations and the World Health Organization is to assist the efforts of member states throughout the world to provide safe and nutritious food supplies locally and globally. There are no exact data on how much of the world's food supply is spoiled, but losses are enormous, especially in developing countries where a warm climate favors the growth of spoilage organisms and hastens the deterioration of stored food. In such countries, the estimated storage loss of cereal grains and legumes is overwhelming high. This review brings in a lateral measure, assessment of impart of food irradiation, advancement and knocks, crises and windfalls with its practices in Nigeria, dissecting for the best global irradiation practices in Nigeria for food security and safety.

Keywords: *food; irradiation; food preservation; ionizing radiation; dose; food Safety*

Introduction

From the beginning of the 19th century, incredible breakthroughs in food preservation had begun. Soldiers and seamen, fighting in Napoleons army, in a quest for survival were living off salt-preserved meats. These poorly cured foods provided minimal nutritional value with other attendant effects, and frequent outbreaks of scurvy were developing suggesting attention of better approaches. It was Napoleon who began the search for a better mechanism of food preservation by offering 12,000-franc pieces to the fellow who invented a safe and a dependable food-preservation process recorded then. At the end, the winner was announced to be a French chemist named Nicolas Appert. Upon a close view, he noticed that food heated in sealed containers was preserved provided that the container remained unopened or no leakage. (Akinloye et al, 2015). This achievement was preceded by Louis Pasteur's establishment on the relationship between micro-organisms and food spoilage increased the dependency of the food canning process as reported (Nummer, 2002). Food irradiation is reported to be the most extensively studied food preservation process in history owing to it source and uncertainty surrounding its uses and long-term effects. The first regulation for the use of gamma radiation for food processing was published by US Food and Drug Administration (FDA) on February 1963 (Ji W and Welt B.A 2012).

Radiation is the energy that emits particles from a source or substance and travel through some material or through space. It is also known as the energy emitted in form of waves or streams of particles either transmitted or absorbed by matter (Ode S. O and Egede O.H, 2022). Food preservation involves preventing the growth of bacteria, fungi (such as yeasts), or other micro-organisms (although some methods work by introducing benign bacteria or fungi to the food), as well as retarding the oxidation of fats that cause rancidity (Akinloye et al, 2015). Before the advent of food irradiation, several methods of food preservation were in practice known as traditional methods. The traditional methods of preserving food can be divided into five major groups: fermentation, chemical treatment, drying, heat treatment, and freezing. Each method used to control spoilage and deterioration of food and to protect the consumer against foodborne disease has both advantages and disadvantages experientially and by research over time. Research is being undertaken in many countries to ascertain effectiveness and efficiency as we advance in the use (WHO, 1988). Repeated scientific research, evaluation, and testing have resulted to a design and policy of operation that led to regulation and regulatory approvals for the food irradiation technology in a good number of countries including Nigeria. Commercial application of this technology has greatly advanced in recent time following approval of the health authorities of different countries and the world health in general (Rita and Singh, 2020).

Food irradiation is a modern method of food preservation which involves the process of exposing foodstuffs to a source of energy capable of removing electrons from individual atoms in the targeted material (ionizing radiation). Food irradiation has generally come to describe the use of ionizing radiation (energetic charged particles such as electrons and alpha particles, or energetic photons such as gamma rays and x-rays) to prevent the growth or spreading of undesirable biological organisms in food substances. Several years of investigation have conclusively shown that food irradiation can have tremendous beneficial applications (Shafia et al, 2019). Food irradiation has been endorsed 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 annually all over the world (Akinloye et al, 2015).

Food irradiation is an energy-efficient, non-chemical method of food processing and preservation that can help reduce huge losses occurring year in and out due to spoilage or contamination by harmful bacteria and other parasitic life forms. It involves exposure of foods to ionizing radiations either prepackaged or in bulk to minimize the risk of food borne illnesses, delaying or eliminating sprouting or ripening. Gamma rays, electron beams, and x-rays are used for irradiation of food (Shafia et al, 2019).

Food irradiation could be applied in consideration of the quality of irradiated food that includes aspects of chemistry, nutrition, microbiology and toxicology of the food substance under consideration (Rossi et al 2006).

By research, radiation for safe treatment of food is achieved through the application of gamma rays (with Co-60 or Cesium-137 radioisotope), electron beams (high energy of up to 10 MeV), or X-rays (high energy of up to 5 MeV) (US-FDA) (2018).

Why irradiation?

An enormous practical application of food irradiation has to do with preservation. Radiation inactivates food spoilage organisms, including bacteria, moulds, yeasts etc. It was found to be effective in lengthening the shelf-life of fresh fruits and vegetables by controlling the normal biological changes associated with ripening, maturation, sprouting, and finally aging. For instance, irradiation delays the ripening of green bananas, inhibits the sprouting of potatoes and onions, and prevents the greening of endive and white potatoes. Radiation also destroys disease-causing organisms, including parasitic worms and insect pests, that damage food in storage. In dissimilitude with other forms of food processing, radiation produces some useful chemical changes in food. Taking for example, it softens legumes (beans), and thus shortens the cooking time. It also improves the yield of juice from grapes, and speeds up the drying of plums (WHO, 1988). Summarily, irradiation helps in:

1. Reduce post-harvest losses cause by insects, microorganism and physiological processes and also increases shelf life.
2. Contribute in improving public health and controlling pathogenic microorganisms, parasites and preservation of food’s nutrients.
3. Surmounting quarantine barriers to trade and enhancing marketability of food substances.
4. Slowing down ripening and ageing
5. Preventing germination and sprouting (NAFDAC, 2021).

Research and history show that, the dose of radiation recommended by the FAO/WHO Codex Alimentarius Commission for human use in food irradiation should not exceed 10 000 grays, usually written as 10 kGy. This is a very small amount of energy, equal to the amount of heat required to raise the temperature of water by 2.40C. Sequel to this degree of energy supplied, it is clear how minute the alteration by irradiation process could be, or that food receiving this amount of radiation on an average is considered safe for human consumption (WHO, 1988).

Methods of irradiation

Gamma rays are produced from the radioisotopes cobalt-60 (60Co) and cesium-137 (137Cs), and (ii) Machine sources generating electron beams (maximum level of 10 MeV) and x-rays (maximum level of 5 MeV). Cobalt-60 and cesium-137 usually emit highly penetrating gamma rays that can be used to treat food in bulk or in its final stage of packaging process. Cobalt-60 is, at present, the radioisotope most extensively deployed for gamma irradiation of food (Steward, 2001). Machine-sourced ionizing radiations have advantage over other sources that no radioactive substance is involved in the whole processing system, this translate to other possible imparts that are associated. Electron-beam machines use linear accelerators with algorithm to produce accelerating electron beams with a speed approaching the speed of light. The high-energy electron beams have limited engagement in terms of penetrating power and as such can only be used on foods of relatively shallow depth (Steward, 2001), or on foods less than 10 centimeters (cm) in depth because of the limited penetrating capacity of the electron beams. Electron beams can be unbundled into various energies of x-rays by the bombardment with a metallic target. Although x-rays have been shown to be more energetic than gamma rays from cobalt-60 and cesium-137, the efficiency of conversion from electrons to x-rays is known to be less than 10% and this has limited the use of machine sourced radiation at advance level feedback (ICGFI, 1999).

Classes of food and irradiation

Irradiation plays a critical role in model food technology and the place of application is a factor to reckon with, in terms of dosage and sources, practical applications of food irradiation are divided based on the radiation doses into three categories namely: low dose applications (up to 1 kGy), medium dose applications (1 kGy to 10 kGy) and high dose applications (above 10 kGy).

Low doses range of 0.02-0.2 kGy are basically used for sprout inhibition in bulbs and tubers; 0.25-1.0 kGy for delay in fruit ripening and 0.1-1.0 kGy for insect disinfestations and destruction of food borne parasites. The second and themedium dose of 1.0–3.0 kGy are used for reducing spoilage microbes for shelf-life extension of food like meat, poultry and sea foods achievable at refrigeration temperature and must be maintained for maximum result; 3.0–7.0 kGy for reduction of pathogenic microbes in fresh and frozen meat, poultry and sea foods and 10.0 kGy for reducing the microbial load of spices and herbs to improve hygienic quality. High doses of 25.0-70.0 kGy are used for sterilization of packaged meat, poultry, and their products that are shelf stable without refrigeration (Rita and Singh, 2020).

Table 1: below shows details of the dose level and target with the food substance most suitable in application.

Dose Level	Purpose	Products applicable
1. Low category (up to 1kGy)	To kill Trichinellaspiralis	In pork
	To slow ripening	In fresh foods
	To kill Arthropod	In foods
2. Medium category (1-10kGy)	For microbial disinfection	In dry enzyme preparations(10kGy)
	For pathogen control	In fresh, or refrigerated, or frozen uncooked meat; Seeds for sprouting; In fresh or frozen molluscan shellfish.
	For control of salmonella	In eggs
	For control of foodborne pathogens and extension of shelf-life	Fresh iceberg lettuce and spinach
3. High category (10kGy-50kGy)	For microbial disinfection	In spices and seasonings
	For sterilization of food for immunocompromised patients.	In frozen packaged meat (solely NASA), Elimination of some disease-causing viruses and decontaminates certain food additives and ingredient

showing three categories of dose level (Ji.W and Welt B.A, 2012).

The complexity of food irradiation opens doors to misconceptions, however, about whether irradiated food is safe to eat and how irradiation can complement or replace other methods of preserving food given the peculiarities associated with radiation. This research is meant to offer holistic parallel and horizontal view to correct those misconceptions and to help consumers and researchers alike in all parts of the world especially in Nigeria to make sound decisions about the place of food irradiation in their efforts to secure an adequate, wholesome, and dependable food supply any day anytime (WHO, 1988).

Highs

Food irradiation has over time gained acceptance, approval and support from government of over 42 countries of the world as well as many international medical, scientific and public health institutions. Several applications are obtainable, one among others are for sterilization of spices and seasonings (Ji and Welt, 2012).

Some of the benefits of using irradiation in food have little or no heating process; subsequently, the material doesn't change its characteristics. Also, irradiation can suppress microorganisms that live in food including for example, the disinfestations of insects in fruits and grains. Irradiation can be carried out on packaged foods, frozen foods, and fresh food through one operation without the use of chemical additives. Irradiation in most cases requires only a small amount of energy (Rossi et al 2006).

Researches by experts from the International Food Irradiation Project (IFIP) has shown that the radiation technique used to process food is much safer than other conventional and traditional methods to achieve same or even better result (Rossi et al 2006).

The safety and wholesomeness of irradiated foods for human consumption has been established and endorsed by international and national agencies basically on the radiological safety, toxicological safety, microbiological safety and nutritional adequacy (Rita and Singh, 2020).

Food irradiation is known to provide an added layer of protection to food without significant changes to taste, nutritional value, color or texture. Since irradiation does not substantially raise the temperature of food or cook it, taste and nutrient losses are small and considerably less than other methods of preservation, such as canning, drying or heat pasteurization (Akinloye et al, 2015). Food irradiation does not increase the normal radioactivity level in foods (Scottie and Whitmer, 2008)

Carbohydrates, fats and proteins which are the main components of food and a wide body of research revealed that these nutrients do not change significantly during irradiation process (Thayer, 1987)

Food irradiation has been extensively studied to assuring safety and efficacy of the technology. Internationally standard and well recognized bodies like World Health Organization (WHO), Food and Agriculture Organization (FAO), International Atomic Energy Agency (IAEA) and Codex Alimentarius have commended irradiation technology for processing of food for human and animal consumption (Rita and Singh, 2020).

Food irradiation has been in practice on agricultural commodities, meat, poultry and seafood to improve food security and reduction of spoilage losses in record annually. The process can be applied to fresh produce or frozen food products with no changes in quality. Radiation is also used for pasteurization or sterilization of all classes of food. Elimination or sterilization of insect pests by irradiation of fresh fruits and vegetables with negligible impact on food quality has played a critical role in strengthening trade between countries of the world. The food irradiation technology also has tremendous potential for supplying fresh and safe food to the armed forces deployed in remote and far-flung locations. Food irradiation is an effective and safe technology with multipurpose role and benefits to the consumers and food industries.

It enhances reduction of microbial load in ready-to-eat foods, extension of shelf life of fresh fruits and vegetables, elimination of meat and fish parasites, insect disinfestations, quarantine treatment, delayed ripening of fruits etc (Rita and Singh, 2020).

Lows

Food irradiation has tremendous imparts in food technology over decades, advance researches are ongoing to improved its practice for minimal flaws, however, report revealed that there were 1,270 foodborne disease outbreaks in United States in 2006 with some trace to food irradiation, resulting to 27,634 cases and 11 deaths (AUSGI, 2008). This doesn't suggest there are no regulations or an institution responsible for enforcement, this could happen when there is a break in critical protocols of regulations, there are different bodies that regulate and monitor irradiation activities from nation to nation with their peculiarity. In US for instance, some among other cardinal regulations are (a) Radiation treatment of food shall agree with the organized process. A scheduled procedure for food irradiation is a written proceedings that ensures that the radiation dose range selected by the food irradiation processor is adequate under commercial processing conditions (including atmosphere and temperature) supervised by professional personnel for the radiation to achieve its intended effect on a specific product and in a specific facility. A default through boycott of any stage or level can be catastrophic considering the kind of energy involved in the irradiation. A food irradiation processor shall operate with a scheduled process established by qualified persons having requisite expert knowledge in radiation processing requirements of food and specific for that food and for that irradiation processor's treatment facility. (b) A food irradiation processor shall maintain records as specified in the terms of regulation for a period of time that exceeds the shelf life of the irradiated food product by a single year, but to a maximum of 3 years, and shall make these records within this time frame available for inspection and copy by authorized personnel of the Food Administration saddled with such responsibility. The required records shall include the food treated, lot identification, scheduled process, evidence of compliance with the scheduled process, ionizing energy source, source calibration, dosimeter, dose and dose distribution in the product, and the date of irradiation (AUSGI, 2008). Report shows that the taste, aroma, color and texture of the foods may be tempered (Akinloye et al, 2015).

Study shows that there is likelihood that foods that have been irradiated may suffer from levels of changes in sensory characteristics, nutritional quality and effects on microorganisms among others (WHO, 1988).

Effects of irradiation on microbiological contaminants of foods substance: In our food, the mechanism of microbial dysfunction by ionizing radiation is liable mainly on the principle of disruption of regular cellular activity through damaging the nucleic acids by "direct" and/or "indirect" effects (Pillai, 2004). The direct effect is generated by the removal of electrons as a result of residual energy deposition by ionizing radiation on target molecules, such as DNA (Erkmen and Bozoglu, 2016). Furthermore, damage to the nucleic acids is likely to occur when the radiation ionizes an adjacent molecule within the range, this contact in otherwise turn and reacts with the genetic material. One of the substance present during the reaction is water, it is often the adjacent molecule and the ionizing radiation causes water molecules to lose an electron, resulting into producing H2O + and e- . These outputs react with other water molecules within the system to produce a number of compounds including hydrogen and hydroxyl radicals, molecular hydrogen, oxygen, and hydrogen peroxide. These products turn to react with other water molecules, with nucleic acids, and with other biologically sensitive molecules. The most reactive by-products are given from the radiolysis of water which is the hydroxyl radicals (OH) and hydrogen peroxide (H2O2). Study revealed that, on account of the highly reactive nature of these radicals, they can cause breakdown of single strand DNA at a bond called sugar–phosphate, similarly with the bonds that link the adjacent base pair to an opposite strand in a double strand DNA (Pillai, 2004; Sádecká, 2007; Erkmen and Bozoglu, 2016). Some of the major target points of irradiation are nucleic acids and cell membrane lipids. Ionizing radiation has negative impact on the cell membrane and other structures that can be injurious (sublethal injury). When there is a change in membrane lipids, particularly polyunsaturated fatty acids, it can result into perturbation of membranes and it has effects on various membrane functionality and build up, such as permeability and sometimes conductivity. The activity of membrane enzymes may not be spared from the impacts (Erkmen and Bozoglu, 2016). In cells like yeasts, molds and bacteria, the consequences of irradiation are pronounced in the induction of genomic, biochemical, physiological and morphogenetic alterations. Inactivation of microorganisms are responsible by several factor and their roles traceable to irradiations, some of them are: type of radiation, species of microorganisms, composition of foods, oxygen content, physical state of foods, physiological state of microorganisms etc (Pillai, 2004; Erkmen and Bozoglu, 2016). Some of the dangerous food spoilage microorganisms and a lot of common foodborne pathogens of different species are generally sensitive to irradiation and can be easily rendered inactive by the use of low and medium doses of radiation ranging from 1- 7 kGy. It was noted that Molds are more sensitive and reactive to irradiation than yeasts; on the other hand, yeasts are more sensitive to irradiation than bacteria, while bacteria are more sensitive to irradiation than viruses (Erkmen and Bozoglu, 2016). Gram-positive bacteria are more resistant to irradiation than Gram-negative, and cocci are more resistant than rods at same irradiation dose. The structure of cell wall plays an important role in bacterial resistance (Lung et al., 2016). The irradiation sensitivity can be different in varieties of strains and isolation of the same species of bacteria (Xu et al., 2019). The resistance to irradiation of microorganisms may increase base on their level of adaptation to certain factors such as stress. Certain resistance genes to specific antibiotics may help some of the pathogenic bacteria to tolerate and withstand higher doses of irradiation and other adverse conditions as well (Gaougaou et al., 2018; Skowron et al., 2018) (Mila et al, 2022).

Effects of irradiation on food components: On the effect of irradiation on food components, it was discovered to depend largely on the dose of irradiation used and the food matrix and preparation method applied. Sometimes heating, drying, and cooking may cause higher nutritional losses. Considering the effectiveness of other methods of food preservation, certain carcinogenic aromatic and heterocyclic ring compounds produced during thermal processing of food at high temperatures are not identified in food after irradiation (Sádecká, 2007). According to research, food macronutrients (carbohydrates, proteins, and lipids) and most micronutrients (mainly water soluble and fat-soluble vitamins) are not fatally affected by low and medium range ionizing doses (up to10 kGy) in consideration of their nutrient contents. Ionizing irradiation is one of the food preservation techniques with minimum interruption of to the functional, nutritional, and sensory properties of food products at lower radiation doses. On the other hand, irradiation with higher dose as high as 10 kGy, can cause physicochemical changes and reasonably deteriorate sensory properties of foods substances (Miller, 2005; Kim et al., 2006). At higher radiation doses (10 kGy and above), the structural properties of the fibrous carbohydrates are liable to degrade (Miller, 2005). The consequences of irradiation (low and medium doses), on the nutritional content of lipids is almost insignificant. Interestingly, that level of doses may not cause the formation of aromatic or heterocyclic rings or the condensation of aromatic rings, they are regarded to be carcinogenic, and it is also found to form at high cooking temperatures. However, the irradiation of lipids at high doses, especially when it is surrounded by oxygen, it can cause formation of liquid hydroperoxides. Contrary to the harmful effects, these substances often have offensive odors and flavors (rancidity). The unsaturated fatty acids are most likely to develop rancidity. Lipid oxidation can be significantly reduced by freezing, and/or by oxygen removal prior to irradiation (Miller, 2005). In the study of effect of irradiation on the fatty acid profile of irradiated beef meat, study shows that a dose-dependent change occurs in fatty acid composition. Performed NMR and GC analyses in a research reveal an increase in the amount of saturated fatty acids and a decrease in the amount of polyunsaturated fatty acids in the irradiated beef samples in comparison with the un-irradiated one, established with elevation of the irradiation dose. In fat-containing food ionizing radiation induces formation of volatile hydrocarbons and 2-alkylcyclobutanones (2-ACBs), which are radiolytic derivatives of triglycerides with or without oxygen. They are generated proportionally to fat content and absorbed radiation dose. 2-ACBs are formed in food only by irradiation, and therefore they are seen as useful inciters for detecting the irradiation of food in the simplest form (Obana et al., 2006). Vitamins are been seen to be susceptible and sensitive to any processing technique (Woodside, 2015). Concerning food irradiation, some vitamins such as riboflavin [B2], pyridoxine [B6] and biotin are usually stable; others such as thiamin [B1] and vitamins A, C and E are relatively labile. Thiamin and vitamin C are the most radiation-sensitive vitamins. The sensitivity of vitamin C is in relation to several factors, such us: exposure to oxygen, temperature elevation, pH modifications (Mila et al, 2022).

Effect of irradiation on lipids: In evaluating the progressive application and growing role of irradiation in food preservation today, several reviews and research studies have been published on the irradiation of foods of both animal and plant origin over interesting number of years (Arvanitoyannis et al., 2009; 2010). The application of ionizing radiation has led to the principle of radiolysis of water, which is functional in most foods such as meat and fish products. This initialized the development of species such as OH−, hydrated electron and H+, which can then generate several chemical reactions with food constituents. It was revealed that the quantity of radiolysis products varies as a function of fat content and fat composition, as well as with the temperature during the irradiation process and the actual dose of radiation used (Merrit et al., 1979). When fatty acids are exposed to high-energy radiation they undergo preferential cleavage in the ester-carbonyl region giving rise to specific radiolytic compounds that are designated for each fatty acid (Nawar et al., 1996). Ozone which is so strong is produced from oxygen at the process of food irradiation and can incite the oxidization of lipids and myoglobin (Venugopal et al., 1999).

Effect of irradiation on proteins and amino acids: In an investigation, likely dangers associated with ionizing radiation on protein includes deamination, decarboxylation (Diehl, 1990), reduction of disulfide linkages, oxidation of sulfydryl groups, cleavage of peptide bonds and changes of valence states of the coordinated metal ions in enzymes (Delincee, 1983). In other works, outcome indicated that there was no significant destruction of cystine, methionine and tryptophan up to a dose of 71 kGy (Josephson et al., 1978). The majority of amino acids in minced lean beef or pork and chicken breast muscle are stable up to a dose of 5 kGy depending on the thickness (Partmann et al., 1979). Reports from literature indicate that irradiation of meat at commercial doses (2–7 kGy) has little or no effect on the nutritional value of proteins or amino acids (Thayer, 1987).

Effect of irradiation on Vitamins: A good number of researchers have studied the effect of irradiation on the stability of vitamins in our foods given a whole lot of insights on the impacts (Liu et al., 1991; Kilcasti, 1994; Muller and Diehl, 1996; Song et al., 2007; Hussain and Maxie, 1974). It was found that no loss of riboflavin was associated with pork chops and chicken breasts irradiated at temperatures between −200°C and 200°C at doses up to 6.6 kGy. Some irradiated samples even exhibited an increase in riboflavin concentration of up to 25% (Kilcast, 1994). Other methods were said to be available that can be employed in order to reasonably minimize detrimental effects of irradiation. Exclusion of oxygen is one of such; the replacement of oxygen with inert gases is yet another, addition of protective agents such as antioxidants, and finally using post-irradiation storage to allow the flavor to return to near-normal levels (Brewer, 2009).

Effect of irradiation on microorganisms: Data are available in volumes on the sensitivity of microorganisms to irradiation processing; this differs relatively from microorganism to microorganism and is also dependent largely on other extrinsic factors. Vegetative cells are less resistant to irradiation than spores; also moulds have high susceptibility to irradiation similar to that of vegetative cells. It was also noted that some fungi can be as resistant as bacterial spores (Farkas, 2006). Compared to bacteria, viruses generally require higher radiation doses for inactivation (Crawford et al., 1996). Reports have shown that irradiation doses of 2-3 kGy destroyed Yersinia spp. and Listeria spp., respectively, with the microorganisms being undetectable during storage of irradiated fish (Montgomery et al., 2003). Irradiation at 1, 2, and 3 kGy significantly improved the microbiological quality of the chicken by reducing the total bacterial count (TBC), with the decrease in TBC being dose-dependent. In all the irradiated samples under review, no fecal coliforms were detected (Kanatt et al., 2005).

Researchers in the past has explored the use of lower doses of irradiation to achieve a lot results in several areas like on fresh produce, to find out whether acceptable reductions in pathogen loading can be achieved while preserving the taste, aroma, color and texture of the foods. This evidently has proven relatively small field of research to have produced some promising evidence that it may be possible, in many cases, to strike the right balance between pathogen reduction and preserving produce quality for the benefit of all. When irradiation is combined with other anti-microbial treatments and food preservation algorithms, recent studies suggest that irradiation may eventually be usefully applied to some current produce pathogen problems. However, this same research indicates that applying food irradiation to a particular food-pathogen combination requires adequate knowledge on large number of parameters that can affect the results of irradiation profitably. In order to find common level of interactions to handle the seemingly complex nature of this problem, research to date has identified many needs for additional and better data (Groth, 2007). It was discovered that, a reasonable number of compounds are formed when food is irradiated, just as there are when food is cooked or exposed to other processing methods. However, based on assorted number of scientific and experimental tests, there is broad co-inherency among scientists and health agencies that these compounds are not a human health related issue. In the factual, more chemical alterations occur when toasting bread or barbecuing steak than when irradiating food (Anon, 1994).

Food irradiation provides an added level of protection to food without significant changes to taste, nutritional value, color or texture. Since irradiation does not substantially raise the temperature of food or cook it, taste and nutria.

0nt losses are small and considerably less than other methods of preservation, such as canning, drying or heat pasteurization (ICGFI, 2002). Carbohydrates, fats and proteins are the main components of food, and a wide body of research has shown that these nutrients do not change significantly after irradiation process (Thayer, 1987; Randy et al., 1987). Some vitamins, most notably vitamins B, have some sensitivity to irradiation, but processors can minimize nutrient losses by irradiating food in an oxygen-free environment or a cold or frozen state (Brewer, 2009). But in as much as food irradiation can be an effective food preservation method, it has been noted that it should never replace proper and hygienic food handling methods. (Akinloye et al, 2015).

Possible spurs

Efforts to maintain free long- and short-term effects of food irradiation in our food has been in place with several research running to meet the global requirement even in food security. Despite robust checks and scrutinizes, maximal compliance to regulations may be a contending force and ignorance and deliberate compromise could wedge harder. Some of the possible causes to the imperial lows may be recorded due to certain factors, namely:

1. 1. Packaging: An important food packaging material that is not approved by some regulatory bodies for irradiation is polyethylene vinyl alcohol co-polymer

(EVOH), it offers oxygen barrier properties. However, EVOH with 32% ethylene content is commonly used for flexible and semi-rigid packaging of shelf-stable ready-to-eat (RTE) foods. Lack of a sensible approach for obtaining broad approvals for packaging materials with a variety of additives represents a critical gap in knowledge that is necessary to permit food irradiation technology to progress and prosper today (Ji W and Welt BA 2012).

2. Deviation from the regulation: Like in Nigeria, food irradiation regulation as reviewed in 2021 terms, critically consider areas such as;
3. Scope of application
4. General requirement
5. Radiation sources
6. Absorption dose
7. Facilities and the control of process
8. Wholesomeness of irradiated food
9. Packaging and quality assurance
10. Documentation
11. Inspection
12. Re-irradiation
13. Labeling
14. Trade and irradiated food
15. Importation
16. Exportation etc and compliance with this regulation is paramount to an effective and safe application (NAFDAC, 2021).

According to the Codex General Standard for irradiated foods, ionizing radiations recommended for use in food processing are: (i) Gamma rays produced from the radioisotopes cobalt-60 (60Co) and cesium-137 (137Cs), and (ii) Machine sources generating electron beams (maximum level of 10 MeV) and x-rays (maximum level of 5 MeV)(Akinloye et al, 2015).

Between lines

The feud of public acceptance of the concept of food irradiation has been less than enthusiastic in many countries. Fears of thermonuclear war and accidents such as those at Three Mile Island in the USA and Chernobyl in the USSR have made many people apprehensive about the use of nuclear energy for any purpose around consumables, even one as obviously desirable as improving the quantity and quality of food. Such apprehension could be based on lack of adequate information on distinct line between the process of irradiation and contamination with radioactivity (WHO, 1988).

The use of ionizing radiation to destroy harmful biological organisms in food is a safe, proven technique that has many useful applications. It has been endorsed by numerous health organizations and has now been approved for many applications by governments of nations around the world. Food irradiation offers a potential to enhance microbiological safety and quality of food through shelf-life extension. It is considered a more effective and appropriate method to enhance food stability and safety, when compared to other processing methods of preservation like heat and chemical methods. Also, it does not reduce significantly the nutritional and the sensory quality of food (Mila et al, 2022).

The results of a study conducted by Okoedo-Okojie and Onemolease (2009), reveals that inadequate information on existence, limited facilities spread across the country on an improved methods of food preservation such as irradiation is a major factor responsible for low patronage in Nigeria (Akinloye et al, 2015).

Conclusion

A regulatory body in Nigeria called Nigerian Atomic Energy Commission (NAEC) which was formulated in 1976 was established as a multi-disciplinary body in order to identify problems of national and regional importance and to proffer sustainable solutions to numerous radiation related problems and to add value and meaning to life through irradiation techniques. In advancing her roles in nation building, Nigeria at the moment possesses one Gamma Irradiation Facility (GIF), located at the Nuclear Technology Centre (NTC), Nigeria Atomic Energy Commission (NAEC), Sheda Abuja, Nigeria.

Food irradiation is not a panacea for all the numerous food supply problems in the world, but it is rather one of the means to provide reassurance that the process may, under certain circumstances, be safely used to improve food safety, to reduce food losses, and to facilitate food trade globally.

Nigeria has just one functional irradiation facility at the moment, obviously, this is insufficient in a country of over two hundred million people; this is where food irradiation technology advancement challenges starts from and should be given due attention. This limitation associated with facilities is a setback and so food irradiation technology is yet to attain the stage of commercialization in Nigeria. Irradiation technology with numerous benefits should in no wise be considered as substitute for good sanitation and proper food handlings. It is only an added layer in improving food security, quality, quantity and an alternative method of food preservation.

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