

## THE STATUS AND PROSPECTS OF FOOD IRRADIATION, AS AN ALTERNATIVE FOOD PRESERVATION TECHNOLOGY, IN NIGERIA

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### ABSTRACT

This paper discusses how food is irradiated, status of application, and factors influencing Food Irradiating Technology (FIT). Reports have shown that Nigerian FIT has not gone beyond the laboratory demonstration level, due to some techno-economic and political limitations. It has been applied at doses of 0.05 –5.0kGy to up to 8 foodstuffs to achieve sprout inhibition and extension (yams and onions), control of moldiness (coca beans, cowpeas and smoked-dried fish) and decontamination (ground red pepper, groundnuts and soyabeans). Nigeria has made preliminary installation and running cost estimates, and has solicited technical assistance from international authorities in this area. The next positive step may usher her into full commercial FTI activities.

### INTRODUCTION

Food irradiation involves treatment of food product by exposing it to ionizing radiation under controlled conditions. There are two basic types of ionizing radiation: Electrons accelerators; Gamma rays produced from a radioactive source such as Cobalt -60 or Caesium-137. Both of these isotopes emit highly penetrating gamma rays as decay products. The rays pass through the food being treated, causing the desired effects upon the products themselves or on microbial or insect contaminants in the products. In addition cheaper source of irradiation than others (Holmes, 1984; ACSH, 1988, IAEA, 1989).

In food irradiation technology (EIT), energies from the above-named radiation sources were reported to be too low to induce radioactivity in any material,

including food, exposed to them (IAEA, 1989). The quantity of radiation energy absorbed by a food as it passes through processing is radiation dose (RD). The RD is usually measured in units of gray (GY) or rad (1Gy=1J/kg food). Gray has been recognized as the S.I unit of radiation (Holmes, 1984).

The FIT is now globally used to supplement existing technologies for ensuring food preservation. Of great public health significance is its reduction of pathogenic microbes (Keferstin, 1990; Roberts and Murrell, 1990).

As regards the safety of irradiated foods, several workers (WHO, 1981; ACSH, 1988; Anderson, 1989; CEC, 1989) have reported favourably of the irradiated foods, symbolized "Radura". Consequent upon their reports, the Consultative Group Irradiation Practice of various of food handling and processing diverse foods

(ICGFI, 1991a-g) towards consolidating consumers safety of health. Subsequently, standards were articulated by joint efforts of Food and Agricultural Organization (FAO) of the United Nations and the World Health Organization (WHO) which serve as global standard regulation/requirements on food irradiation technology, FIT (CAC, 1992).

Nigeria has hitherto not evolved a well-articulated policy on FIT. Her scientist and technologist have, however, for over two decades, been carrying out research and developmental works in FIT. The pioneering endeavour in this area was done with yam on a laboratory-scale at the University of Ibadan, (Adesuyi and Mackenzie 1973). Further preservation works in FIT. On Nigerian foodstuffs were done by Adesiyi (1977), Appiah et al. (1980) and Agbaji et al. (1981). Techno-economic feasibility studies have been carried out in Nigeria for a pilot-scale FIT by Farkas et al. (1982). That was done as a consequence of an earlier report that food storage losses could be minimized via FIT in Nigeria (Adesuyi, 1973). The factors limiting successful introduction of FIT in Nigeria include:- lack of requisite expertise (appropriate scientific and technical disciplines), government regulatory and huge financial requirements (Aworh, 1986).

Over the years, increase interest in FIT for practical application have been shown by Nigeria in the following endeavours: viz: - In 1989 she collaborated under the Co-ordinated Research programme (CRP) set-up in 1988 by the Joint FAO/IAEA Division of Nuclear Techniques in food and Agriculture on the "Application of irradiation Technology Technique for Food processing in Africa". The Centre for Energy Research and Development, Obafemi Awolowo University represented Nigeria (IAEA, 1990). IAEA (1991b) reported that Nigeria has achieved the following results: Smoked dried fish packaged in foils were irradiated at 5kGY

with complete elimination of fungi and beetles, thereby extending the shelf life from 2 to 12 months; cowpeas were disinfested at a dose of 0.5kGy and stored in polyethylene bags (140-micro thick); sprouting inhibition studies were being conducted on onions, potatoes and yams; and consumer test on irradiation maize had been conducted with the results that showed popular acceptance. In 1992, University of Agriculture, Abeokuta represented Nigeria, participated in a Training Course of "The use of Irradiation to Reduce Post-harvest Food Losses in Africa" organized by FAO/IAEA held in Accra, Ghana (IAEA, 1993). In July 1994, Nigeria submitted a formal request for technical co-operation project for 1995-96 plan of Action on the joint FAO/IAEA Division of Nuclear Techniques in Nuclear Techniques in Food and Agriculture, in the areas of experts, training and equipment (IAEA, 1995a). Again in November 1994, University of Ibadan representing Nigeria benefited from the African Regional Training Course on "Techno-economic Feasibility of Food Irradiation" on Instructorial Status, in Addis Ababa, Ethiopia (IAEA, 1995b).

### **The Basic Process of Fit**

The process entails exposing foods to ionizing radiation in a shielded chamber through which the foods usually pass on a conveyor system. When the foods leave the irradiation facility, the date, doses and facility identification number are stamped on the products for proper inspection and identification (CAST, 1989). The application of ionizing radiation as food preservation technique aims at combining particular purpose of interest, type of food, type of radiation source, and dose.

Food irradiation processes have been found, in practice, to be of five general categories, which have been summarized in Table 1. The processes are sprout inhibition, insect destruction, radurization (which is analogous to thermal

pasteurization), radacidation (equivalent of boiling/atmospheric steaming treatment) and radappertization (equivalent of thermal sterilization).

The appropriate and associated dosage, package requirements and storage temperature are specified. It is observed from the data that the lower the storage temperature, the longer the useful storage life of the product: for instance when potatoes were irradiated at 0.075kGy; held in open or porous containers and stored at 41°F and 85% RH, they had a minimum useful life of 2 years when the same batch was stored at 68°F had a maximum useful life of 10 months. It

means that relatively lower temperature storage after irradiation improves longevity of foods. Observations also indicated that the food irradiation processes/dosages are product specific. Furthermore, all the processes caused extension of shelf life in the order of three-folds (Diehl, 1977; WHO, 1981; Gidding and Welt, 1982; Holmes, 1984. Thompson, 1984; Anderson, 1989; CAST, 1989; fink and Rehmann, 1994). It seems inferential from the data that FIT does not offer the sole effect to increase shelf-life of Product. Rather, the improvement in longevity is contributed from FIT and other factors like temperature, humidity

**TABLE 1. Food Irradiation Product and Process Specification**

Process	Dose (KGy)	Product	Package requirements	Storage temp (°F)	Estimated useful storage life
Sprout Inhibition	0.075	Potatoes	Open or porous containers	41.85% R.H 68	2yr (min) <sup>a</sup> 10mnth(max) <sup>b</sup>
Insect Destruction	0.05	Flour	Sealed paper or cloth bags, and hermetic package to prevent re-infestation.	Room temp.40	2yr (min) 5yr (min)
Radurization	1.50	Berries	Sealed in O <sub>2</sub> CO <sub>2</sub> permeable film.	34	21 day (min)
Radacidation	10.0	Slice meat and Fish	Sealed in gas proof container	32	60 day (min)
Radappertization	24.0	Fruits	Vacuum sealed in durable container (tin can) with odour scavenger	Room temp. 32	2 yr (min) 5yr
Radappertization	48.0	Animal, fish and veg tissue	Vacuum sealed in durable container (tin can) with odour scavenger	Room temp. 32	2yr min) 5yr

Sources: Walter Urban, Michigan State Univ.

Min= Minimum; Max=Maximum

KGy= Kilogray; Igy = 100Rad = 1J/kg

and package (type, character and condition of packaging).

Data in Table 2 have shown that radiation does in FIT can be classified into three: low (<1.0 kGy), medium (1.0-10.0kGy)

and high (10.0-50.0kGy). The type of food and effect of treatment under each main sub-class are also reported.

Closer observation reveals that applications of optimal dosage during

ionizing radiation of foods, three distinct results are caused in the foods concerned. Summarizing the studies by some workers (ACSH, 1988; Anderson, 1989; CEC, 1989 and Fink and Rehmann, 1994) showed that disinfestations, pathogenic reduction and shelf-life extension were obtained. Disinfestations of grains, fruits and vegetables have virtually replaced chemical fumigation via low dosage radiation; Pathogenic reduction: irradiation at medium doses has been employed to eliminate pathogenic organisms like salmonella, campulobacter, listeria and toxoplasma and thereby prevent food-borne diseases; Shelf-life extension: irradiation which helps to reduce spoilage organisms (bacteria, mold and fungi) leads to extension of storage life of meat, poultry, seafood, fruits and vegetables. It inhibits sprouting and hence extends the shelf life of potatoes, onions and garlic. It slows the rate of ripening of some fruits (e.g. strawberries)

#### **Status of fit application in Nigeria**

Radiation treatment of foods is required to be carried out in facilities licensed and registered for this purpose by the competent national authorities. Its control and safety regulations must conform to practice jointly established by the IAEA, international standards and codes of FAO and WHO (IAEA, 1989; CAC, 1992).

The extent of FIT application in Nigeria has been summarized in Table 3, covering about two decades of efforts. The data showed that a total of at least eight different foodstuffs have been test-irradiated in the dose range of 0.05-5.0kGy to effect disinfestations, disease pathogen reduction, and shelf-life extension while they are supplied, packaged and stored at

ambient temperature and humidity conditions prevalent at the tropics.

#### **Limiting Factors of Fit Applications**

Despite the distinctive states of FIT's applications, there are still some factors that stand as barriers to an early global implementation of FIT, viz-

- (a) Installation cost is very high, far above the reach of the less developed countries (LDCs): A small pilot plant costs minimum of 1.2 million dollars;
- (b) International trade agreement has not been simple to come by regarding irradiation foods;
- (c) Consumer acceptance of irradiation foods, "Radura",
- (d) Nation-by-nation availability of the requisite expertise (CAST, 1989; Fink and Rehmann, 1994).

In the case of Nigeria, for a successful introduction of commercial-scale food irradiation and supplementary facilities, some economic, political and technical hurdles must be conquered:

- (e) Economically, the main cost components for establishing and operating an irradiation plant, according to Aworh (1986), include (i) capital costs for land, building, radiation source, conveyor system, other supporting mechanical and electrical equipment, and miscellaneous; (ii) Annual operating costs for labour, overhead, maintenance of building and equipment, insurance, power, water, and contingencies;

**Table 2: Application of food Irradiation**

Radiation Dose (kGy)		Food Type	Treatment Effect
Dose Type	Range		
Low (Up to 1.0)	0.05-0.15	Potatoes, onions, garlic, ginger rot.	Inhibition of sprouting
	0.05 - 0.50	Cereals and pulses, fresh and dried fruits, dried fish and meat.	Insect and parasite disinfestations
	0.50-1.0	fresh pork Fresh fruits and vegetables	Delay of physiological processes
Medium (1.0-10.0)	1.5-3.0	Fresh fish, strawberries and other fruits	
	2.0-5.0	Fresh and frozen seafood poultry and meat in raw or frozen state, eggs and egg powder	Extension of food shelf life by delaying mould growth
	2.0-7.0	Grapes and dehydrated vegetables	Elimination of spoilage organisms
High (10.0-50.0)	10.0-50.0	Seasonings, spices, nuts, dried vegetables, enzyme preparation, natural gum	Improvement of technological properties of food
	30.0-50.0	Meat, poultry, seafood, some vegetables, baked foods prepared foods, sterilized hospital diet.	Decontamination of certain food additives and ingredients

Sources: ACSH (1988), Anderson (1989), CEC (1989), and Fink and Rehmann (1994)

**Table 3 Data for Laboratory Demonstration of Food Irradiation Technology (FIT) on Nigeria Foodstuffs**

Dose (kGy)	Foodstuff	Storage temperature (°C) and package	Effects of Treatment
0.05 - 0.15	Onions	20-25	Sprout inhibition for up to 7 months
0.09 or 0.12	Onions	26	Decreased rotting
0.05 - 0.15	Yams	Ambient (30+2)	Sprout inhibition for up to 8 months
0.5	Cowpeas	Polythene bag	Dis-infestation
4.0	Cowpeas	26	Complete prevention of moulding
4.0	Coco beans	28, polypropylene bag	Reduce mould count from 10 <sup>6</sup> to 10 <sup>1</sup> per for 4 months
5.0	Fish	Aluminum foil	Complete elimination of fungi and beetle; extension of shelf life from 2 to 12 months
5.0	Groundnut and soybean	Ambient (30+2)	Complete suppression of aflatoxin production.
5.0	Red pepper (dry ground)	Ambient (30+2)	Effectively decontaminated.

Source: Adesuyi (1973, 1976), Appiah et al (1980), Agbaji et al (1981), Farkas (1981), Ogbadu (1981), Farkas et al (1982), and IAEA (1991c).

Politically, the government of the day must make deliberate policy decision on appreciating the overall benefit and significance of FIT and show willingness to support it by providing the requisite funds and setting up appropriate regulatory authorities to oversee FIT' endeavours. The above situations have not occurred yet (Olorunda and Aworh, 1990); and

Technical, (i) the most suitable combination treatments for the most effective results from irradiation should accompany the major facilities; (ii) Improvement of the traditional handling, packaging, storage and distribution systems to enhance the FIT, (iii) The expertise for construction, operation and maintenance of irradiation plant for safe application is lacking in the country, currently, (iv) Knowledge is also needed on the package (materials, adhesives, and printing inks) which will be most suitable for irradiation (Olorunda and Aboaba, 1978; Aworh, 1986; Olorunda and Aworh, 1990; Frink and Rehmann, 1994).

### **The Prospects of Fit**

Globally, FIT has come to stay because of its overwhelming advantages over the conventional food processing/preservation technologies for consumer goods in the areas of low energy cost leading to very low unit production cost, shelf life extension several-folds, and unmatched scope of applicability (WHO, 1981; CEC, 1989; IAEA, 1991a; ICGFI, 1991a-g;

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For Nigeria, the current estimates for a fully operable plant put at 5.0 million US dollars (N425 million at N85/dollar) (Fink and Rehmann, 1994) could pose a great obstacle but the over-riding benefits of FIT, resulting from studies of over two decades, should be the main impetus for forging ahead towards establishing commercial FIT. Nigeria has already sought for international assistance in this connection (IAEA, 1995a). This effort should be pursued to its positive conclusion, and coupled with financial assistance, which could be sought through venture capital request from the European Communities CORDIS-RTD Project, as well as from Nigerian Petroleum Trust Fund (PTF). These financial potential reserves when put together with the possible technical aids from International Atomic Energy Agency (IAEA), Nigeria will be able to commercialise irradiated foods ("Radura") by the end of the next millennium.

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