



Radiological Health Risk Assessment of Some Selected Fruits from Major Markets in Eti-Osa Local Government Lagos State

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Abstract

Fruit is an essential part of human balance diet. Exposure to radiation is a natural phenomenon in human environment. Natural radionuclides are found in the air, water, soil, and food. Ingestion is one of the major pathways through which radionuclides can enter human system. Radiological health risk assessment of some fruits (Mango –*Mangifera indica*, Cucumber –*Cucumis sativus*, Pineapple –*Ananas comosus*, African cherry –*Chrysophyllum albidum*, Orange – *Citrus sinensis*, and Watermelon –*Citrullus lanatus*) purchased from major markets in Eti-Osa, Lagos state, Nigeria was carried out. Geiger Muller detector was used in taking readings of the absorbed dose rate of the ionizing radiation from the fruit samples. The obtained values of absorbed dose rate ranged from $0.25\mu\text{Svhr}^{-1}$ to $0.41\mu\text{Svhr}^{-1}$ found in orange and pineapple respectively. The annual committed effective dose ranged from 1.75mSvyr^{-1} to 2.87mSvyr^{-1} while values for excess lifetime cancer risks (ELCR) ranged from 0.613 to 1.003×10^{-2} . The average annual committed effective dose and mean excess lifetime cancer due to the intake of these fruits were calculated to be 2.282mSvyr^{-1} and 0.792×10^{-2} respectively. These results were found to be higher than the recommended world average value of 1.0mSvyr^{-1} and excess lifetime cancer risks annual limit of 0.29×10^{-3} respectively. This indicated that the consumption of fruits by the people in the study area posed significant radiological health risk to them.

Introduction

Radiation is energy that moves from one place to another in a form that can be described as waves or particles [1]. There are many kinds of radiation all around us. The forces at work in radiation are revealed upon examining the structure of atoms. Atoms are a million times thinner than a single strand of human hair, and are composed of even smaller particles – some of which are electrically charged.

Radiation has a lot of effects on living tissues, some are good while some harmful. Radiological assessment of our environment is of great importance to ascertain the safety of human from radionuclides. Sources of radiation are all around us all the time. Some are natural and some are man-made. The amount of radiation absorbed by an individual is measured in Dose. A dose is the amount of radiation energy absorbed by the body.

All living things are continuously exposed to ionizing radiation from Naturally Occurring Radioactive Materials (NORM). NORM existing in soil could pose potential health risk [2], especially when aided by natural processes such as weathering deposition and wind erosion [3]. Naturally Occurring Radioactive Materials (NORMs) have always been

present in every part of the earth and in the tissue of all living beings [4].

Radionuclides are found naturally and can be artificially produced. Natural radionuclides such as ^{238}U , ^{232}Th and ^{40}K can be found almost everywhere; in soil, public water supplies, oil and atmosphere thereby subjecting human beings to reasonable exposure [5,6].

The artificial sources of radionuclides are largely due to medical and industrial activities. Studies on radiation levels and radionuclide distribution in the environment provide vital radiological baseline information. Such information is essential in estimating human exposure from natural and man-made sources of radiation and necessary in establishing rules and regulations relating to radiation protection [19].

The global average natural dose of background ionizing radiation to humans is estimated to 2.40mSvyr^{-1} . Eighty percent (80%) of which comes from nature, while remaining 20% results from exposures to artificial radiation sources, primarily from medical imaging and industries [7].

85% of an individual's annual dose of radiation comes from natural sources; radon (a gas that is emitted from the rocks that form the crust of the planet), food, cosmic radiation, exposure from buildings and soils. 15% is from man-made sources, 14% from medical field/apparatus exposure and 1% comes from the nuclear industry [20].

With the growing awareness of the risks associated with exposure to radiation, the twentieth century witnessed the development of intensive research on the effects of radiation on humans and the environment. The most important evaluation of population groups exposed to radiation is the study of approximately 86,500 survivors of the atomic bombings of Hiroshima and Nagasaki at the end of the Second World War in 1945 (henceforth referred to as the survivors of the atomic bombings). Further, reliable data on the subject comes from experience with irradiated patients, and with workers after accidental exposure (e.g. Chernobyl nuclear power plant accident), and from animal and cell experiments in laboratories [8].

Radiation

Radiation is the energy emitted when particles or waves travel through space or a medium [9]. People are exposed to radiation from cosmic rays as well as to radioactive materials found in the soil, water, food, air, and inside the body. Human-made radiation sources are widely used in medicine, industry and research. People may be exposed to radiation at doses from ranging from negligible to life threatening [10].

Brief History of Radiation

In 1895, Wilhelm Conrad Roentgen, a German physicist, discovered radiation - which he called X-rays—that could be used to look into the human body. This discovery heralded the medical uses of radiation, which have been expanding ever since. Roentgen was awarded the first Nobel Prize in physics in 1901 in recognition of the extraordinary services he had rendered to humanity. One year after Roentgen's discovery, Henri Becquerel, a French scientist, put some photographic plates away in a drawer with fragments of mineral containing uranium. When he developed them, he found to his surprise that they had been affected by radiation. This phenomenon is called radioactivity and occurs when energy is released from an atom spontaneously and is measured today in units called Becquerel (Bq) after Henri Becquerel. Soon afterwards, a young chemist, Marie Skłodowska-Curie, took the research further and was the first to coin the word radioactivity. In 1898, she and her husband Pierre Curie discovered that as uranium gave off radiation, it mysteriously turned into other elements, one of which they called polonium, after her homeland, and another they called radium, the “shining” element. Marie Curie shared the Nobel Prize in physics in 1903 with Pierre Curie and Henri Becquerel. She was the first woman to win the Nobel Prize a second time in 1911 for her discoveries in radiation chemistry [11].

Effects of Radiation

Radiation has effects on human, offspring, children, unborn child, animals and plants. Each of them is briefly described below

Effects of Radiation on Humans

Wilhelm Conrad Roentgen, who discovered X-rays in 1895, died of cancer of the intestine in 1923. Marie Curie, who was also exposed to radiation throughout her working life, died of a blood disease in 1934.

It is reported that by the end of the 1950s, at least 359 early radiation workers (mainly doctors and other scientists) had died from their exposure to radiation, unaware of the need for protection.

Since the discovery of radiation, more than a century of radiation research has yielded extensive information on the mechanisms by which radiation can affect health. It is known that radiation can produce effects at the level of cells, causing death or modification of cells and this is usually because of direct damage done to deoxyribonucleic acid (DNA) strands in a chromosome. If the number of damaged or killed cells is large enough, it may result in organ dysfunction and even death. Also, other damage to DNA may occur that does not kill the cell. Such damage is usually repaired completely but if not, the resulting modification (cell mutation) and this will be reflected in subsequent cell divisions and may ultimately lead to cancer. If the cells modified are those transmitting hereditary information to descendants, genetic disorders may arise.

Effects on Offspring

If radiation damage occurs in reproductive cells, the sperm or ovum, it can lead to heritable effects in descendants. Moreover, radiation can directly damage an embryo or fetus already developing within the womb. It is important to differentiate between radiation exposure of adults, children and embryos/fetuses. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has conducted comprehensive reviews of health effects, including heritable effects, in these groups.

Effects on Children

Health effects in humans depend upon a number of physical factors. Because of their anatomical and physiological differences, the impacts of radiation exposure on children and on adults are different. Children have smaller bodies and are less protected by overlying tissues; the dose to their internal organs will be higher than that of adults for a given external exposure. Also, children are shorter in height than adults, so they may receive higher doses from radionuclides deposited on the ground.

Concerning internal exposure, because of the smaller size of children's body, and because their organs are closer together, radionuclides concentrated in one organ irradiate other organs more than would be the case for adults. There are also many other age-related factors involving metabolism and physiology that make a substantial difference in dose at different ages. Several radionuclides are of particular concern regarding internal exposure of children. Accidents involving releases of radioactive iodine-131 can be significant sources of exposure of the thyroid. For a given intake, the dose to the thyroid for infants is about nine times higher than that for adults. Studies of the Chernobyl nuclear power plant accident have confirmed the link between thyroid cancer and iodine-131, which concentrates mainly in this organ.

Effects on The Unborn Child

An embryo or fetus can be exposed through radioactive material transferred by the mother via food and drink (internal exposure) or directly through external exposure. Because a fetus is protected in the uterus, its radiation dose tends to be lower than the dose to its mother for most radiation exposure events. However, the embryo and fetus are particularly sensitive to radiation, and the health consequences of exposure can be severe, even at radiation doses lower than those that immediately affect the mother. Such consequences can include growth retardation, malformations, impaired brain function and cancer.

Effects on Animals and Plants

Effects of radiation exposure on animals and plants are receiving more attention than previously. In past decades, the prevailing view was that if human life were adequately protected, both plants and animals would be similarly protected. UNSCEAR evaluated the effects of radiation exposure on plants and animals and found that a theoretical dose range of 1–10 Gy was unlikely to result in effects on animal and plant populations and that individual responses to radiation exposure varied (mammals are the most sensitive of all animals). Those effects that are likely to be significant at the population level concerns fertility, mortality and the induction of mutations. Reproductive changes, such as in the numbers of offspring, are a more sensitive indicator of radiation effects than mortality.

Forms of Radiation

There are two forms of radiation, which include

1. Non-ionizing radiation
2. Ionizing radiation

Non-Ionizing Radiation

Non-ionizing radiation has less energy than ionizing radiation; it does not possess enough energy to produce ions. Examples of non-ionizing radiation are visible light, infrared, radio waves, microwaves, and sunlight.

Global positioning systems, cellular telephones, television stations, FM and AM radio, cordless phones, garage-door

openers, and ham radios use non-ionizing radiation [12]. Other forms include the earth's magnetic field, as well as magnetic field exposure from proximity to transmission lines, household wiring and electric appliances. These are defined as extremely low-frequency (ELF) waves and are not considered to pose a health risk [13].

Ionizing Radiation

Ionizing radiation is capable of knocking electrons out of their orbits around atoms, upsetting the electron/proton balance and giving the atom a positive charge. Electrically charged molecules and atoms are called ions. Ionizing radiation includes the radiation that comes from both natural and man-made radioactive materials. Example of ionizing radiation includes the following Alpha particles, Beta particles, Gamma rays, X-rays and Neutrons.

Ionizing radiation is a type of energy released by atoms that travels in the form of electromagnetic waves (gamma or X-rays) or particles (neutrons, beta or alpha). The spontaneous disintegration of atoms is called radioactivity, and the excess energy emitted is a form of ionizing radiation. Unstable elements which disintegrate and emit ionizing radiation are called radionuclides [14].

An atom whose nucleus is unstable is referred to as a radionuclide. The excess energy possessed by this nucleus is transmitted to newly created radiation particles, resulting in the release of gamma, alpha or beta particles or radiation [15].

Radionuclides are uniquely identified by the type of radiation they emit, the energy of the radiation and their half-life. The number of radionuclides present in a material or food is measured in Becquerels (Bq). One Becquerel is equal to one disintegration per second. Radionuclides are naturally present in the environment, and that includes our bodies and our food and water.

We are exposed to radiations (also known as background radiation) from these radionuclides on a daily basis. Radiation comes from space (cosmic rays) as well as from naturally-occurring radioactive materials (radionuclides) found in the soil, water and air. Radioactivity can be detected in food and water and the concentration of naturally-occurring radionuclides varies depending on several factors such as local geology, climate and agricultural practices [16].

Natural radionuclides are elements that are found in the air, water and soil. They find their ways into the plants through the leaves and absorption of nutrients and water from the soil through the roots. Intake of fruits is very essential for human beings as part of balance diet [4].

Food is one of the major pathways through which radionuclide is transferred to man. Some foods we consume are sometimes contaminated with radionuclides. It is therefore necessary to estimate the radiation doses obtained from the ingestion of contaminated food [17].

Determination of radionuclides' activity concentration in fruits is essential for the protection of human health. Fruits

can be radioactive due to the presence of naturally occurring radioactive materials (NORMs) and technically enhanced radioactive materials (TENORMs) in the environment [7].

Food is essential for life, providing our bodies with carbohydrates, fats, fiber, minerals, protein, vitamins and water. Good nutrition is vital for good health and disease prevention. Food is central not only to our health but also our psychology and culture. As such, food and food quality are highly emotive issues. The physical phenomenon of radioactivity can also generate strong feelings, explaining why the subject of radioactivity in food is equally emotive [20].

Individual diets are highly variable but in general, the foods that we eat reflect our state of food security and this can be defined according to four basic principles:

- (1) Availability - for example the quantity and quality of food that can be produced or purchased;
- (2) Accessibility - the individual's ability to acquire appropriate foods (i.e., given their legal, political, economic and social arrangements);
- (3) Utilization - the ability to make proper use of food in terms of storage, adequate sanitation, preparation and the provision of sufficient energy and nutrients;
- (4) Stability with time - is food available, accessible and can it be utilized at all times?

Local soil and climatic conditions and access to natural resources such as forests and aquatic ecosystems, play an important role in determining the foods that were available to local populations. More recently however, globalization of the food production industry, the commercial development of aquaculture and the large reduction in transport costs has broadened the range of foods available in all regions of the world. Food availability has increased and increasing numbers of people can access and utilize a broad range of different foods in addition to those that are locally produced [20].

Statement of The Problem

Our environment is full of radiations, and there is need to ascertain the safety of lives due to exposure to these radiations.

A lot of research work had been done on soil samples and water radiologically. There is a need to also think of the ingestion of these radionuclides through fruits especially now that the cases of kidney failure and cancer of internal organs of human beings are so rampant.

The Aim and Objectives of The Research

Aim of this research is to determine the radiological health risk of ionizing radiation of some selected fruits from major markets in Eti-Osa to consumers.

The objectives of this research are as follows:

- i. To measure the absorbed dose rate of ionizing radiation in purchased samples of fruits from Sangotedo, Ajah, Jakande, Abraham Adesanya and Eleganza, markets in Eti-osa, Lagos, Nigeria.
- ii. To determine the annual committed effective doses of ionizing radiation to the consumers.
- iii. To determine the excess lifetime cancer risk to the consumers of the fruits.

Significance of The Study

The objective of this research work is to determine if consumption of the fruits from the selected major markets at Eti- Osa, Lagos state, Nigeria is safe for the people radiologically in this study area.

Definition of Terms

❖ Radiation

The energy emitted when particles or waves travel through space or a medium.

❖ Absorbed Dose

The total amount of energy absorbed per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a rad. In the international system of units, 100 rad equals 1 gray (Gy).

❖ Equivalent Dose

The product of the absorbed dose (rad) in tissue and a radiation weighting factor. Equivalent dose is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

❖ Committed Equivalent Dose

The calculated equivalent dose to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed equivalent dose is expressed in units of rem (or sievert).

❖ Committed Effective Dose

The sum of the committed equivalent doses to various tissues in the body, each multiplied by the appropriate tissue weighting factor. Committed effective dose is expressed in units of rem (or sievert).

Effective Dose

The sum of the doses received by all organs or tissues of the body after each one has been multiplied by the appropriate tissue weighting factor. It includes the dose from radiation sources internal and/or external to the body. Effective dose is expressed in units of rem (or sievert). In this report, the term "effective dose" is often shortened to "dose".

Materials and Methods

❖ Geographical Location

Eti-Osa is a city in Nigeria, located in Lagos state. The local population is estimated to total about 290,000 people (population census of 2006-03-21) and 174.9 km² land areas. The coastal city is one of the main industrial hubs of the area, but mainly the local population is involved in land dredging, fishing, and other similar activities. Notable places in Eti-Osa are; Ajah, Sangotedo, Obalende, Victoria Island, Ikoyi, Lekki, Okun-ajah, Igbo efon, Jakande, Abraham Adesanya etc.

The latitude of Eti-Osa, Nigeria is 6.458985, and the longitude is 3.601521. Eti-Osa, Nigeria is located at Nigeria country in the Cities place category with the GPS coordinates of 6° 27' 32.3460" N and 3° 36' 5.4756" E.

❖ Samples and Collection Preparation

This research work focuses on six (6) fruits of which thirty 30 samples were purchased from five major markets: Ajah, Sangotedo, Eleganza, Abraham Adesanya, Jakande markets at Eti-osa local government area, Lagos state.

- At the point of purchase, each sample was carefully placed in separate polythene bags and properly labeled for easy identification.
- Samples were washed with distilled water; peeled and edible parts were diced and blended into juice form.
- Samples were transferred into plastic containers, well labelled and sealed.
- Detector was placed on the sealed covered plastic and readings were taken.

❖ Measurements

A calibrated portable BR 9c series Geiger Muller detector was used in taking readings of the absorbed dose rate of ionizing radiation from the samples in this research work. This device is used to detect ionizing radiation exposure. The device was placed on each container in order to take the readings of the radiation emitted.

The average value of absorbed dose rate for each fruit sample was recorded after the background count rate of 80 counts.

Table 1 Description of Food Samples Analyzed in the Study

Common name	Botanical name
Mango	Mangifera indica
Orange	Citrus sinensis
Watermelon	Citrullus lanatus
African Cherry	Chrysophyllum albidum
Pineapple	Ananas comosus
Cucumber	Cucumis sativus
Total samples 30	

Calculations on Radiological Parameters Used

Dose Rate (DR)

- Dose rate is the quality radiation absorbed or delivered per time.
- It is measured in milli-Sievert and micro- Sievert (μSv).

Annual Committed Effective Dose (ACED)

Annual committed effective dose (ACED) in fruits samples to the consumers were calculated using the equation stated below (UNSCEAR, 2000):

$$ACED = D \times 8760 \times 0.8 \times 10^{-3} \quad (3.1)$$

Where: D = Absorbed dose rate

Excess Life Cancer Risk (ELCR)

The excess lifetime cancer risk (ELCR) was determined based on the values of the annual committed effective dose using the equation (ICRP, 2007):

$$ELCR = ACED \times LE \times RF \quad (3.2)$$

Where: LE = Life Expectancy taken to be 70 years;

RF = fatal Risk Factor per Sievert which is 0.05 (ICRP, 2007)

Results and Discussion

❖ Estimated Radiological Parameters in Fruits

The results of the measurement of radiological parameters in fruits samples from major markers in Eti-osa, Lagos are given in Table 4.1 to Table 4.7.

In Table 4.1, the maximum value of the absorbed dose rate measured by Geiger Muller detector was 0.36 μSvhr⁻¹ found in Orange with annual committed effective dose (ACED) of 2.52 mSvy⁻¹ and excess lifetime cancer risk (ELCR) of 0.883 × 10⁻²

The minimum value of absorbed dose rate was 0.28 μSvhr⁻¹ found in Cucumber with annual committed effective dose (ACED) of 1.96 mSvy⁻¹ and excess lifetime cancer risk of 0.686 × 10⁻².

In Table 4.2, the maximum value of the absorbed dose rate measured by Geiger Muller detector was 0.41 μSvhr⁻¹ found in Pineapple with annual committed effective dose (ACED) of 2.87 mSvy⁻¹ and excess lifetime cancer risk (ELCR) of 1.003 × 10⁻².

The minimum value of absorbed dose rate was 0.25 μSvhr⁻¹ found in Orange with annual committed effective dose (ACED) of 1.75 mSvy⁻¹ and excess lifetime cancer risk of 0.613 × 10⁻¹.

In Table 4.3, the maximum value of the absorbed dose rate measured by Geiger Muller detector was 0.35 μSvhr⁻¹ found in African cherry with annual committed effective dose (ACED) of 2.45 mSvy⁻¹ and excess lifetime cancer risk (ELCR) of 0.858 × 10⁻².

The minimum value of absorbed dose rate was $0.27 \mu\text{Svhr}^{-1}$ found in Orange with annual committed effective dose (ACED) of 1.96 mSvyr^{-1} and excess lifetime cancer risk of 0.662×10^{-2} .

In Table 4.4, the maximum value of the absorbed dose rate measured by Geiger Muller detector was $0.40 \mu\text{Svhr}^{-1}$ found in Watermelon with annual committed effective dose (ACED) of 2.80 mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.981×10^{-2} .

The minimum value of absorbed dose rate was $0.29 \mu\text{Svhr}^{-1}$ found in Mango with annual committed effective dose (ACED) of 2.03 mSvyr^{-1} and excess lifetime cancer risk of 0.711×10^{-2} .

In table 4.5, the maximum value of the absorbed dose rate measured by Geiger Muller detector was $0.39 \mu\text{Svhr}^{-1}$ found in orange and Mango with annual committed effective dose (ACED) of 2.73 mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.956×10^{-2} .

The minimum value of absorbed dose rate was $0.28 \mu\text{Svhr}^{-1}$ found in Cucumber with annual committed effective dose (ACED) of 1.96 mSvyr^{-1} and excess lifetime cancer risk of 0.686×10^{-2} .

In summary, the values of the radiological parameters in fruits samples from major markets in Eti-Osa, Lagos state as shown in the tables 4.2 the minimum value of the absorbed dose rate measured by Geiger Muller detector was $0.25 \mu\text{Svhr}^{-1}$ while the maximum value was $0.41 \mu\text{Svhr}^{-1}$.

The determined annual committed effective dose (ACED) minimum value was 1.752 mSvyr^{-1} with the maximum value of 2.873 mSvyr^{-1} .

The determined excess lifetime cancer risk (ELCR) had the minimum value to be 0.613×10^{-2} while the maximum value was 1.0×10^{-2} respectively.

The mean values of the absorbed dose rate, annual committed effective dose (ACED) and excess lifetime cancer risk (ELCR) are 0.326 , 2.282 and 0.792×10^{-2} as shown in table 4.6.

In Table 4.7, it was shown that the obtained results were higher than the recommended world average mean value of 1.0 mSvyr^{-1} [19] and excess lifetime cancer risk annual limit of 0.29×10^{-3} [19] respectively.

Table 4.1: Values of ADR, ACED and ELCR from fruits to the consumers as purchased from Ajah Market.

FRUIT	GEOGRAPHICAL COORDINATES	SAMPLE	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Mango	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS1	0.35	2.45	0.858
Orange	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS2	0.36	2.52	0.883
Watermelon	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS3	0.35	2.45	0.858

Pineapple	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS4	0.32	2.24	0.784
Cucumber	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS5	0.28	1.96	0.686
African-cherry	$6^{\circ} 28' 0'' \text{ N}$ $3^{\circ} 33' 43'' \text{ E}$	AFS6	0.31	2.17	0.760

Source: Field Survey, 2023

NOTE: FS means Fruit samples, AFS means fruit samples from Ajah market.

Table 4.2: Values of ADR, ACED and ELCR from fruits to the consumers as purchased from Eleganza Market.

FRUIT	GEOGRAPHICAL COORDINATES	SAMPLE	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Mango	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS7	0.29	2.03	0.711
Orange	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS8	0.25	1.75	0.613
Watermelon	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS9	0.36	2.52	0.883
Pineapple	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS10	0.41	2.87	1.003
Cucumber	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS11	0.27	1.89	0.662
African-cherry	$6^{\circ} 26' 48'' \text{ N}$ $3^{\circ} 32' 39'' \text{ E}$	EFS12	0.32	2.24	0.784

Source: Field Survey, 2023

NOTE: FS means Fruit samples, EFS means fruit samples from Eleganza market

Table 4.3: Values of ADR, ACED and ELCR from fruits to the consumers as purchased from Jakande Market

FRUIT	GEOGRAPHICAL COORDINATES	SAMPLE	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Mango	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS13	0.34	2.38	0.833
Orange	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS14	0.27	1.89	0.662
Watermelon	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS15	0.29	2.03	0.711
Pineapple	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS16	0.34	2.38	0.833
African Cherry	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS17	0.35	2.45	0.858
Cucumber	$6^{\circ} 26' 12'' \text{ N}$ $3^{\circ} 30' 22'' \text{ E}$	JFS18	0.32	2.24	0.784

Source: Field Survey, 2023

NOTE: FS means Fruit samples, JFS means fruit samples from Jakande market

Table 4.4: Values of ADR, ACED and ELCR from fruits to the consumers as purchased from Sangotedo Market

FRUIT	GEOGRAPHICAL COORDINATES	SAMPLE	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Mango	6° 28' 24" N 3° 37' 38" E	SFS19	0.29	2.03	0.711
Orange	6° 28' 24" N 3° 37' 38" E	SFS20	0.36	2.52	0.883
Watermelon	6° 28' 24" N 3° 37' 38" E	SFS21	0.40	2.80	0.981
Pineapple	6° 28' 24" N 3° 37' 38" E	SFS22	0.32	2.24	0.784
Cucumber	6° 28' 24" N 3° 37' 38" E	SFS23	0.31	2.17	0.760
African cherry	6° 28' 24" N 3° 37' 38" E	SFS24	0.32	2.24	0.784

Source: Field Survey, 2023

NOTE: FS means Fruit samples, SFS means fruit samples from Sangotedo market

Table 4.5: Values of ADR, ACED and ELCR from fruits to the consumers as purchased from Abraham Adesanya Market

FRUIT	GEOGRAPHICAL COORDINATES	SAMPLE	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Watermelon	6° 28' 8" N 3° 35' 6" E	AAFS25	0.30	2.10	0.735
Orange	6° 28' 8" N 3° 35' 6" E	AAFS26	0.39	2.73	0.956
Mango	6° 28' 8" N 3° 35' 6" E	AAFS27	0.39	2.73	0.956
Pineapple	6° 28' 8" N 3° 35' 6" E	AAFS28	0.32	2.24	0.784
Cucumber	6° 28' 8" N 3° 35' 6" E	AAFS29	0.28	1.96	0.686
African cherry	6° 28' 8" N 3° 35' 6" E	AAFS30	0.32	2.24	0.784

Source: Field Survey, 2023

NOTE: FS means Fruit samples, AAFS means fruit samples from Abraham Adesanya market

Table 4.6: Mean values of DR, ACED and ELCR from fruits to the consumers

	SAMPLE ID	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Total	30	9.78	68.46	23.918
Mean value		0.326	2.282	0.792

Table 4.7: Comparison of the determined mean DR (μSvhr^{-1}), ACED (mSvyr^{-1}), and ELCR $\times 10^{-2}$ gotten from the fruits purchase at markets with the world average mean value

RADIOLOGICAL PARAMETERS	ADR (μSvhr^{-1})	ACED (mSvyr^{-1})	ELCR $\times 10^{-2}$
Determined mean values	0.326	2.282	0.792
		1.0 (ICRP, 2007)	0.29×10^{-3} (ICRP, 2007)

Radiological Risk in The Fruit Samples

The fruits samples gotten from different locations were also compared to know the particular location associated with highest radiological health risk.

In Fig 4.1 it was revealed that the absorbed dose rate of radiation from the fruits purchased at the markets to the consumers ranged from $0.41 \mu\text{Svhr}^{-1}$ to $0.25 \mu\text{Svhr}^{-1}$. This indicated that there is health associated with the consumption of fruits from these selected areas of study, since there is connection between absorbed dose rate, annual committed effective dose and excess life time risk.

The annual committed effective dose (ACED) from the fruits purchased at the markets to the consumer ranged from 2.87mSvyr^{-1} to 1.75mSvyr^{-1} which higher than the recommended limit of 1.0mSvyr^{-1} [19] as shown in fig 4.2.

In Fig 4.3 it shows that the excess lifetime cancer risk (ELCR) from the fruits purchased at the markets to the consumers ranged from 1.003×10^{-2} to 0.613×10^{-2} . This was found to be higher than the recommended limit of 0.29×10^{-3} [19].

The African cherry purchased at Jakande has the highest absorbed dose rate of $0.35 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.45mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.858×10^{-2} as indicated in Fig 4.4

From Fig 4.5 its shows that the Cucumber purchased at Jakande possessed the highest absorbed dose rate of $0.32 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.24mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.784×10^{-2} .

The Mangoes purchased at Abraham Adesanya has the highest dose rate of $0.39 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.73mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.956×10^{-2} as shown in figure 4.6.

The Orange purchased at Abraham Adesanya has the highest dose rate of $0.39 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.73mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.956×10^{-2} as shown in Fig. 4.7.

In Fig 4.8 it was revealed that the Watermelon purchased at Sangotedo possessed the highest absorbed dose rate of $0.40 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.80mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 0.981×10^{-2} .

The Pineapple purchased at Eleganza has the highest absorbed dose rate of $0.41 \mu\text{Svhr}^{-1}$ with annual committed effective dose (ACED) of 2.87mSvyr^{-1} and excess lifetime cancer risk (ELCR) of 1.003×10^{-2} as indicated in Fig 4.9.

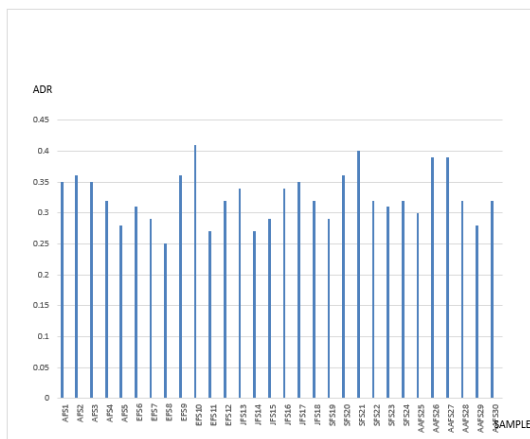


Fig 4.1 Graphical representation of absorbed dose rate of radiations from the fruits purchased at the markets to the consumers.

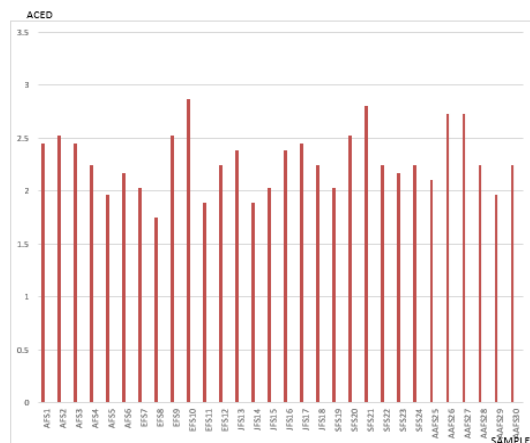


Fig 4.2 Graphical representation of annual committed effective dose (ACED) from the fruits purchased at the markets to the consumers

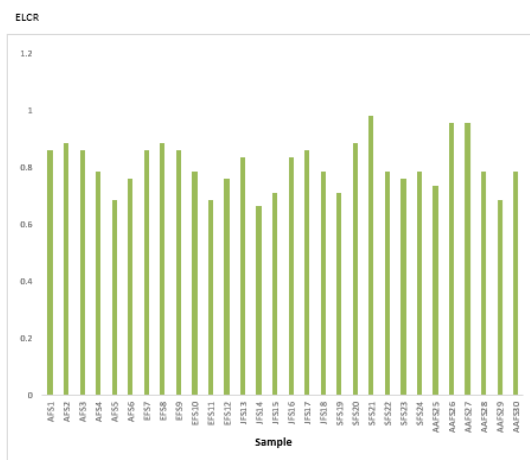


Fig 4.3 Graphical representation of excess lifetime cancer risk (ELCR) from the fruits purchased at the markets to the consumers

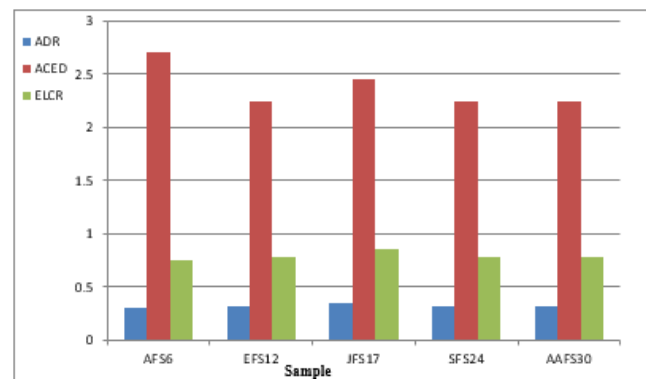


Fig 4.4 Graphical representation of the comparison of African cherry purchased in the five (5) major markets in Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya

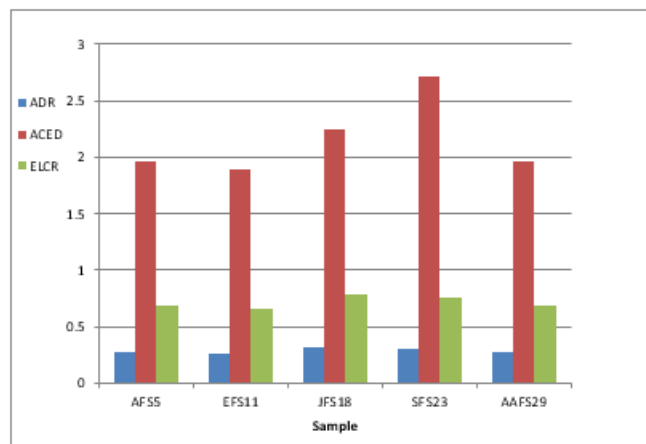


Fig 4.5 Graphical representation of the comparison of cucumbers purchased in the five (5) major markets: Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya.

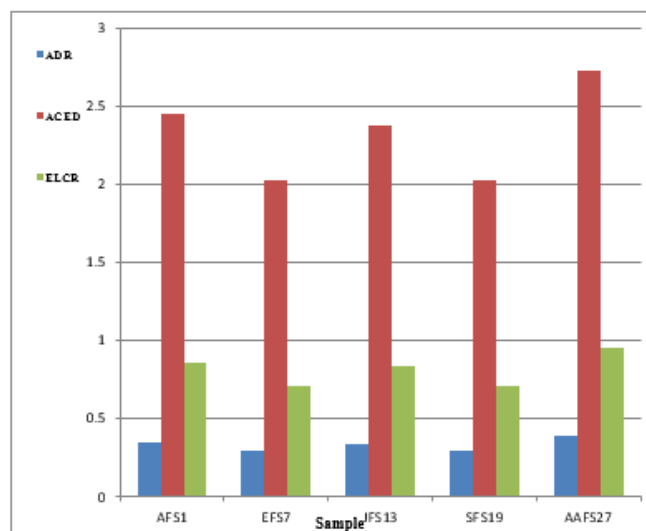


Fig 4.6 Graphical representation of comparison of the mangoes purchased in the five (5) major markets: Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya

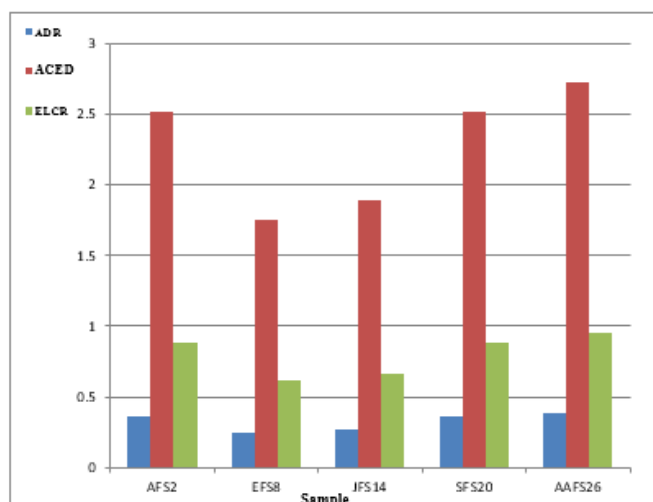


Fig 4.7 Graphical representation of comparison of oranges purchased in the five (5) major markets: Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya

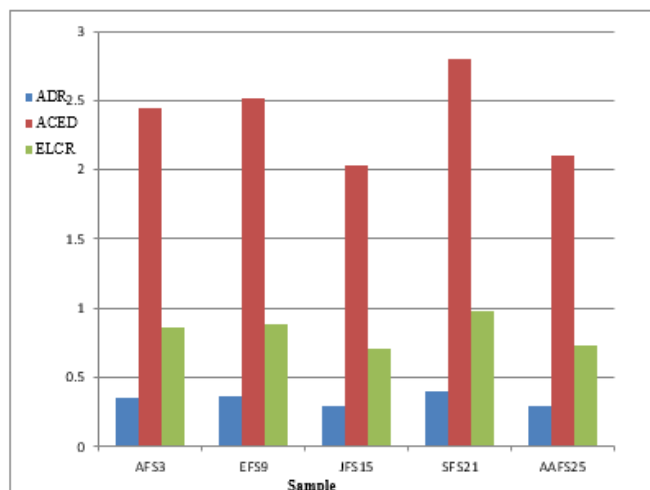


Fig 4.8: Graphical representation of comparison of watermelon purchased in the five (5) major markets; Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya

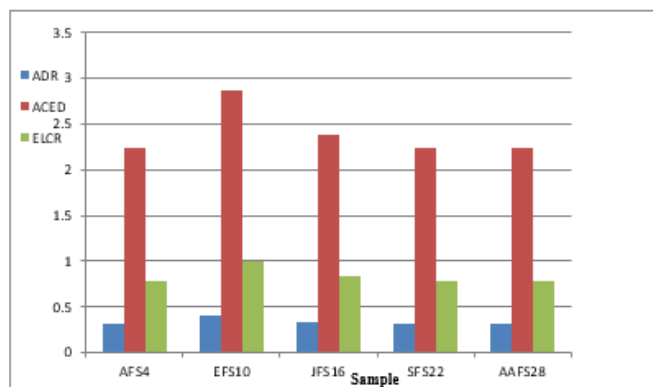


Fig 4.9 Graphical representation of the comparison of pineapple purchased in the five (5) major markets: Ajah, Eleganza, Jakande, Sangotedo and Abraham Adesanya

Findings

The values of the radiological parameters gotten from the fruits samples as purchased from major markets in Eti-Osa, Lagos state as shown in the tables 4.2 the minimum value of

the absorbed dose rate measured by Geiger Muller detector was $0.25 \mu\text{Svhr}^{-1}$ while the maximum value was $0.41 \mu\text{Svhr}^{-1}$.

The determined annual committed effective dose (ACED) minimum value was 1.752 mSvy^{-1} with the maximum value of 2.873 mSvy^{-1} .

The determined excess lifetime cancer risk (ELCR) had the minimum value to be 0.613×10^{-2} while the maximum value was 1.0×10^{-2} respectively.

The mean values of the absorbed dose rate, annual committed effective dose (ACED) and excess lifetime cancer risk (ELCR) are 0.326 , 2.282 and 0.792×10^{-2} as shown in table 4.6.

In Table 4.7, it was shown that the obtained results were higher than the recommended world average mean value of 1.0 mSvy^{-1} [19] and excess lifetime cancer risk annual limit of 0.29×10^{-3} [19] respectively.

Conclusion

A radiological study was conducted to determine the annual committed effective dose of radiations and excess lifetime cancer risk in human due to the intake of some fruits purchased from major markets in Eti-osa town, Lagos state, Nigeria. The mean values obtained were 2.282 mSvy^{-1} and 0.792×10^{-2} respectively.

The results obtained from the fruits purchased at the markets to the consumers were found to be higher than the recommended world average mean value for annual committed effective dose (ACED) of 1.0 mSvy^{-1} recommended by [19] and excess lifetime cancer risk (ELCR) of 0.29×10^{-3} [19] respectively. This indicated that consumption of the fruits by the people in the study area posed significant radiological health risk to them.

Recommendations

Since, the result obtained indicated that consumption of the fruits by the people in the study area posed significant radiological health risk to them. Therefore, I recommend that further studies should be carried out on the radionuclides contents of the soil where the fruits were planted.

Also, further studies should be carried out to know if fruits were allowed to ripe naturally or artificially through the use of Calcium carbide because this can lead to increase in radionuclide contents of the fruits that are forcefully ripened using this method.

Contribution to Knowledge

This study contributes in the following ways:

- It provides new and updated data on the ionizing radiation concentration in fruits in Eti-Osa, Lagos, Nigeria.
- It compares the absorbed dose rate in fruits from selected area of study (Eti-osa, Lagos, Nigeria) to the recommended limit and finds that the concentration is higher.

- It calculates the annual effective committed dose and excess lifetime cancer risk by ingestion of the fruits.
- It concludes that the values of the radiological parameters in the study area are higher than the recommended limit of safety and this indicated the fruits posed health risk to the consumers.

Suggestions for Further Studies

Future studies should be extended to cereals and other foodstuffs to provide a more detailed insight into the health risks associated with consumption of vegetal food stuffs from these areas. It is also important to continue and expand such research to strengthen the scientific basis of local government decisions for appropriate strategic planning aimed at reducing the human health risks in areas exposed to radionuclide.

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References

- [1] International Atomic Energy Agency (IAEA). Radiation effects and sources. Vienna: International Atomic Energy Agency; 2021. Available from: <https://www.iaea.org/newscenter/news/what-is-radiation>.
- [2] Wilson MJ. Anthropogenic and naturally occurring radioactive materials detected on radiological survey of properties in Monticello, Utah. Environmental Health. 1993;26th Midyear Topical Meeting, 24-28 January;556.
- [3] Elles MP, Armstrong A, Lee SY. Characterization and solubility measurements of uranium-contaminated soils to support risk assessment. J Health Physic. 1997;72:716-726.
- [4] Sowole O, Olaniyi OE. Assessment of radioactivity concentrations and effective of radionuclides in selected fruits from major markets at Ijebu-Ode in Ogun State, Southwest of Nigeria. J Appl Sci Environ Manage. 2018;22(1):95-98. doi:10.4314/jasem.v22i1.17.
- [5] Ali FA. Measurements of naturally occurring radioactive materials (NORMs) in environmental samples. 2008. Available from: <https://personal.ph.surrey.ac.uk/~phs/msc-dissertations/msc-diss-2008/fuad-ali-msc-diss-NORM-2008.pdf>.
- [6] Varier MK. Nuclear radiation detection: Measurements and analysis. New Delhi, India: Narosa Publishing House; 2009.
- [7] Mgbemere CJ, Ononugbo CP, Avwiri GO. Assessment of radionuclides in some fruits from Niger Delta, Nigeria and its health risk. Asian J Res Rev Phys. 2021;5(3):41-53. Article no. AJR2P.77873.
- [8] United Nations Environment Programme (UNEP). Radiation: effects and sources. United Nations Environment Programme; 2016. ISBN: 978-92-807-3517-8. Job No. DEW/1937/NA.
- [9] Tanimowo HI. Assessment of internal ionizing radiations in human through the ingestion of vegetables from major markets at Ijebu-Ode in Ogun State. 2021.
- [10] World Health Organization (WHO). WHO updates critical medicines list for radiological and nuclear emergencies. Geneva: World Health Organization; 2023. Available from: <https://www.who.int/news/item/27-01-2023-who-updates-critical-medicines-list-for-radiological-and-nuclear-emergencies>.

[11] International Atomic Energy Agency (IAEA). Extent of environmental contamination by naturally occurring radioactive material (NORM) and technological options for mitigation. Technical Report Series No. 419. Vienna: International Atomic Energy Agency; 2023.

[12] Canadian Nuclear Safety Commission (CNSC). Types and sources of radiation. Canadian Nuclear Safety Commission; 2014. Available from: <https://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/types-and-sources-of-radiation>.

[13] Brahemy SM. Radiation and its effect on the human body. 2019. ISSN: 2706-6495. Available from: <https://www.ajrsp.com>.

[14] World Health Organization (WHO). Ionizing radiation and health effects. Geneva: World Health Organization; 2022. Available from: <http://www.who.int/news-room/fact-sheets/detail/ionizing-radiation-and-health-effects>.

[15] Oluyide SO, Tchokossa P, Orosun MM, Akinyose FC, Louis H, Ige SO. Natural radioactivity and radiological impact assessment of soil, food and water around iron and steel smelting area in Fashina Village, Ile-Ife, Osun State, Nigeria. J Appl Sci Environ Manage. 2019;23(1):135-143.

[16] World Health Organization (WHO). Guidelines for drinking-water quality. 4th ed. Geneva: World Health Organization; 2011.

[17] Syarbaini AW, Iskandar D. Natural radioactivity in some food crops from Bangka-Belitung Islands, Indonesia. Atom Indonesia. 2014;40(1).

[18] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and effects of ionizing radiation. Annex B. New York: United Nations; 2000.

[19] Thies F, Mills LM, Moir S, Masson LF. Cardiovascular benefits of lycopene: fantasy or reality? Proc Nutr Soc. 2016;76(2):122-129. doi:10.1017/S0029665116000744.

[20] Ware M. Health benefits of cucumber. Medical News Today; 2023. Available from: <https://www.medicalnewstoday.com/articles/283006>.

Declarations:

Author's Contribution:

- Conceptualization, data collection, interpretation, drafting of the manuscript and intellectual revisions
- The author agrees to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed

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