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Neutron Activation Analysis (NAA) of Cereals Commonly Sold in Lapai

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Abstract The concentrations of twenty elements in ten cereals commonly sold in Lapai market were determined using Neutron Activation Analysis (NAA). The elements are Al, As, Ba, Br, Ca, Cl, Co, Fe, K, La, Mg, Mn, Na, Rb, Sc, Sm, Sr, Th, V, Zn and the cereals are beans, guinea corn (red and white), maize (white and yellow), millet, rice (basmatic, foreign, and local) and wheat. The results obtained for these elements were compared with World Health Organization (WHO) permissible limits and showed that the concentrations of all the heavy metals studied (Co, Fe, La, Mn, Sm, Th, V, Zn) and some of the mineral elements (Ca, k, Mg, Na) in the cereal samples were below WHO standards limits excepting wheat that showed a higher value in Mg (2.309 %) compared with the WHO permissible limit of 0.139 %. The levels of the twenty elements in the cereals sold at Lapai did not exceed their permissible levels and are therefore safe for human consumption.

Keywords NIRR-1, Basmati rice, Maize, Guinea corn, Rice, Millet, Wheat and INAA

1. Introduction

1.1. Cereals

Cereals are small, hard, dry seeds, with or without attached hulls or fruit layers, harvested for human or animal consumption [1]. Cereals are edible seeds and are released from the plant when they fully mature. Cereals can be divided into three groups; cereals (maize, millet, rice, wheat, etc.), pulses (beans, cowpeas, peas, etc.), and oil seeds (linseed, soyabeans, sunflower, etc.). Because cereals are small, hard and dry, they can be stored, measured, and transported more readily than can other kinds of food crops such as fresh fruits, roots and tubers. The development of cereal agriculture allowed excess food to be produced and stored easily which could have led to the creation of the first permanent settlements and the division of society into classes [2].

Cereals are edible seeds and, as such, would eventually be released from the plant when fully mature. Cereals such as maize, millet, guinea corn, rice, and wheat having several species are widely cultivated in Nigeria especially in the northern states of Nigeria. The main sources of all the essential elements, heavy metals in these cereals are the soil, pollutants from the environment and the use of fertilizer and pesticides such as fungicides and insecticides. The cereals; guinea corn, maize, millet, rice, and wheat forms about 40-60 % of the daily dietary intake in not only the northern states but also in other states of Nigeria. They are therefore representative of the daily dietary intake in Nigeria.

1.2. Discussion of some selected samples of cereals

1.2.1. Beans

Common bean (*Phaseolus vulgaris L.*) is a multipurpose diploid ($2n = 2x = 22$) self-pollinated crop [3] and the most widely grown pulse in eastern and southern Africa (Center for Tropical Agriculture CIAT, 2005). There are two

major commercial classes of bean; snap and dry beans [4] with nine types of dry bean majorly grown in the Uganda [5]. These include: Calima (red flecked) and reds (large and small) accounting for about 50 % and with a high market demand.
Others are navy, creams, brown-tan, yellow, purple, white and black beans.

1.2.2. Guinea Corn

Guinea corn also known as sorghum is Africa's contribute ion to the world's top crops. It belongs to the elite handful of plants that collectively provide more than 85 percent of all human energy, and today it is the dietary staple of more than 500 million people in more than 30 countries. According to statistics from food and agriculture organizations of the United Nations, the average annual global production of sorghum in 1979 was 68.7 million tons. Over 52 million hectres were planted each year with numerous varieties of sorghum. Sorghum is a grass similar to maize in its vegetative appearance, though sorghum has more tillers and more finely branched roots than maize [6].

1.2.3. Maize Grain

Maize is an annual grass that can grow up to 4 m tall. It is grown widely throughout the world in a range of agro-ecological environments. Maize was introduced into Africa in the 1500s and now represents one of the continent's most crucial cereal crops [7]. Maize is consumed fresh as a vegetable, although the vast majority is conserved as dry grain. The Cereals are rich in carbohydrates; vitamins A, C, and E; and essential minerals.
Maize commonly known in North America and elsewhere as corn, agbado, masara and uka by the Yoruba, Hausa and Ibo people of Nigeria respectively is a large grain plant first domesticated by indigenous peoples in Mexico about 10,000 years ago. The leafy stalk of the plant produces separate pollen and ovuliferous inflorescences or ears, which are fruits, yielding kernels (often erroneously called seeds). The maize Cereals are rich in vitamins A, C, and E; carbohydrates; and essential minerals. Maize kernels are often used in cooking as a starch.

1.2.4. Millet

Millet (*Pennisetum americanum*) is a high nutritive value annual grain crop, popular among livestock producers. Millet is an open-pollinated (more than 85 percent outcrossing) diploid annual crop grown on about 26 million hectares in the warm tropics divided equally between Africa, particularly in the West African Sahel region, and the Indian subcontinent. In these areas, pearl millet is grown almost exclusively as human food; in fact, millet is the staple cereal of 90 million people who live in climate zones where severe abiotic stresses limit crop production due to heat, low and erratic rainfall, and poor soils. Without irrigation, millet is the only cereal planted in areas receiving less than 400 mm of rainfall.

1.2.5. Rice

Rice is a major commodity in world trade. Rice has become the second most important cereal in the world after wheat in terms of production, due to a recent decline in maize production [8]. It is widely cultivated throughout the tropics; and where flood controls are effective as in South-east Asia, production is high. Much of the foreign rice imported into West Africa is from South-east Asia. In Sub-Saharan Africa, West Africa is the leading producer and consumer of rice [9]. West Africa accounts for 64.2% and 61.9% of total rice production and consumption in Sub-Saharan Africa respectively.
Basmatic rice is a naturally low energy food but as with all carbohydrate foods, it's the portion size that is important: an average serving of boiled rice is 150-180 g providing 207-248 calories; a small serving (100 g) provides approximately 138 calories. By contrast a typical takeaway portion of fried rice is 300 g providing 558 calories, so it's important not to assume all rice types are the same. Wholegrain Basmati rice has the lowest GI (glycaemic index) of all rice types, which means once digested it releases its energy slowly keeping blood sugar levels more stable, which is a crucial part of diabetes management.

1.2.6. Wheat

The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources. The importance of wheat is mainly due to the fact that its seed can be ground into flour, semolina, etc., which form the basic ingredients of bread and other bakery products, as well as pastas, and thus it presents the main source of nutrients to the most of the world population [10].

1.3. Heavy Metals

The term heavy metal refers to any metallic chemical element that has a relatively high density of above 5 gcm^{-3} and is toxic or poisonous at low concentrations. Examples of heavy metals include cadmium (Cd), chromium (Cr), lead (Pb), mecury (Hg), and thallium (Tl).

Although there is no clear definition of what a heavy metal is, density is in most cases seen to be the defining factor. Heavy metals are thus commonly defined as those having a specific density of more than 5 gcm^{-3}. The main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic (arsenic is a metalloid, but is most at times usually classified as an heavy metal).

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies through food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), or intake through the food chain.

Heavy metals are dangerous because they tend to bio-accumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism with time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are ingested and stored faster than they are metabolized or excreted. Heavy metals can enter a water supply through industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into rivers, streams, lakes and the groundwater.

1.3.1. Heavy Metals in Food

Heavy metals refer to those metallic elements which have density of above 5 gcm^{-3}. These metals include Cadmium, Nickel, Zinc, Molybdenum Chromium, Copper, and Vanadium. However, the main threats to human health from heavy metals are associated with exposure to lead, cadmium, and mercury.

Food chain contamination by heavy metals has become an important issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and irrigation water. Industrial discharge, fertilizers, fossil fuels, sewage sludge and municipality wastes are the major sources of heavy metal contamination in soils and subsequent uptake by crops [11].

Food is the main source of uptake of toxic trace metals for humans. Absorption of heavy metals through food has been shown to have serious consequences on the human health and thereby economic development, associated with a decline in labour productivity as well as increased direct costs of treating illness- such as kidney and liver diseases, damage to the nervous system, diminished intellectual capacity, heart diseases, gastrointestinal diseases, bone fracture, cancer and death [12]. The excessive uptake of certain minerals by food crops from contaminated soils might have detrimental effects on food quality and safety, thus bestowing detrimental impacts on human health.

Heavy metal contamination of the food items is one of the most important assessment parameters of food quality assurance [13-16]. International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of the risk that these metals pose to the food chain and its contamination [14].

1.3.2. Effect of Heavy Metals on Man

Cadmium

Cadmium is an extremely toxic metal commonly found in industrial workplaces and it target the placenta, kidneys, lungs, liver, brain, and bones and Cd is also carcinogenic, causes renal dysfunction, lung disease, bone defects

Renal-dysfunction. Cadmium is also toxic to plants, animals and micro-organisms. Cadmium accumulates mainly in the kidney and liver of vertebrates and in aquatic invertebrates and algae. Acute toxic effects on fish, birds and other animals may include death or fatal malformations. Cadmium can affect plants resulting in decreased growth rate and even death. In general, Cd has been shown to interfere with the uptake, transport and use of several elements (Ca, Mg, P and K) and water by plants [17].

Cobalt

Cobaltis essential to the metabolism of all animals. It is the key constituent of cobalamin, also known as vitamin B_{12}, [18-19] the primary biological reservoir of cobalt as an ultra-trace element. But at above permissible limits it leads to adverse respiratory effects: respiratory irritation, wheezing, asthma, decreased lung function, pneumonia, and fibrosis; cardiomyopathy, gastrointestinal effects, etc.

Copper

The symptoms of Cu poisoning by ingestion include headaches, fatigue, insomnia, depression, hypotension, melena skin rashes, spaciness or detachment, learning disorders, premenstrual syndrome, interferes with zinc metabolism, etc. chronic exposure to can damage the liver and kidneys.

The human body contains about 12 mg of manganese, mostly in the bones. The soft tissue remainder is concentrated in the liver and kidneys [20].

Iron

Iron is an essential element in many metabolic processes and is indispensable for all organisms. Iron is also found as a constituent of heme enzymes such as cytochromes, catalases and peroxidizes and other non heme compounds [20].

Iron functions as haemoglobin in the transport of oxygen. In cellular respiration, it functions as essential component of enzymes involved in biological oxidation such as cytochromes c, c1, a1, etc [22]. Fe is an important constituent of succinate dehydrogenase as well as a part of the haeme of haemoglobin (Hb), myoglobin and the cytochromes [23]. Iron is required for proper myelination of spinal cord and white matter of cerebellar folds in brain and is a cofactor for a number of enzymes involved in neurotransmitter synthesis [24].

Lead

Lead occurs naturally in the environment. However, most lead concentrations that are found in the environment are a result of human activities, natural and anthropogenic sources. Lead serves no useful purpose in the body and its toxicity affects virtually all organs in the human body system. Its ability to mimic or inhibit calcium affects the actions of calcium-dependent or related processes. Pb also interacts with proteins such as amine, phosphate and carboxyl groups. The toxic metal primarily affects the peripheral and central nervous systems, renal functions, blood cells, metabolism of vitamins D. It is associated with hypertension, reproductive toxicity, developmental effects and neurological disorders, some of which may be irreversible [25].

Lead is a ubiquitous environmental and industrial pollutant that has been detected in every facet of environmental and biological systems.

Mercury

All humans are exposed to some level of mercury and most people are exposed to low levels of mercury. Mercury poisoning can result in several diseases, including acrodynia (pink disease) [26], Hunter-Russell syndrome [27]. Also in plants, high level of Hg^{2+} is strongly phytotoxic to plant cells. Toxic level of Hg^{2+} can induce visible injuries and physiological disorders in plants [28].

1.4. Mineral Elements

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the elements or minerals for their normal life processes [29-30]. Minerals are inorganic nutrients, usually required in small amounts from less than 1 to 25 µg per day, depending on the mineral.

Minerals may be broadly classified as macro, micro and ultra trace elements. The macro-elements include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur [31]. The ultra trace elements include boron, silicon, arsenic and nickel which have been found in animals and are believed to be essential for these animals. Evidence for requirements and essentialness of others like cadmium, lead, tin, lithium and vanadium is weak [32].

The mineral elements are separate entities from the other essential nutrients like proteins, fats, carbohydrates, and vitamins. Animal husbandry had demonstrated the need for minerals in the diet [33].

The importance of mineral elements in human, animal and plant nutrition has been well recognized [34-35]. Deficiencies or disturbances in the nutrition of an animal cause a variety of diseases and can arise in several ways [36].

Several factors directly or indirectly influence the levels of minerals in plants and hence the amounts available for humans and animals that depend on plants for foods and feeds respectively. The amount of a particular nutrient in the diet may be insufficient to meet the requirements. However, the metabolism of the animal may be deranged by the interaction of dietary, environmental and genetic factors [36].

1.5. Neutron Activation Analysis

Neutron activation analysis (NAA) is a sensitive multi-element analytical technique used for both quantitative and qualitative analysis of major, minor, trace and rare elements. Neutron activation analysis is a nuclear process used for determining the concentrations of elements in a large amount of materials. NAA allows discrete sampling of elements as it disregards the chemical form of a sample, and focuses solely on its nucleus. The method is based on neutron activation analysis and therefore requires a source of neutrons. The sample is bombarded with neutrons, causing the elements to form radioactive isotopes. The radioactive emissions and radioactive decay paths for each element are well known. Using this information, it is possible to study spectra of the emissions of the radioactive sample, and determine the concentrations of the elements within it.

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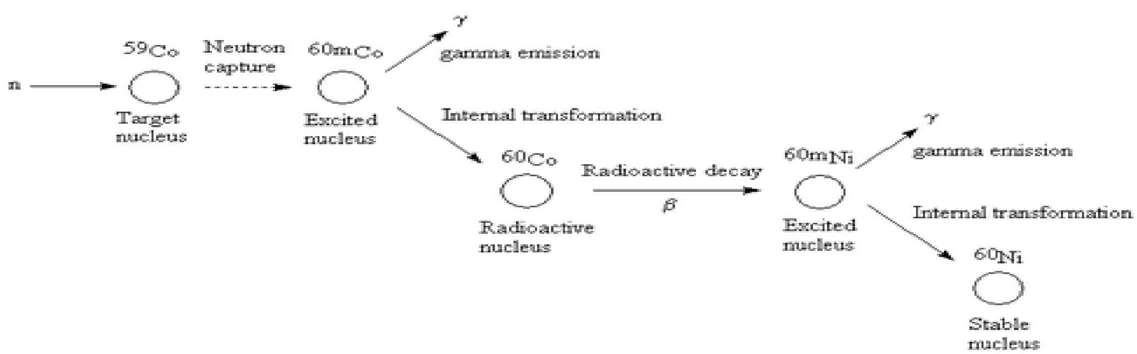

Figure 1: Sequence of events that occur during the most common type of nuclear reaction used for activation analysis

2. Materials and Method

2.1. Facility Description

The Nigeria Research Reactor-1 (NIRR-1) is specifically designed for use in Neutron Activation Analysis (NAA), thus there is the need for a complete and careful characterization of the neutron flux parameters in the irradiation channels in order to optimize its utilization for NAA through relative, absolute and single comparator methods. Stable neutron flux characteristics are exhibited by low-power research reactors, such as, the NIRR-1, the Canadian SLOWPOKE and the Chinese MNSR, which are suitable for NAA via the k_0-standarndized method [37-38].

In this work, NIRR-1 facility was utilized. The NIRR-1 swimming pool-type reactor (30 kW) at the Centre for Energy Research and Training, Ahmadu Bello University, Zaria, is a nuclear research reactor, which uses high-enriched uranium as fuel and light water as moderator and coolant. The reactor is used for neutron irradiation in the study; high resolution gamma-ray spectrometers were used in this study.

A detailed description of the reactor and the irradiation facility has been enumerated by Jonah [39]. The association facility for radioactivity measurements is a gamma-ray data acquisition system. It consists of a horizontal dip-stick High-purity Germanium (HPGe) detector with a relative efficiency of 10 % at 1332.5 keV gamma ray line, the MAESTRO emulation software compatible with the ADCAM multi-channel analyzer (MCA) card, associated electronic modules all made by EG and GORTEC and a personal computer. On the basis of the well-known activation equation, the software requires that calibration factors be pre-determined by a multi-elements standard reference material for elements of interest using adopted irradiation and counting regimes. In addition to NAA calculations, WINSPAN 2004 performs peak analysis, remote control of the multi-channel Analyzer (MCA) and other auxiliary functions such as efficiency calibration, and nuclear data generation.

2.2. Sample Collection

Samples in NIRR-1 are classified into several categories: Biological, Geological, liquid and some other special samples. Biological samples can be any sample of biological origin (e.g. animal's blood, grains, vegetables, etc.). Geological samples consist of rocks and soil materials (e.g. rock and sand). While liquid consists of water, crude oil, etc.

A total of ten different cereal samples such as:

Basmati rice, beans, foreign rice (rising sun rice), guinea corn (red and white), Lapai local rice, maize (white and yellow), millet and wheat were (bought) collected from Lapai main market on the market day (Tuesday).

The samples were crushed into powder form using agate mortar and pestle separately to avoid contaminations. They were properly dried and pack in a rabbit capsule for long and short irradiation in the reactor. In this work, the certified reference material NIST 1547 (peach leave) was used to determine the calibration factors for all elements. For the determination of calibration factors, sample of standards of approximately 2.5000 g were weighed and wrapped in polyethylene films.

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2.3. Sample Irradiation

This is the exposure of the sample to nuclear radiation (fission reaction). When samples are bombarded with neutrons they get excited and release its characteristics radiations (i.e. it emits gamma rays). Nigerian Research Reactor 1 (NIRR-I) was used for the neutron activation analysis. The analysis was done at the Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. The reactor is a miniature neutron source reactor (MNSR) and has a tank-in-pool structural configuration with a nominal thermal power rating of 31 KW. The NIRR-1 is specifically designed for neutron activation analysis and it has enhanced the capability for the analyses of traces of minor and major elements in different sample matrices. The neutron flux parameters of the MNS reactors are known to be very stable, thus permitting the use of the semi-absolute NAA method (Akaho, Nyarko & Jonah, 2006). The procedures involved include minimum sample preparation, two irradiation regimes and four counting strategies, which have been adopted on the basis of the half-life of product radionuclide and the neutron spectrum parameters in the inner and outer irradiation channels. The NIRR-1 has highly enriched uranium as fuel, light water as a moderator and Beryllium as a reflector. The associated facility for radioactive measurement is a gamma ray data acquisition system. It consists of a horizontal, deep-stick high purity germanium (HPGe) detector with a relative efficiency of 10 % at 1332.5 KeV gamma ray line, the MAESTRO emulation software compatible with the ADCAMR multi-channel analyzer Neutron Activation and Flame Atomic Absorption Elemental Analyses of Selected Hair Dyes 25 (MCA) card.

3. Results and Discussion

Table 1: A SUMMARY OF ANALYTICAL RESULT in part per million (ppm)

Elements	RB	BS	GCR	GCW	LLR	MW	MY	MT	RSR	WT
Al	33.2±1.9	22.8±1.5	162±4	128±3	62.0±2.6	75.2±2.5	56.4±2.5	177±4	82.2±3.4	329±7
As	0.025±0.006	0.017	BDL	BDL	BDL	BDL	BDL	BDL	0.054±0.005	BDL
Ba	42.2±10.2	20.4	BDL	BDL	BDL	21.4	BDL	BDL	BDL	BDL
Br	8.35±0.08	0.88±0.15	1.35±0.17	2.90±0.20	0.50±0.03	3.84±0.23	3.59±0.22	5.02±0.05	0.47±0.03	8.55±0.08
Ca	467±78	1089±114	447±74	568±76	587±87	465±12	439±75	575±86	902±111	1089±123
Cl	352±12	280±11	412±13	464±3	291±11	637±16	541±15	513±14	244±10	636±17
Co	BDL	BDL	BDL	71.2	BDL	BDL	BDL	BDL	BDL	BDL
Fe	146±39	319±40	410±49	154±42	170±41	324±39	BDL	237±44	BDL	269±50
K	1630±42	10810±184	5034±131	4271±124	1678±73.6	5559±133	3529±106	3183±38	1899±46	2637±53
La	0.034±0.007	0.41±0.06	0.94±0.07	1.73±0.07	0.096±0.009	0.43±0.06	0.28±0.05	0.21±0.01	BDL	0.24±0.01
Mg	135±18	1670 ±45	2309±53	1623±44	528±27	1638±46	1095±38	710±34	376±25	829±36
Mn	3.23±0.07	19.7±0.2	21.3±0.2	16.3±0.1	13.5±0.1	9.27±0.11	6.33±0.09	11.6±0.1	7.71±0.1	27.8±0.2
Na	10.9±0.2	7.36±0.54	5.29±0.48	10.9±0.6	9.90±0.21	6.22±0.49	4.11±0.38	6.31±0.12	12.5±0.2	11.1±0.2
Rb	BDL	11.4±2.2	11.9±1.5	2.51±0.36	15.7±1.38	11.8±2.2	6.66±1.42	10.5±1.76	8.10±1.43	26.2±1.2
Sc	BDL	0.011±0.002	0.014±0.002	0.027±0.003	BDL	0.011±0.002	0.017±0.002	0.030±0.005	BDL	0.052±0.006
Sm	BDL	0.17±0.05	BDL	BDL	0.017±0.004	BDL	BDL	0.031±0.002	BDL	0.056±0.004
Sr	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Th	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
V	BDL	BDL	BDL	0.17±0.03	BDL	BDL	BDL	BDL	0.15±0.04	0.44±0.09
Zn	9.80±2.79	16.6±1.4	11.9±1.7	9.08±1.43	24.3±4.7	16.7±1.4	10.0±1.2	43.0±4	15.1±2.9	32.8±3.8

Keys: BR: Basmatic Rice; BS: Beans; GCR: Guinea Corn (Red); GCW: Guinea Corn (White); LLR: Lapai Local rice; MW: Maize (White); MY: Maize (Yellow); MT:Millet; RSR: Rising Sun Rice: WT: Wheat
BDL Bellow Detection Limit.

4. Summary of the above charts

It was observed that among all the elements in the ten samples, Calcium (Ca) recorded the highest Concentration in Beans (1.089±53 %) and Wheat (1.089±123 %) followed by RSR (0.902±111 %). White Maize (0.637±16 %) recorded the highest level of Cl is all the cereal samples followed by Yellow Maize (0.541±15 %) Ba is below detection limits in almost all of the cereal samples except BR (0.0422±10.2 %), Beans (0.0204±4 %), and White Maize (0.0214 %).

K has a relative high concentration over all other elements and Beans recorded the highest concentration (10.810±184 %) among other samples analysed followed by White maize (5.559±133 %) and Red guinea corn (5.034±131 %). Basmatic rice recorded the lowest in K concentration (1.630±42 %).

Sr and Th are bellow detection limits in all the ten cereal samples analyzed, Vanadium (V) is also bellow detection limit in all the cereal samples except in RGC (0.00017±0.03 %), RSR (0.00015±0.04 %) and WT (0.00044±0.09 %). Millet recorded the highest concentration of Zn (0.043±4 %)

Table 2: Samples with Highest Values and W.H.O recommended permissible limits in Human (%).

Elements	**Symbols**	**Samples with highest value**	**Concentration (%)**	**W.H.O Standard Limits (%)**
Magnesium	Mg	Red guinea corn	2.309	0.139
Calcium	Ca	Wheat	1.089	6.3066
Iron	Fe	Wheat	0.269	8.16
Manganese	Mn	Wheat	0.0278	0.54
Vanadium	V	Wheat	0.0004	0.013
Zinc	Zn	Millet	0.043	0.16

From the table 5 above, it shows that Only (GCR) Guinea Corn Red was seen to have recorded the highest value in Magnesium (2.309 %), and is above the W.H.O standard (0.1394 %).

Table 3: Some essential and trace elements in the ten samples in comparison with W.H.O recommended permissible limits in Human (%).

Samples	**Magnesium**		**Calcium**		**Sodium**		**Iron**		**Manganese**		**Zinc**		**Vanadium**	
	This work	**WHO**	**This work**	**WHO**	**This work**	**WHO**	**This work**	**WHO**	**This work**	**WHO**	**This work**	**WHO**	**This work**	**WHO**
BR	0.135	0.139	0.467	6.306	0.0109	1.500	0.146	8.16	0.0032	0.54	0.0098	0.16	BDL	0.013
BS	**1.670**	**0.139**	1.089	6.306	0.00736	1.500	0.319	8.16	0.0197	0.54	0.0166	0.16	BDL	0.013
GCR	**2.309**	**0.139**	0.447	6.306	0.00529	1.500	0.410	8.16	0.0213	0.54	0.0119	0.16	BDL	0.013
GCW	**1.623**	**0.139**	0.568	6.306	0.0109	1.500	0.154	8.16	0.0163	0.54	0.00908	0.16	0.00017	0.013
LLR	0.528	0.139	0.587	6.306	0.0099	1.500	0.170	8.16	0.0135	0.54	0.0243	0.16	BDL	0.013
MW	**1.638**	**0.139**	0.637	6.306	0.00622	1.500	0.324	8.16	0.00927	0.54	0.0167	0.16	BDL	0.013
MY	**1.095**	**0.139**	0.439	6.306	0.00411	1.500	BDL	8.16	0.00633	0.54	0.010	0.16	BDL	0.013
MT	0.710	0.139	0.575	6.306	0.00631	1.500	0.237	8.16	0.0116	0.54	0.043	0.16	BDL	0.013
RSR	0.376	0.139	0.902	6.306	0.0125	1.500	BDL	8.16	0.0077	0.54	0.0151	0.16	0.00015	0.013
WT	0.829	0.139	1.089	6.306	0.0111	1.500	0.269	8.16	0.0278	0.54	0.0328	0.16	0.0004	0.013

Key: BR-Basmatic Rice, BS-Beans, GCR-Guinea Corn (Red), GCW-Guinea Corn (White), LLR-Lapai Local Rice, MW-Maize (White), MY-Maize (Yellow), MT Millet, RSR-Rising Sun Rice, WT-Wheat, BDL-Bellow Detection Limit.

From table 6 above, the results of (BS) Beans, (GCR) Red guinea corn, (GCW) White guinea corn, (MW) White maize, (MY) Yellow maize (1.670, **2.309**, 1.623, 1.638, 1.095) respectively in magnesium are above the above the WHO permissible limits in Human **(0.139).** The results of the samples in Calcium, Iron, Manganese, Sodium, Vanadium and Zinc are within the WHO permissible limits.

Calcium (Ca) and Magnesium (Mg) are essential macro nutrients required for proper functioning of the human body. For instance, Ca is a constituent of bone and required for muscular contraction. Whereas, magnesium plays a role in the transport process of sodium (Na) and potassium (K) across cellular membrane and in the functional integrity of the neuromuscular system.

5. Conclusion

Heavy metals have been proved to be toxic to both human health and the environment. Owing to their toxicity and their possible bioaccumulation, these compounds should be subjected to mandatory monitoring and survey.

From the results of the ten grain samples analyzed, using NRR-1 of the CERT (Centre for Energy Research and Training, Ahmadu Bello University, Zaria) facility. The data showed that the concentrations of trace, toxic and mineral elements in the samples vary to certain extents, these possibilities are due to many factors especially from cultivation, post-harvest and storage processes. Elemental composition of soil, fertilizer and agricultural chemicals (herbicides, fungicides and insecticides) usually plays a significant contribution to the elemental composition in cereals [40].

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