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Elemental evaluation of local cereal by instrumental neutron activation analysis using NIRR-1 facility

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ABSTRACT

The nutritional role and the essentiality of trace elements as well as their biochemical and pathological significance to man and animals have been recently reviewed by several researchers. Elemental concentrations of local rice and maize were determined using the instrumental Neutron Activation Analysis (INAA) technique. Twenty one elements (Na, K, As, Br, La, Sm, Np, Sc, Cr, Fe, Co, Zn, Se, Rb, Sb, Ba, Eu,Yb, Lu, Hg and Pa) were determined and analyzed in these cereals foods. Two locally cultivated rice and maize samples were obtained directly from the farmers and two rice and maize samples grown under surveillance condition were collected from Institute of Agricultural Research (IAR) of the Ahmadu Bello University, Zaria, Nigeria. The samples were irradiated for long regimes (6 hours) in a neutron flux of $5x10^{11}ncm^{-2}s^{-1}$ with the Nigerian Research Reactor at the Centre for Energy Research and Training, CERT, A.B.U, Zaria.

Keywords: NIRR-1, Concentration, Rice, Maize and INAA.

INTRODUCTION

Despite abundant global food supplies, widespread malnutrition persists in many developing countries. Nigeria has shown that a combination of cereals and legumes or tubers with vegetables and animal sourced food rather than the single diets, better supported growth and development. Poor processing methods and hygiene have also been identified as other factors responsible for low nutrient density in local's foods. Processes such as milling, fermentation, and parboiling are intended to achieve specific purposes but however, tend to affect the nutrient content of the food negatively. [1]. reported a 90% loss of free folic acid content of cereals and certain vegetables, 50% of yam thiamine and ascorbic acid and up to 20% of milk vitamin E content during boiling. The presence of non-nutrient constituents (antinutritional factors) in plant-based foods has been shown to also negatively influence the bioavailability of nutrients. The best documented being oxalic acid which forms oxalate precipitates with dietary calcium, while phytic acid forms insoluble phytates with Ca, Fe, Zn and possibly other metals. For instance the relatively poor availability of the fairly high Fe content of cereals is mainly due to their correspondingly high phytic acid levels [1]. Trace elements can be divided from a dietary point of view into three groups; the essential trace elements (micronutrients) which are constituents of hormones, vitamins and catalysts for the enzyme systems for the metabolic processes in the cells and they function at low concentrations in living tissues; the possibly essential trace elements; and the non-essential trace elements; which are made up of the toxic and non-toxic elements which have no metabolic functions in the living organism [2].

It has been documented that diet is the main source of trace element [3] and the nutritional importance of many trace elements has been established [4,5]. However, many elements can be present in foods naturally, or through human activities, such as processing, storage, farming activities and industrial emission [6]. To maintain the physiological and metabolic processes of the body, the appropriate intakes of these elements are required. Since, deprivation can lead to diseases; whereas, excessive intake of some of these essential elements may adversely affect the human metabolic function [7, 8]. At high concentrations these essential elements can lead to poisoning [9]. Literature has also revealed that some toxic elements are also present [10]; which enters into the food chain through processing and their presence has been a source of concern to health practitioners due to their health implications. Though, these toxic elements are added sometimes' intentionally with additives on formula resulting in excess of toxicity [11, 12]. There is therefore the need to obtain better information of trace element levels in local cereals in Nigeria. It is obvious that cereal food products on the Nigerian market have not be fully investigated to determine the trace and minor element contents in these cereals which is being widely used by the populace. Notwithstanding, the need for the routine monitoring of these cereal food cannot be overemphasized. We have therefore carried out this work in order to have an up to date knowledge on the local cereal food collected directly from the farmers and the control samples collected from IAR, A.B.U, Zaria. To ensure dependable work, we have adopted the Instrumental Neutron Activation Analysis (INAA) due to its advantages of low detection limit, multi elemental capability, a non-destructive method and no sample preparation is required for analysis of this work.

The purpose of this paper is to determine the elemental concentrations in local rice and maize by instrument neutron activation analysis (INAA) in Cereals obtained from Zaria of Kaduna state, Nigeria, using NIRR-1 facility.

MATERIALS AND METHODS

Collection and Preparation of Samples

The materials used in this work are maily cereals crops (rice and maize) locally produced in the northern region of Nigeria. A total of four samples were collected of which two were directly from the farmers and the other two were of hybrid crops grown under surveillance condition collected from IAR Samaru, Zaria, Nigeria. The cereals were obtained in a dry uncrushed form labeled by the institute. The whole samples were crushed into powder form using agate mortar and pestle and were thoroughly mixed to ensure homogenization. The powdered samples were packed in a rabbit capsule for long irradiation on the reactor neutron source. A similar procedure was adopted for Standard Reference Materials (SRM) IAEA Lichen 336 which were also weighted and packed together with the samples for long irradiation. The purpose of the SRM is for quality control of the experimental procedure.

Sample obtained from IAR

S/N	*Sample Name*	*Sample Source*
1.	Sammaz -15-Maize	IAR ABU ZAR
2.	CP-175-Rice	IAR ABU ZAR

Irradiations, Counting and Analysis

The irradiation facility is the Nigeria Research Reactor-1 (NIRR-1) at the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Kaduna State, Nigeria. Like all Miniature Neutron Source Reactor (MNSR) facilities, NIRR-1, is specifically designed for neutron activation analysis, (NAA) therefore it has the capabilities for the analysis of trace, minor and major elements in different sample matrices. It uses high-enriched uranium as fuel and light water as moderator and coolant. A high resolution gamma-ray spectrometers were used in this study. HP(Ge) detector (model GEM 30P4 - 76) with a resolution of 1.74keV FWHM operated at 1332.5 keV of Co- 60, H.V. biased supply model 659 ortec, 5kV, spectroscopy amplifier model 672 ortec, acquisition interface card with computer and basic spectroscopy software (Winspan 2003) was employed in the analysis. The spectroscopy modules is from ORTEC, USA .

The sample together with the standard were sealed and irradiated in NIRR-1 at a flux of $5x10^{11}$ $ncm^{-2} s^{-1}$for 6 hours and counted for 1800s and 3600s after 4 and 14 days of cooling period respectively. The stability of neutron flux throughout the period of long irradiation was checked by monitoring the neutron flux from the computer control display and the activity of the standards after irradiation. Identification of gamma-ray of product radionuclide through their energies and quantitative analysis of their concentrations were achieved using the gamma-ray spectrum analysis software, [13].

RESULTS AND DISCUSSION

Table 1 shows the elemental concentrations in IAR control samples.

Table 2 presents the elemental concentrations in the samples considered in this study. Elements of interest detected are: Br, Na, K, and Zn.

The data showed that amounts of toxic elements in local cultivated rice and maize vary to certain extents; it is probably due to many factors which directly linked to the cultivation, post harvest and crop storage processes. Elemental Composition of soil, fertilizer and agricultural chemicals (herbicides, fungicides and insecticides) usually plays a significant contribution to the elemental composition in grains [14].

The Standard reference material ***Lichen IAEA-336*** was also analyzed for method substantiation and quality control purposes. The results obtained for analysis of standard reference material is presented in table 3. From results obtained, it is observed that most of the elemental concentrations are within ±10% of certified values since the concentrations of most of the elements are similar to their respective certified values except for those that are below detection limit.

In this study, Bromine is not considered an essential element. It was present in the rice and maize samples analyzed. Its highest concentration was 0.6423 ± 0.047ppm in *rice and the lowest concentration was 0.5409 ± 0.03 24.*

Bromine is corrosive to human tissue in a liquid state and its vapors irritate eyes and throat. Bromine vapors are very toxic with inhalation. Humans can absorb organic bromines through the skin, with food and during breathing. Organic bromines are widely used as sprays to kill insects and other unwanted pests. But they are not only poisonous to the animals that they are used against, but also to larger animals. In many cases they are poisonous to humans, too.

The most important health effects that can be caused by bromine-containing organic contaminants are malfunctioning of the nervous system and disturbances in genetic materials.

But organic bromines can also cause damage to organs such as liver, kidneys, lungs and milt and they can cause stomach and gastrointestinal malfunctioning. Some forms of organic bromines, such as ethylene bromine, can even cause cancer.

Inorganic bromines are found in nature, but whereas they occur naturally humans have added too much through the years. Through food and drinking water humans absorb high doses of inorganic bromines. These bromines can damage the nervous system and the thyroid gland. [15].

Zinc was only present in rice sample at substantial levels with concentration of 27.04 ± 5.78 Zinc is one of the essential mineral elements that is found in almost every cell, where it stimulates the activity of over 100 enzymes needed for various biochemical reactions [16].In fact, it has been established that the six categories of the international nomenclature are zinc metalloenzymes [17]. Important enzymes stimulated by zinc, support metabolic processes such as the immune system, wound healing, organoleptic abilities of taste and smell, brain development, synthesis of DNA and RNA, normal growth and development during pregnancy, cell division, sexual maturation, storage and release of insulin among others [18]. Because of its roles in the biochemical processes of growth and development, zinc is considered as one of the most essential mineral elements in foetal, infant and early childhood development. For instance, the essentiality of zinc in normal brain development suggests a clinical function for the element during the prenatal period [19]. The role of zinc in the immune system has also been associated with mother- to –child transmission of HIV [20].

Na and K act as electrolytes in the human body. Na is the principal cation in the extracellular fluids and modulates the maintenance of the intracellular and interstitial volumes. Sodium was present at major levels with its highest concentration found in *rice* at 11.1 ± 0.344ppm and the least concentration was 6.679 ± 0.28ppm in *maize*. A potassium concentration was found to be higher in maize (3215±67.52ppm) than in rice (1913±53.564ppm). It is the major intercellular cation. The regulation of K is closely involved with that of Na.

Table 1: Result of Concentrations of Elements (ppm) in IAR Control Samples

Elements	**Maize** (This Work)	**Maize** (IAR Values)	**Rice** (This Work)	**Rice** (IAR Values)
Na	6.6±0.2	4.4±0.9	11.1±0.3	35±2.0
K	3215±67.5	3700±200	1913±53.56	1900±100
As	BDL	BDL	0.0022±0.0003	0.087±0.009
Br	0.54±0.03	6.5±0.8	0.64±0.047	0.64±0.06
Zn	27.04±5.7	19±1.0	BDL	BDL
Rb	13.41±2.0	5.9±0.4	BDL	BDL

Table 2: Result of Concentration of maize and rice cereals samples

S/N	Nuclide	Maize (ppm)	Rice (ppm)
1	^{24}Na	6.679±0.28	11.1±0.344
2	^{42}K	3215±67.52	1913±53.56
3	^{76}As	<0.000861±0.002	0.00221±0.0003
4	^{82}Br	0.5409±0.0324	0.6423±0.047
5	^{140}La	< 0.05449±0.02	< 0.04678±0.018
6	^{153}Sm	< 0.012033	< 0.011563
7	^{239}Np	< 0.0038570	< 0.0036379
8	^{46}Sc	< 0.026355	< 0.025527
9	^{51}Cr	< 0.8907	< 0.96387
10	^{59}Fe	< 48.67±44.48	< 159.58
11	^{60}Co	< 0.023846	< 0.024055
12	^{65}Zn	27.04±5.78	< 22.435
13	^{75}Se	< 0.021564	< 0.027060
14	^{86}Rb	13.41±2.01	< 1.140±0.76
15	^{122}Sb	< 0.21019	< 0.00904±0.006
16	^{131}Ba	< 30.634	< 23.048
17	^{152}Eu	< 0.01224±0.003	< 0.019188
18	^{175}Yb	< 0.12620	< 0.02215±0.017
19	^{177}Lu	< 0.013654	< 0.0078723
20	^{203}Hg	< 0.033974	< 0.039252
21	^{233}Pa	0.08312±0.016	0.0744±0.019

Table 3: Result of Lichen IAEA 336 Standard for Quality Assurance

S/N	Nuclide	This Work (ppm)	Certified Value (ppm)95% C.I
1	^{24}Na	320.2±1.9212	280 – 360
2	^{42}K	1819±78.217	1640 – 2040
3	^{76}As	0.01206±0.0009	0.55 - 0.71
4	^{82}Br	11.23±1426	11.2 - 14.6
5	^{140}La	0.5918±0.028	0.56 - 0.76
6	^{153}Sm	0.1183±0.006	0.092 - 0.120
7	^{46}Sc	0.1846±0.0129	0.15 - 0.19
8	^{59}Fe	358.2±48.72	380 – 480
9	^{233}Pa	0.06979±0.01452	0.12 - 0.16
10	^{239}Np	< 0.0062672	---
11	^{51}Cr	< 0.7865	0.89 - 1.23
12	^{60}Co	< 0.09834±0.0322	0.24 - 0.34
13	^{65}Zn	< 22.45±7.27	27.0 - 33.8
14	^{75}Se	< 0.021818	0.18 - 0.26
15	^{86}Rb	< 1.251±0.976	1.54 - 1.98
16	^{122}Sb	< 0.038016	0.063 - 0.083
17	^{131}Ba	< 8.557±5.656	5.3 - 7.5
18	^{152}Eu	< 0.01213±0.007	0.019 - 0.027
19	^{175}Yb	< 0.044819	0.025 - 0.049
20	^{177}Lu	< 0.0067947	0.0042 - 0.0090
21	^{203}Hg	< 0.031468	0.16 - 0.24

CONCLUSION

The study of these samples shows that samples do not contain abnormal concentration of essential elements. Though within intake limits, some of the non essential elements are of great concern.

The use of locally available foodstuff agrees with the guideline and criteria set out by the federal Ministry of Health in Nigeria [21].Calling for the use of available foodstuff in various communities in the country to prepare food for infants and children, so as to ensure availability and affordability. Such guideline are particularly important in a developing country like Nigeria, where gross malnutrition has largely been attributed to inadequate intake of food materials due to inability of parents or families to afford the proper diets (especially animal source foods), and disease states that could prevent adequate utilization of the food materials as well as loss of appetite associated with these diseases [22]. In Some cases, ignorance about the essential food materials that could provide a balance diet has resulted in poor dieting. It will be appropriate to study the effects of soil, climatic and environmental conditions on the elements constituents of these cereal samples. This work has further demonstrated that Instrumental Neutron Activation Analysis is a useful technique in the multi elemental analysis over a wide range of concentration since its free of matrix interference hence reduced possibility of contamination due to extensive sample preparation and pre treatment.

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REFERENCES

[1] Okayed Z.S.C (**1992**) Biochemical Aspects of Nutrition Prentice-Hall of India, New Delhi pp 147-195
[2] UNDERWOOD, E. J. (**1977).** Trace elements in Human and Animal Nutrition, 4th Edition, Academic Press, New York, USA, pp 1-369, 442-443, 459-471.
[3] Dim L. A, Funtua I. I, Oyewale A. O, Grass F, Umar I. M, Gworzo U. S, Gwozdz R, *J. (***2004***). Radioanal Nuclear Chemistry*, pp 261: 225.
[4] World Health organization (**1994).** Report of a WHO/FAO/IAEA Expert Consultation on Trace Elements in Human and Health, WHO, Geneva.
[5] SCHRAUZER, G. N. (Ed), (**1994**). Toxic Heavy Metals and Other Trace Elements in Foodstuffs from 12 Different Countries, Humana Press Inc, pp 415.
[6] Fein, S. B. and Falci, C. D. (**1999).** *J. Am. Deistic Asso*.: 99: pp 1234-1240.
[7] Oskarsson, A. and Sandstoerm, B. (**1995).** *Analyst:* 120: pp 911.
[8] Prasad, A. S., (Ed). (**1993).** Essential and Toxic Elements in Human Health and Disease: AnUpdate, Wiley Liss. Inc., New York.
[9] United States Environmental Protection Agency (U.S EPA) (**2004).** Drinking Water Health Advisory for Manganese, Office of Water Regulation and Standards. Washington D.C, 2004.
[10] Oztruk, N. and Yilmaz, Y. Z. (**2000).** *water Res.* 34: pp 704-708.
[11] American Academy of pediatrics' (AAP) (**1999b).** *Pediatr.* 104: pp119-124.
[12] Fernandez-Lorenzo J. R, Cacho J. A, Rey Goldar J. L, Couce M, and Frarag J. M. (**1999).** *J.Pediatric Gasroenterol. Nutri.* 28: pp270-275.
[13] Emulsion soft ware winspan 2003
[14] Thunus L, Lejeune R, **(1994),** Handbook on Metals in Clinical and Analytical Chemistry. Marcel Dekker, New York.
[15] http://www.lenntech.com/periodic/elements br.htm/
[16] National Institute of Health (NIH) (**2002**) Facts about Dietary supplements. Clinical Nutrition services, warren Grant Magnuson Clinical center. Office of Dietary supplement, National Institute of Health.
[17] Goldez, A. and Vallee, B.L. (**1983**) Metal ions and Biological Systems. John Wiley Inc. New, York pp 112-118.
[18] Goldez, A. and Vallee, B.L. (**1983**) Metal ions and Biological Systems. John Wiley Inc. New, York pp 112-118.
[19] Prasad, S.A. (**1982**) Clinical, Biochemical and Nutritional Aspects of Trace Elements. Alan-Liss Inc. New York. Pp112-118.
[20] ACC/SCN (**2000**) Fourth Report on the World Nutrition Situation: Nutrition throughout life cycle. January 2000 pp 33-41.
[21] Federal Ministry of Health (FMOH) (**1999**). Food-based Dietary Guidelines for Nigeria. Nutrition Division, Abuja.
[22] Nigeria Nutrition Network (**2000**) Communiqués and Papers presented/distributed at the 1st Annual Nigeria Nutrition Network (NNN) meeting. 12-13 Dec.(**2002**), Abeokuta.