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Research Article

Elemental Analysis of Commonly Consumed Rice in Nigeria using PIXE Technique

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Abstract. This study investigated the essential element (P, Cl, K, Ca, Mn, Fe, Cu and Zn) concentrations of some local and imported rice commonly consumed in Nigeria. This is done in order to select the rice with high nutrient to combat malnutrition, especially in children. Proton-induced X-ray emission (PIXE) techniques available at iThemba Labs Someset West, South Africa was used for the analysis. The elemental concentration obtained for Ofada are 8805.5±221, 276.5±32, 3704.5±39, 212±8, 110.5±8, 125.5±7, 14.5±1 and 44.5±4 ppm, while for the imported rice we got 2862.5±150, 399±22, 1433±28, 4.15±2, 8.4±0.8, 4.75±1 and 9.5±2 ppm for P, Cl, K, Ca, Mn, Fe, Cu and Zn respectively. Phosporus (P) has the highest elemental concentration in all samples. Ofada, one of the local rice was found to have the highest elemental concentration while pure imported rice had the lowest concentrations of the elements. The study suggests that consumption of locally-cultivated (Ofada) rice should be encouraged in order to reduce malnutrition in children in Nigeria.

Keywords. Elemental Concentration; PIXE; Rice; Malnutrition

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1. Introduction

Human required more than twenty elements, which are mainly provided by the food. The elements that are most deficient in our diets are Iron (Fe), Zinc (Zn) and Iodine (I) [9]. It has been estimated that 600 million people suffer from iron deficiency and 200 million from iodine deficiency. These deficiencies have an impact on neurological development and are therefore of considerable socio-economic importance. Trace element malnutrition is reported to be the biggest cause of death of children in developing countries. It contributes to 53% of death related to infectious diseases in children of under the age of 5 years [10]. This happens because trace elements deficiency lowers the immunity system of a body and makes the body susceptible to communicable diseases. Malnutrition occurs when the essential elements are not in the right proportion and sufficient for the proper growth and development of the body [4, 8]. This may arise as a result of poor access to nutritious food, decreased bioavailability of the elements in food, excessive loss due to infectious diseases or combination of these factors. Nutritional deficiency in Fe and Zn occur mainly in countries that depend on cereals as source of staple foods. This is because cereals contain phytates, which bind Fe and Zn to form insoluble salts which in turns hinder their absorption in the gastrointestinal track.

A report by the Federal Ministry of Health says 41% of Nigerian children under age five suffer stunted growth as a result of malnutrition. The survey, conducted in all the states of the federation by the ministry, shows that there is acute malnutrition among children in all the states in the North [5]. The severity of malnutrition in children is further coupled with the prevalence of malaria and parasitic infections hookworms, which increase the morbidity and mortality rates in children. Studies of essential elements in food and diets are fundamental to the reduction of malnutrition, improvement of human welfare and resistance to disease. Hence, this study seeks to determine the concentration levels of essential trace elements in rice cultivated in Nigeria and those imported to correlate their nutritive values.

2. Material And Methods

Hundred 100 g each of seven different rice cultivated in Benue State Nigeria namely Tom 1, Ofada, Osi, Suppy, Tom 2, Gisambe, Barri were purchased from rice mills and three imported rice commonly consumed were equally purchased from market namely Rising Sun, Tomato rice and Pure in order to compare elemental concentration level. The samples were stuck on 3 mm thick aluminum plates using double-sided adhesion tape and were carbon coated by vacuum carbon evaporation and then graphite was tagged on each side of the grains to ensure good passage of charge. The proton beam of energy 3 MeV and diameter 3 mm obtained from a 3 MV accelerator at the iThemba Labs in Western Cape South Africa, was used to irradiate the samples in vacuum inside a PIXE chamber. The target holder was held at 45° to the beam direction. Micro-PIXE measurements were performed using a nuclear microprobe [6]. A proton beam of 3.0 MeV energy and 200-300 pA current was focused to 3 μm × 3 μm spot and raster scanned over grasshoppers' tissues. External absorber (190 μm Kapton foil) was positioned between the PIXE Si (Li) detector and the specimen. Data were collected using XSYS data acquisition system. Further analysis was performed using GeoPIXE II software package [7]. The matrix composition and area density was obtained from analysis of corresponding proton backscattering (BS) spectra using a RUMP simulation package [2]. Generation of true, quantitative elemental maps was performed using Dynamic Analysis method.

3. Results and Discussion

The concentrations of different elements obtained in the rice are shown in Table 1. The PIXE spectrum of Ofada, Suppy and Pure are depicted in Figure 2. The application of PIXE enabled us to generate qualitative elemental maps (Figures 3–5) of the rice using dynamical analysis (DA) which showed the variation of the elements (P, Fe and Zn) in the samples. Eight elements namely P, Cl, K, Ca, Mn, Fe, Cu and Zn were identified in all the rice samples while Selenium (Se) was also identified in Ofada rice only. It was found that the concentration of elements in rice cultivated locally were significantly higher than the imported ones (Figure 1). Ofada, locally cultivated rice has the highest concentration of P and Zn, while Suppy also locally cultivated rice has the highest concentration of Fe. The lowest concentrations of P, K, Ca, Mn, Fe, Cu and Zn were consistently measured from pure, an imported rice. The lower elemental contents of imported rice might be due to excessive polishing of the imported rice. Although elemental concentrations obtained in rice in this study were lower than those reported in unpolished rice from Taiwan [11]. This suggests the effect of polishing on elemental concentrations of rice. The bioavailability of elements in the food is one of the determinants of the nutritional value of the diet. Phytic acid is key determinant of the bioavailability of elements (Fe and Zn) in the stomach.

Table 1. Elemental concentrations of rice commonly consumed in Nigeria (ppm)

Sample	**P**	**Cl**	**K**	**Ca**	**Mn**	**Fe**	**Cu**	**Zn**
Tom 1	3618.5±78	147±14	1287±15	113.5±4	8.5±1	63±3	14.5±1	12.95±1
Ofada	8805.5±221	276.5±32	3704.5±39	212±8	110.5±8	125.5±7	14.5±1	44.5±4
Osi	4074±160	138.5±27	2058.5±27	186±8	41±6	65±4	8.2±0.9	17±2
Suppy	5572±126	109±19	2041±26	221±6	35±4	141±6	54±0.6	71±4
Tom 2	3296±79	216.5±31	1611.5±24	249.5±7	36.5±2	96±4	5.7±2	19.5±2
Gisambe	3200.5±116	290.5±18	1784.5±19	163±5	27.5±3	76±2	27.5±0.9	16.5±2
Barri	4154.5±96	192.5±15	1525±22	231.5±6	66.5±3	104±1	21±1	28.5±5
Local	**4674.43**	**195.79**	**2001.71**	**196.64**	**46.5**	**95.79**	**20.77**	**29.99**
Rising Sun	4811.5±75	155±13	2238.5±8	95.5±4	24.5±2	18±1	3.5±0.9	17.5±1
Tomato	5013±103	243.5±18	2068±25	102.5±4	22±0.7	16.15±6	7±3	30±2
Pure	2862.5±150	399±22	1433±28	66±7	4.15±2	8.4±0.8	4.75±1	9.5±2
Imported	**4229**	**265.83**	**1913.33**	**88**	**16.88**	**14.18**	**5.083**	**19**

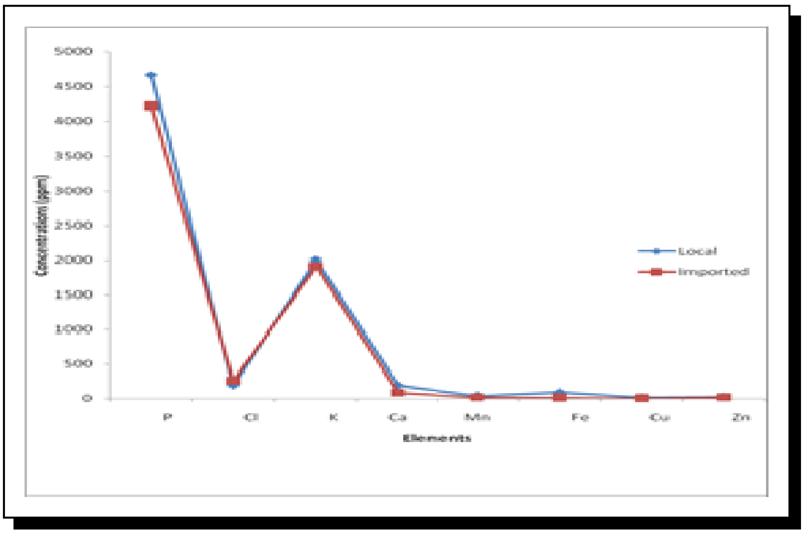

Figure 1. Variation of elemental concentration of local and imported rice

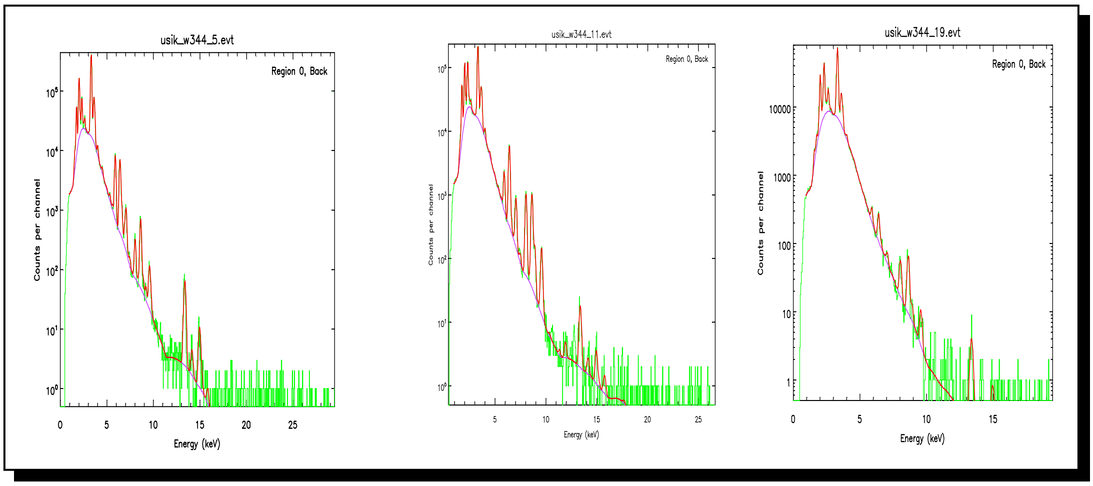

Figure 2. PIXE spectrum of Ofada, Suppy and Pure rice respectively

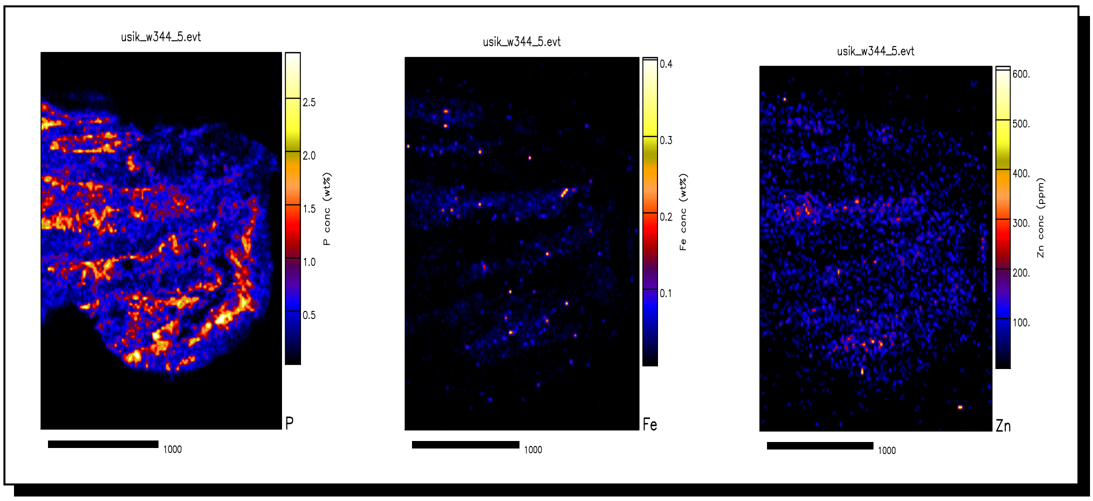

Figure 3. Elemental maps of P, Fe and Zn over the right surface of Ofada rice

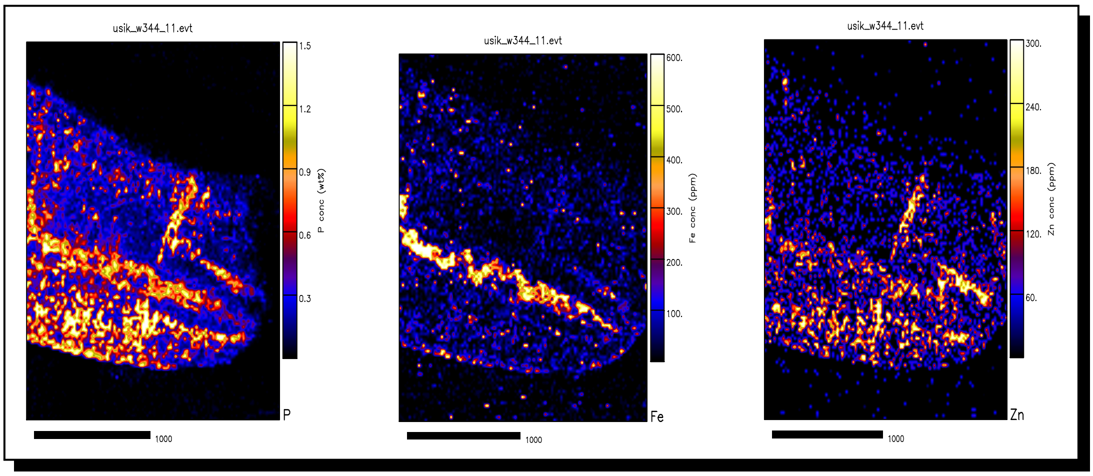

Figure 4. Elemental maps of P, Fe and Zn over the right surface of Suppy rice

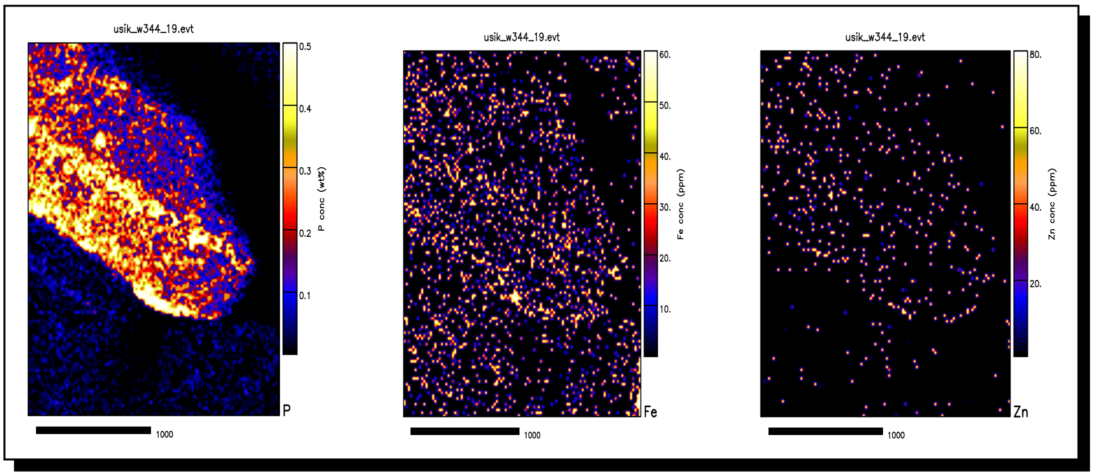

Figure 5. Elemental maps of P, Fe and Zn over the right surface of Pure rice

The average concentrations of the elements were comparable to those reported by [1] in Nigeria and [3]. P has the highest concentration in all the rice both local and imported. This indicates that the concentration of the anti nutrient compound phytic acid in the rice is equally high, which in turn implies low absorption of Fe and Zn in the stomach, that might lead to trace element malnutrition in children because rice is the main food consumed by children. The absorption of Fe and Zn could be increased if the meal is taken with animal proteins as these would prevent the elements from dissolving the phytates, but most people in Nigeria could not afford it.

4. Conclusion

Seven different types of rice cultivated locally and three imported rice in Nigeria were analyzed by PIXE and eight elements namely; P, Cl, K, Ca, Mn, Fe, Cu and Zn were identified. The elemental contents were in the range reported in the literature for rice elemental concentrations.

Ofada rice was found to have the highest concentrations of all the elements determined except for Cu. The locally cultivated rice had significantly higher concentrations of all the elements than the imported rice.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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