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Profiling of Selected Nigerian Local Rice Varieties for their Essential Trace Elements Content

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Abstract
Rice is a staple food crop which is widely grown across the continents. This study evaluates the essential trace element contents of some locally grown varieties of rice in Nigeria. Eighteen local variety from 14 rice producing states in Nigeria were obtained from popular markets. Samples were dried, homogenized and later digested using proportionate amount of HNO_3/H_2O_2. The concentrations of the three elements (Cu, Mn, Fe) were determined using Atomic Absorption Spectrophotometer. The method used was validated using a certified reference. The result showed the following ranges of concentrations: Cu (1.00 ± 0.02-5.00 ± 0.14), Fe (10.85 ± 0.50-38.40 ± 0.99), and Mn (1.95 ± 0.65-32.10 ± 0.24) mg/kg. The concentration of Cu, Fe and Mn in the studied local rice suggest their nutritional potentials as food for sourcing essential trace elements. The values of the essential trace elements were below the WHO permissible limit which indicates consumption safety. The rice from Idanre and Lafiagi have substantial content of Cu. Ofada and Ikirun rice are rich in Fe content. Substantial amount of Mn was found in Abakaliki and Efon-Alaaye rice. The studied local rice could play a beneficial role in management of mineral deficiency diseases.

Keywords: local rice; Nigeria; trace elements; essential; copper; manganese; iron; mineral deficiency

1.0 INTRODUCTION

Rice has been known to be very rich in carbohydrate and as well as other essential nutrients. Also, research findings have revealed that it contains an appreciable content of both beneficial and toxic heavy metals (Wong *et al.,* 2004). They are absorbed by plants through the atmosphere, fertilizers, pesticides and deposition of urban and industrial waste on the soil and the water (Duruibe *et al.,* 2007) used to irrigate the plants. So, when these food crops are consumed by humans, they are bound to absorb some of these heavy metals into their system (Jarup, 2003). Excess heavy metal accumulation in the environment is capable of having toxicological implication in humans, plants and other animals (Otitoju *et al.,* 2012).

Copper is an essential trace element that plays a vital role in the health of all living things. In humans, it is needed for the proper functioning of organs and metabolic processes. However, like all essential elements and nutrients, too much or too little nutritional ingestion of copper can result in a corresponding health effect. Daily dietary standards for copper have been set by various health agencies around the world. Some nations of the world have recommended various levels for copper intake by adults, pregnant, women, infants and children. (Scheiber *et al.,* 2013).

Iron is a chemical element with symbol Fe and atomic number 26. It is a member of first transition series, often refers to as the most common element on Earth and forming much of Earth's outer and inner core (Meija, 2016). Iron plays an important role in biological system, forming complexes with molecular oxygen in hemoglobin and myoglobin- major components of oxygen transport proteins in vertebrates. It also acts as an active site metal for many of the important redox enzymatic reactions dealing with cellular respiration and as well as oxidation-reduction reactions in plants and animals.

Manganese is a chemical element with symbol Mn and atomic number 25, found in a combined form either as minerals in combination with iron (Meija, 2016). Manganese (II) ions function as cofactors for a large variety of enzymes with many functions such as glucose utilization, lipid synthesis and its metabolism. It is also involved in the normal skeletal growth and activation of enzyme functions. The human system has about 10 mg of Mn which is reported to be more concentrated in the bones. Recommended dietary intake of Mn per individual with respect to age 15 is 3.3 mg/day, pregnancy is 3.0 mg/day, ages 2 - 14 (0.6 to 2.1 mg/day) while ages 19 - 50 is 2.3mg/day. Some of the side effect of high concentrations of Manganese in the body include hallucinations and nerve damage (WHO, 2001).

2. Materials and Methods

2.1 Sample collection and Pretreatment.

Eighteen different brands of locally farmed rice were sourced *from Lafiagi, Doko, Kwakuti, Kaduna, Katsina, Kano, Abakaliki, Adani, Oso-Akwa, Omor, Efon-Alaaye, Oke-Ogun, Idanre, Ofada, Ijebu Ode, Kuta, Patigi, Ikirun* in their farms. 100 grams each of the rice sample were ground using mortar and pestle. The powdered samples were sieved using 5nm mesh to remove any large debris left. The sieved samples were then kept in an air-tight container for further analysis.

2.2 Sample Pretreatment, Ashing and instrumental analysis

Large Ceramic Pestle and mortar were washed, cleaned and cleansed with concentrated Nitric Acid and then distilled water. These rice samples were homogenized thoroughly in the ceramic mortar using the pestle wide enough to accommodate the minute components of the rice mixture. The process was continued until a homogeneous blend was obtained and transferred to oven, in previously cleaned porcelain crucibles. The samples were dried and grinded into fine powder in titanium blade grinding machine. The fine powder of 100g was the average dried sample obtained. This was then kept separately in polyethylene bags, sealed, labeled and kept until further analysis.

Ground rice sample, 1g, was put in a crucible and heated on a hot plate at about 80^{o}C. The ash obtained thereafter was diluted with 2.5cm^{3}of HNO_3 and 5cm^3 hydrogen Peroxide. The digestion continued until a clear solution was obtained to signify a complete digestion. After cooling, the digested sample were filtered and diluted to 50cm^3 with distilled water into a 100cm^3 volumetric flask which was then transferred into a sample bottle for further analysis. Bulk Scientific Atomic absorption spectroscopy (AAS); *Model:* Accusys 211; *Manufacturer*: USA determined Copper, Iron and Manganese content of the samples.

2.2 Statistical Analysis

Collected data were subjected to one-way analysis of variance (ANOVA) for comparison using the SPSS software (Version 15, SPSS Inc, Chicago, USA). Results were expressed as mean ± SD and variations were considered significant when $P < 0.05$.

3. RESULTS AND DISCUSSION

The concentrations of essential trace elements in Nigerian local rice are presented in Table 1. The copper level in rice samples ranges from 1.00 ± 0.02 - 5.00 ± 0.14 while that of iron ranges from 10.85 ± 0.50 -38.40 ± 0.99 mg/kg. Manganese concentration ranges from 1.95 ± 0.65-32.10 ± 0.24 (mg/kg).

Table 1: Copper, Iron, Manganese concentration of the local rice samples

Sample	Identity	State	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)
S_1	Lafiagi	Kwara	4.85±0.10	19.50±0.39	2.65±0.05
S_2	Doko	Niger	2.35±0.08	13.35±0.46	3.90±0.14
S_3	kwakuti	Niger	1.80±0.01	18.85±0.11	2.85±0.02
S_4	Kaduna	Kaduna	1.30±0.01	23.60±0.27	18.79±0.06
S_5	Katsina	Katsina	4.70±0.11	26.30±0.27	16.45±0.05
S_6	Kano	Kano	1.25±0.03	16.05±0.32	1.95±0.65
S_7	abakaliki	Ebonyi	2.40±0.11	10.85±0.50	32.10±0.24
S_8	Adani	Enugu	2.20±0.10	20.25±0.82	5.25±0.13
S_9	Oso akwa	Anambra	1.80±0.10	21.95±1.14	3.60±0.19
S_{10}	Omor	Anambra	1.00±0.02	24.20±0.66	3.20±0.07
S_{11}	Efon-Alaaye	Ekiti	4.20±0.09	26.90±0.66	24.30±0.51
S_{12}	Oke-Ogun	Oyo	4.40±0.14	24.60±0.80	8.00±0.52
S_{13}	Idanre	Ondo	5.00±0.14	20.50±0.60	6.90±0.20
S_{14}	Ofada	Ogun	3.90±0.11	34.60±1.02	6.80±0.20
S_{15}	Ijebu Ode	Ogun	3.40±1.10	27.40±8.96	6.80±2.20
S_{16}	Kuta	Niger	2 .20±0.04	17.75±0.16	10.60±0.1
S_{17}	Patigi	Kwara	1.80±0.10	23.25±1.21	3.90±0.20
S_{18}	Ikirun	Osun	3.90±0.10	38.40±0.10	5.70±0.13
	RDA daily range		0.54-1.0mg	8.00-30.00mg	1.80-2.30mg
	RDA Tolerable daily Limit		10mg	45mg	11mg

Mean ±SD
**Malaysian
RDA = Recommended Dietary Allowance (μg/day), N/A = No data Dietary Guidelines available, UL = Tolerable Upper Intake Level (2010)

3.1 Copper

The rice samples from *Idanre* and Lafiagi have the highest value of copper. The concentration of *Idanre* rice (5.00±0.14) was significantly higher than all other rice samples from other locations while that of *Omor* was significantly lower than all other locations. *Katsina* was significantly higher than *Ijebu-Ode* rice but was statistically comparable to those of *Osun, Ofada* and *Efon-Alaaye*. This is attributed to difference in the specie of the samples under consideration; total content of soil trace elements, soil chemical and physical properties; which affect bioavailability of trace elements in plants (Cheng *et al,* 2011).

In decreasing order, the concentration of copper in the rice from the selected areas are *Idanre > Lafiagi > Katsina > Oke-Ogun > Efon-Alaaye > Ofada > Ikirun > Ijebu-Ode> Abakaliki > Doko > Kuta > Adani > Oso-Akwa > Kwakuti >Patigi > Kano > Kaduna > Omor*. When an individual of 60kg weight consumes about 200g of rice daily. The individual is bound to absorb 0.97 ,0.47, 0.36, 0.26, 0.94, 0.25, 0.48, 0.44, 0.36, 0.2, 0.84, 0.80, 1, 0.78, 0.68, 0.44, 0.36 and 0.78 mg/day of copper concentration of samples; S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17} and S_{18} respectively. These copper concentrations (mg/day) by an individual are within the Recommended Dietary Allowance limit of (0.54-1.00) mg/day. Comparing the results of this work with similar studies, a work carried out on locally produced rice in Thailand (Wannee *et al*, 2018) showed that the estimated daily intake of copper content of the rice samples was (0.18-0.37) mg/day and was lower than the estimated daily intake of Copper content (0.20-1.00) mg/day.

3.2 Iron

The highest amount of Iron is gotten from *Ikirun* rice and *Ofada* rice. The concentration of rice from *Ikirun* (38.40±0.99) was significantly higher than all other rice samples from other locations while that of *Abakaliki* was significantly lower (10.85±0.50) than all other locations. *Oke-Ogun* was significantly higher than *Enugu, Kaduna, Patigi, Oso-Akwa, Idanre, Adani, Lafigi, Kwakuti* rice but was statistically comparable to those of *Katsina, Ekiti, Ijebu-Ode.* This is attributed to anthropogenic activities such as the use of phosphate fertilizers, industrial activities and deposition of contaminated particles (Yuanan *et al*, 2013). In decreasing order, the concentration of Iron in the rice from the selected area was *Osun > Ofada > Ijebu Ode > Efon-Alaaye > Katsina > Oke-Ogun > Omor > Kaduna> Patigi > Oso Akwa > Idanre > Adani> Lafiagi> Kwakuti > Kuta > Kano > Doko > Abakaliki.* When an individual of 60kg weight consumes about 200g of rice daily. The individual is bound to absorb 3.9 ,2.67, 3.77, 4.72, 5.26, 3.21, 2.17, 4.05, 4.39, 4.84, 5.38, 4.92, 4.10, 6.92, 5.48, 3.55, 4.65 and 7.38 mg/day of iron concentration of samples S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17} and S_{18} respectively. The Recommended Dietary Allowance of iron in this study ranges from (2.17-7.38) mg/day and it's below the Recommended Dietary Allowance (8.00-30.00) mg/day, this shows that the rice samples will be able to prevent many iron deficiencies like anemia especially in women of childbearing age, pregnant women and teenage girls because they are at greatest risk of developing iron deficiency.

3.3 Manganese

Abakaliki and Efon-Alaaye rice have the highest amount of Manganese. The concentration of manganese in the rice from *Abakaliki* (32.10±0.24) was significantly higher than all other rice samples from other locations while that of *Kano* was significantly lower (1.95±0.65) than all other locations. *Idanre* was significantly higher than *Abakaliki, Kaduna, and Doko* rice but was statistically comparable to those of *Ofada, Ijebu Ode, Idanre.* This may be due to difference in the specie of the samples under consideration; total content of soil essential elements, soil chemical and physical properties; which affect bioavailability of essential element in plants (Cheng *et al,* 2011).

In decreasing order, the concentration of Iron in the rice from the selected area was *Kano > Efon-Alaaye > Kuta > Oke-Ogun > Idanre > Ijebu- Ode > Ofada > Ikirun > Abakaliki > Kaduna > Doko > Patigi > Oso-Akwa> Omor > Adani > Kwakuti > Lafiagi> Katsina*. When an individual of 60kg weight consumes about 200g of rice daily. The individual is bound to absorb 0.53, 0.78, 0.57, 3.76, 3.29, 0.39, 6.42, 1.05, 0.72, 0.64, 4.86, 1.60, 1.38, 1.36, 1.36, 2.12, 0.78, and 1.14 mg/day of copper concentration of samples; S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15}, S_{16}, S_{17} and S_{18} respectively. The manganese concentrations of S_4, S_5, S_7, S_{11}, are above RDA while S_1, S_2, S_3, S_6, S_8, S_9, S_{10}, S_{12}, S_{13}, S_{14}, S_{16}, S_{17}, S_{18} (mg/day) are below and within the limit of Recommended Dietary Allowance (1.8-2.3) mg/day. Comparing the results of this work with similar studies, a work carried out on locally produced rice in Thailand (Wannee *et al*, 2018) showed that the estimated daily intake of manganese (Mn) content of the rice samples was (2.94-3.75) mg/day and was lower than the estimated daily intake of manganese (Mn) content from the present study (1.95 ± 0.65-32.10 ± 0.24) mg/kg.

4. CONCLUSION

It is important to mention that trace elements in rice are paramount in maintaining a good healthy living, judging by the optimum level of copper, iron and manganese. This study has shown that rice samples such *Idanre, Lafiagi, Ofada, Ikirun Abakaliki, Efon-Alaaye* rice are very valuable due to their rich content in the studied elements. The concentrations of these essential trace elements are below the recommended dietary allowance which signifies that they are not toxic and are safe for consumption.

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