EVALUATION OF CHEMICAL AND HEAVY METAL CONCENTRATIONS IN MAIZE (*Zea mays*) FROM INDUSTRIAL AREA OF OGUN STATE, NIGERIA

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Abstract
Consumption of maize is significant and cut across all economic class in Nigeria especially at its season. The chemical and heavy metal concentrations of maize cultivated in industrial area of Ogun State Nigeria were evaluated for two seasons 2010 and 2011. The metal concentrations Fe, Cu, Mg, Zn, Pb, and As were determined using Atomic Absorption Spectrophotometer (AAS). The results of the chemical analysis and minerals Fe, Cu, Zn, and Mg for the two seasons were comparable and related. The Fe, Cu, and Zn concentrations for the two seasons were above the recommended safe limit for consumption by WHO. The level of Pb and As detected in 2010 rainy season were low and should result in no acute toxicities of the metal while the levels detected for 2011 season were high and raised public concern and warning in order to reduce adverse toxic effect of these metals. The study was carried out to sound a note of warning of the extent of industrial heavy metals pollution and its effect on plants especially maize harvest from the industrial estates in Ogun State Nigeria.
Keywords: Maize, Heavy metal, Chemical Composition, Raining Season and Pollution.

INTRODUCTION

Maize is the third most important crop in the World after wheat and rice. In Nigeria, it also takes third place behind sorghum and millet (Adebayo et al., 2009). Worldwide production of maize is 785 million tonnes with the Africa producing 6.5% and the largest African producer is Nigeria with nearly 8 million tonnes (IITA, 2009). Most maize production in Nigeria is rain fed and 95% of total maize production is consumed locally compared to the World regions that use most of its maize as animal feed. This is evident in Nigerian meal as consumption of maize cut across all economy class especially at its seasons as either boiled or roasted. Nutritionally, it has high content of carbohydrates, fats, proteins, and some of the important vitamins and minerals, the product has acquired a well deserved reputation as a poor man's nutricereal (Punita, 2006).

However, with the current emphasis on eating more healthy diets and public concerns on presence of metals in foods/agricultural produce, it is very essential to assess to the chemical composition and heavy metal concentration in maize that is popularly consumed by people. The presence of essential metals like iron, copper, zinc, magnesium are associated with enzyme systems particularly those involved in oxidation process and other important biochemical process (Akaninwor et al.,2006). They are very useful for the healthy growth of the body though very high levels are intolerable. Metals like mercury, lead, cadmium and arsenic are toxic at very low concentrations (Nkansah and Amoako, 2010). They have the potential hazardous effect, not only on compounds but human health. This is due to their cumulative behaviour and toxicity although they are generally present in agricultural soils at low levels. Increasing industrialisation has been accompanied throughout the world by the extraction and distribution of mineral substances from their natural deposits. Following concentration, many of these have undergone chemical changes through technological processes and finally pass, finely dispersed and in solutions by way of effluent, sewage, dumps and dust, into the water, the earth and the air and thus into the food chain. These include metals and thus also the heavy metals relevant for this document (IOCCC, 1996). There are large scale industries in Ogun State Nigeria, both privately and publicly owned. These include cement, pharmaceuticals, paint, ceramics, roofing sheets, agro allied, beverages and so on. These are partly as a result of raw material availability or nearness to market (Lagos).

The auditing and monitoring of metals in the environment (soil, water and foods) is fast becoming an essential aspect of pollution studies, particularly in industrialised area. The main objective of this study was to determine nutrient composition and content of some heavy metals (Cu, Fe, Zn, Pb, and As) in maize cultivated in industrial area of Ogun State Nigeria.

MATERIALS AND METHODS

Matured maize cobs were harvested fresh from farm lands in various industrial area of Ogun State Nigeria. The maize cobs were shelled manually and cleaned. The samples were dried at 100°C for twelve hours using an oven and grounded into powder using mortal and pestle. The chemical analysis (proximate) moisture, protein, ether extract, and ash were estimated using the method of AOAC, 2000. The carbohydrate content was estimated by difference. The metabolizable energy (kcal/100g) was determined using Atwater general conversion system as described by FAO (2002).

For the determination of metal concentrations, wet digestion of the dried samples were done as described by Akaninwor et al, 2006 using undiluted concentrated H_2SO_4 and $HClO_4$ at ratio 1:1. To a 2 gram of dry sample, 10 ml of H_2SO_4 and $HClO_4$ were added and digested on FOSS TECATOR digestor model 210 at 250°C for 1 hour at the first instance and continued until a clear solution was obtained. The clear solution was filtered into a 100 ml volumetric flask and completed to the mark with de-ionised water. De-ionised water was used as a blank to zero the equipment for the analysis. Atomic Absorption Spectrophotometer Buck Scientific Model 210A was used for the analysis of metals. Standards for each element under investigation was prepared in part per million (ppm) and the limit standard concentration for each element was adhered to according to the BUCK Scientific instruction and used for the calibration. Air/acetylene flame was used, the standard solutions were aspirated and the graph obtained. The concentrations of various metals in the samples were done against metal standard solutions.

RESULT AND DISCUSSION

The results of the chemical and metal concentration are presented. The proximate composition and metal concentration of the maize for 2010 and 2011 rainy seasons were shown in table 1-4.

Table 1: Result of Chemical Composition of Maize from Industrial Area of Ogun State in 2010 Raining Season

	Moisture,%	Protein,%	Ether Extract, %	Ash,%	Carbohydrate,%	Metabolizable Energy, kcal/100g
Sango	41.7	8.01	1.83	1.04	47.43	238.23
Ota Ind. Est.	43.06	12.88	1.42	2.23	40.41	225.94
Papa	36.45	9.02	2.65	1.09	50.8	263.13
Ewekoro	48.1	13.08	1.35	1.1	36.37	209.95
Agbara Ind.Est.	44.23	9.11	2.87	1.2	42.59	232.63
Atan	41.65	9.95	1.97	1.42	45.03	237.65
Ijebu Ode	39.75	8.78	2.28	1.42	47.77	246.72
Abeokuta	40.12	8.64	3.9	1.56	45.7	252.46
Ibeshe(Ilaro)	33.5	9.54	2.03	2.01	52.92	268.11
Sagamu	45.36	8.46	1.81	1.06	43.31	223.37

Table 2: Result of Chemical Composition of Maize from Industrial Area of Ogun State in 2011 Raining Season

	Moisture,%	Protein,%	Ether Extract, %	Ash,%	Carbohydrate,%	Metabolizable Energy, kcal/100g
Sango	44.36	9.08	1.05	1.97	43.54	219.93
Ota Ind. Est.	46.33	11.83	2.14	1.68	38.02	212.96
Papa	44.16	12.06	2.-02	1.92	39.84	219.8
Ewekoro	55.25	12.68	2.62	3.06	25.01	173.03
Agbara Ind.Est.	39.87	8.31	2.26	2.16	47.4	236.07
Atan	35.44	8.67	3.02	1.25	51.62	260.62
Ijebu Ode	39.23	10.89	1.89	1.78	46.21	238.48
Abeokuta	41.69	9.58	2.42	1.57	44.74	232.35

Ibeshe(Ilaro)	54.83	8.26	1.64	1.88	33.99	173.24
Sagamu	60.35	12.31	1.43	2.57	23.41	152.19

Table 3: Concentration of Metals in the maize in 2010 Rainy Season

	Fe,ppm	Cu,ppm	Zn,ppm	Mg,ppm	Pb,ppm	As,ppm
Sango	45	15	53	178	1.58	0.01
Ota Ind. Est.	53	24	46	134	0.09	ND
Papa	21	35	25	145	1.93	0.03
Ewekoro	48	13.2	29	139	0.86	2.1
Agbara Ind.Est.	40	28	23	179	2.16	0.3
Atan	48	31	40	179.7	3.41	0.05
Ijebu Ode	42	19	21	203	0.02	ND
Abeokuta	39	12	18	163.9	0.01	0.28
Ibeshe(Ilaro)	48	18	18	180.3	5.6	1.06
Sagamu	3	10	42	152.6	0.32	ND

Note: ND means Not Detected

Table 4: Concentration of Metals in the maize in 2011 Rainy Season

	Fe,ppm	Cu,ppm	Zn,ppm	Mg,ppm	Pb,ppm	As,ppm
Sango	41	20	38	371	1.48	0.22
Ota Ind. Est.	34	13	47.5	362.5	9.2	0.06
Papa	98	10	52.5	357.5	2.5	0.12
Ewekoro	104	3.5	25	358.5	24.i3	0.06
Agbara Ind.Est.	60	0	36.5	360	0.21	1.86
Atan	36	3	3	350	14.5	ND
Ijebu Ode	67	2	47	365.5	0.8	0.04

Abeokuta	26	8	33	352.5	ND	ND
Ibeshe(Ilaro)	2.5	3.5	50.5	352	15.52	ND
Sagamu	54	16	36	356.5	16.5	0.01

ND means not detected

The proximate composition ranged between 8.01-13.08 % crude proteins, 1.35-3.90 % ether extract, 1.64-2.23 % ash, 33.50-48.10 % moisture, 36.37-52.92 % carbohydrate for 2010 while the proximate for 2011 are 35.44-60.35 % moisture, 8.31-12.68 % crude protein, 1.05-3.02 % ether extract, 1.25-3.06 % ash, 23.41-51.62 % carbohydrate. The results of the proximate analysis for the two seasons are comparable and related. Maize is reported to have considerable high content of carbohydrates, fats, proteins (Punita, 2006). The chemical composition is related to the findings of Ibrahim and Halla, 2007 but the carbohydrate is higher than the present finding. This might be as a result of high moisture content since the maize was rain fed. It is estimated that several million people, particularly in the developing countries derive their protein and calorie (11.1g and 342 kcal/day) requirement from maize (Gopalan et al., 1997). The weather, geographical location, crop variety, type of soil, farm system practices and environmental conditions could be responsible for the slight variation in chemical compositions recorded for the two consecutive seasons

Table 3 and 4 revealed the concentration of metals consecutively. Fe, Cu, Mg, and Zn are regarded as essential metals and Pb and As are known as heavy metals. The minimum and maximum concentration of metals Fe, Cu, Zn, Mg, Pb, and As in mg/kg are 3.0-53, 10-35,18-53, 134-203, 0.01-5.60 and 0-2.10 in the first season while the concentration for the second season ranged between 2.50-104, 0-20, 3-52.50, 350-371,0-24.13, and 0-1.86 respectively. It has been seen that the concentrations of essential metals for the two seasons are related except Mg. The concentration of copper in maize is below the recommended safe limit of WHO/FAO Codex alimentary commission (1984) of 40.00 mg/kg but some are above the maximum safe level given by Standard Organisation of Nigeria (SON) (20mg/kg) while FAO documented 0.02ppm as safe limit (Anjula and Sangeeta, 2011). The Recommended Dietary Allowance (RDA) for copper is given as between 0.9-2.0 (Alasalvar et al., 2009).

Zinc is a ubiquitous essential trace element necessary for normal growth of animals and is present in a host enzyme in the human body and foods vary in their Zinc content. The range of Zn for the two seasons are 18-53 and 3.0-52.5 mg/kg respectively. The concentration of Zn reported by Bressani et al., 1989 (4.6 ± 1.2) for maize is lower compared to most of the result obtained for this work. The Recommended Dietary Allowance for Zn is 11 mg. The WHO/FAO safe level for Zn is put at 0.06 mg/kg. Nkansah and Amoako, 2010 reported 100 mg/kg as WHO limit for spices. Unsafe levels of Zn can lead to respiratory system damage, stress and inhibition of normal growth and maturation (Weatherley et al., 1988). 1.5 ppm is recorded as dangerous to the health of pregnant woman. WHO and UNICEF (2004) in a joint statement proposed to use Zn supplement as a therapy to reduce the severity of diarrhoea.

The safety limit of iron is high as coated by Nkansah and Amoako, 2010 (300mg/kg). The Recommended Dietary Allowance for Fe is in the range of 8-15 mg. High concentration of Fe can pose risk to the consumer. The iron concentration documented for the duo seasons are related and comparable except in few cases i.e Ewekoro where 104 ppm was recorded. Fe is a common element in humans and plants.

They usually occur in plants in form of phytate or ferric hydroxides. Thus. Iron has a relatively high WHO levels in food. Deleterious effects of daily intakes between 25 and 75 mg are unlikely in healthy persons (Ozkutlu et al., 2011). Excess Fe is toxic and has been reported to inhibit the absorption of Zn (Solomons and Ruz, 1997) and the people are prone to increase adverse effect and death due to malaria and communicable diseases (Najat, 2008).

Magnesium is the most abundant of all the metals examined. There was a significant difference between the concentrations of Mg recorded for the two seasons. The highest levels of Mg were obtained in the 2011 season. Farm practice methods, variety of the species of maize cultivated, soil type and other forms of human activities such as air pollution might be the cause. The lead accumulation in the maize (2010) is found to be lower and almost in the limits of WHO/FAO (1984), 5ppm but exceeded the maximum limit of 1ppm recommended by Standard Organisation of Nigeria (SON). High lead concentration (9.20, 14.50, 15.52, 16.50, and 24.0) obtained in some area in 2011 season could be deleterious to health. The concentration recorded in 2011 in some area was at high side compared to the former. Lead has no known essential function in human and is a well known metal that damages the liver, kidneys, brain, central nervous and reproductive systems of man (Lovei and Ley, 2000). Heavy metals pollution can originate from natural and anthropogenic sources. Activities such as mining and smelting operation, agriculture and industrial waste have contaminated extensive area of the World such as Japan, Indonesia, and Chjna (Harawati et al., 2000). Heavy metals have been found in most cases abundant in the soil and relatively small portion in the atmosphere at particular vapours. Metal toxicity to plants varies with plant species, specific metals, concentrations, chemical form, soil composition, and pH (Mukesh et al., 2008). According to the Agency for Toxic Substances and Disease Registry (USA) has identify fruits and grains as major mean of exposure of lead to the general populace (McNamara, 2008).

Arsenic is another heavy metal which is toxic to the body as a result of accumulation. The highest As content was found in Ewekoro (2010), Agbara Industrial Estate (2011) and Ibeshe (2011) (2.1, 1.86, and 1.06 mg/kg) respectively. Some of the concentration of As were below detection level. The recommended safe intake of As is 15-25 µg/day (adults) and 2-25 µg/day for children (Mukesh et al., 2008).

CONCLUSION

Maize maintained its position as an important nutricereal with is nutrient profile. It revealed considerableprotein content, high carbohydrate and metabolizable energy for sustainability and stability. The proximate compositions for the two seasons considered are related. Consumption of maize with elevated levels of essential and non essential metals can lead to the accumulation of the metals in the body and result to health disorder. Most of the concentration levels documented are beyond Recommended Daily Allowance (RDA) Fe (8-15 mg/D), Zn (11 mg/D), cu (0.9-2.0 mg/D), Pb (20 µg/D). Provisional Tolerable Weekly Intake for As is 0.015 ppm (WHO, 2003).

Heavy metal concentration (Pb, As) varied between the seasons investigated, which reflect the differences in their mineral uptake and or effect of environmental/ soil pollution. Industralsation and their pollution effects might have been responsible for high heavy metals recorded in some areas such as Ota Industrial Estate. High levels of metals above safe limit in staple food like maize called for public concern and this revealed the importance of regular monitoring of heavy metals in staple foods grown in industrial areas to avert health risks related to excessive mineral ingestion. Appropriate regulatory body should ensure proper filteration or treatment of industrial emission to avoid hazards which characterise environmental pollution.

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