Research Article

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Assessment of Metals Contamination Levels In Wheat, Maize and Beans Processed With Four Different Grinding Tools Using XRF

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Abstract

The levels of some metals contaminants in wheat, maize and beans processed with four different grinding tools namely; hand grinder (HG), wooden mortar (WM), grinding stone (GS) and domestic blender (DB) were investigated. The grains were purchased from a municipal market in Port Harcourt and analyzed for Cr, Fe, Mn, Co, Ni, Cu, Zn,Pb, Cd, Si and Al using X-ray fluorescence (XRF). The results obtained showed that samples ground with grinding stone had the highest concentrations of most of the metals followed by the hand grinder in the order of grinding stone >hand grinder> wooden mortar > domestic blender. Out of the nine metals and two metalloids investigated Co, Cd and Pb were below detection levels. However, Co was detected in beans only. Si was detected only in samples ground with grinding stone. V, Mo, W, Sn and Sb were found to be present in these samples and their concentrations were high in all three grains processed using the four tools. These high concentrations of Sn and Sb are a source of concern.XRF technique has been successfully employed in the evaluation of the concentrations of some metals and metalloids in wheat, maize and beans.

Keywords: Contaminants, XRF, Concentrations, Grinding Stone, Wheat, Maize, Beans

Introduction

Modern food processing method involves a lot of operations; this operation includes harvesting, cleaning, sorting, grading of foods and screening of solids and preservation of foods. In the past, grinding of food was done using stones, bricks, mortar and pestle [1].The traditional methods were effective, but very slow, time consuming and unhygienic.New technologies were developed as the needs of people increased and modern grinding methods were introduced to replace the traditional methods. These are blenders, mills and crushers. During food processing heavy metals are introduced into the food stuff. The contaminants can be introduced into the food sample as a result of the grinding tools or processing tools used. Food processing for human consumption is very vital and important as the food itself. During food processing toxic materials or elements such as, Pb Al, Hg, Cd,etc are introduced into the matrix of the food materials. The degrees of contamination that result from these equipments have detrimental effect on human health. The tools rub each other and toxic metals are introduced into the food samples. The constituent elements found in some of the guiding tools are, Cd, Cr, Cu, Fe, Ni and Zn [2].

Furthermore, the consumption of heavy metals contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psychosocial behaviors, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer [3].Contamination of food by heavy metals is a major threat to public health, as food is the primary source of essential nutrients to man [4]. Monitoring the presence of heavy metals in foods for humans is of interest because of their toxic effects, as heavy metals bio-accumulate and poses serious risk to human health [5].The main threats to human health from heavy metals are associated with exposure to Pb, Cd, Hg, and As. These metals have been extensively studied and their effects on human health regularly reviewed by international bodies such as WHO [6]. Although adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas [7]. Some of these heavy metals such as Cu, Fe, Mn, Mo, Ni, and Co are micro nutrients and are only toxic when taken in excess of requirement [8, 9]. Food safety is a major public health concern and its demand by consumers worldwide has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by heavy metals. A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals [10].

A large number of techniques have been developed throughout history to improve the safely, nutritional value and functional properties of food.It has been discovered that food contamination by heavy metals includes techniques and materials used in food processing and transformation [11,12].The food processing methods involves lots of operations which include grinding of food materials [1]. From literature, the grinding tools used for this study have

different chemical compositions. The hand grinder (HG) is mostly made from iron scraps. Other elements such as Ni, Zn, Cd, Cr and Cu are also present [2]. The grinding stone (GS) which is an igneous rock contains feldspar and magnetite composed of Na, K, Fe and some other metals. The blades of the domestic blender (DB) are made from stainless steel which is an alloy of Fe, C,Cr, Ni and other metals [13]. Co-W combination is used to make cutting and grinding tools as well as dies in the milling and drilling industries [14]. The wooden mortar (WM) and its pestle are made from hard wood. The typical composition of wood varies from species to species but is approximately 50% C, 42% O, 6% H, 1% N and 1% other elements; mainly Ca, K, Na, Mg, Fe and Mn by weight [15].

Most of the studies carried out on food milled with different grinding methods and tools have been analyzed using atomic absorption spectroscopy (AAS) [1,10,16-18] and instrumental neutron activation analyses (INAA)[19]. Studies by [20] have shown that field portable X-ray florescence (FPXRF) is a powerful tool in screening major metal and metalloid contaminants. This study is therefore focused on the use of XRF to measure the concentrations of some metals in wheat, maize and beans processed with hand grinder (HG), grinding stone (GS), wooden mortar (WM) and domestic blender (DB).

Materials and Methods

Sample Collection

Fresh samples of wheat, maize and beans were purchased from one of the municipal markets in the capital city of Rivers State, Nigeria.

Samples Preparation

Ten grams of wheat, maize and beans were each poured on clean Whatmanfilter paper (24cm diameter) and carefully selected by removing stones and other impurities before grinding with hand grinder, grinding stone, wooden mortar and domestic blender. The three grains were ground into fine powder which was used for XRF analyses.

XRF Analysis

In XRF analysis, the energy of each X-ray detected identifies a particular element present in the sample and the rate at which x-rays of a given energy are counted provides a determination of the quantity of that element in the sample [20]. Quantitativeanalyses were carried out on the samples without acid digestion in the Department of Materials Science and Engineering, Kwara State University, Malete, using an XRF instrument by Jiangsu Skyray Instrument Co. Ltd. Jaingsu Province china.

Results and Discussion

In Tables 1 (a) and (b) are presented XRF results for wheat ground with the four different tools. Out of the nine metals and two metalloids studied, Co, Cd and Pb were not detected. Si was not found in the samples ground with HG, WM and DB. Other metals not included in the study but detected were the trace metals (K, Ca and Mg) and the heavy metals, V, Mo, Sn, Sband W. From the results, the highest concentrations of Al, Si, Cr and Fe were obtained from wheat samples ground with GS. This could be attributed to attrition. Results from other studies [16, 17, 21] show high concentrations of metals due to attrition and this are in agreement with the results obtained in this work. Samples ground with the Wooden mortar (WM) had the highest concentration for Mn, Cu, Zn, Mo, W and V while the results from DB samples had Sb as the only metal with the highest concentrations. Samples ground withhand grinder (HG) had the least concentrations for Al, Cr, Mo, Cu Fe, Zn and V. For the trace elements, the highest concentrations for K, Ca and Mg were obtained from the grinding stone. The trend for the grinding tools is GS>HG>WM>DB.

Table 1(a): XRF values for metals in wheat (mg/kg)

Tools	Al	Si	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb	V	Mo	Sn	Sb	W
HG	333	-	20	256	600	-	999	275	1981	_	_	36	1321	12901	9658	2851
WM	451	_	33	432	2548	_	921	3324	2201	_	_	75	1750	10688	8880	2758
GS	1124	643	40	426	13360	_	823	2155	2155	_	_	68	1409	10317	8585	2050
DB	408	_	33	390	1940	_	971	2861	2054	_	_	65	1236	10899	9692	2508

Table 1(b): XRF values for trace metals in wheat (mg/kg)

Tools	K	Mg	Ca
HG	7043	456	750
WM	11058	1078	1140
GS	16302	1294	61375
DB	14105	831	935

HG = Hand Grinder, WM = Wooden Mortar, GS = Grinding Stone, DB = Domestic Blender.

Results for maize are presented in Tables 2(a) and (b). Co, Cd and Pb were not detected in the samples ground with the four different tools. Si was not found in the samples ground with HG, WM and DB. Samples ground with the grinding stone (GS) had the highest concentration of Al, Si, Cr, Mn and Fe. Samples ground with DB and HG had some high levels of Ni and Zn concentrations while samples from DB had the highest concentrations for Cu, Mo and V. The least values for Mn and V were obtained from samples ground with HG.Samples ground with wooden mortar had the least values for Al and Fe and the highest concentrations for Sb and W.The values obtained for K, Ca and Mgshowed that the samples ground with GS had the highest values.The order of concentrations of these trace metals in maize using these tools is of the order of GS> HG>DB >WM. This trend is in agreement with results obtained by [1,10,21].Pounding with wooden mortar and pestle introduced minimum amount of Pb and Cd according to [22]. However, from this study, these metals were not found in the samples.

Table 2(a): XRF values for metals in maize (mg/kg)

Tools	Al	Si	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb	V	Mo	Sn	Sb	W
HG	644	-	38	24	6410	-	951	2309	2216	_	_	45	1326	22743	9070	2132
WM	431	_	34	45	1511	_	933	2474	2102	_	_	47	1634	10965	9467	2322
GS	993	811	45	268	20994	_	731	1624	1906	_	_	60	1760	9164	8560	1061
DB	716	_	26	84	1540	_	996	3235	2239	_	_	67	2242	10756	8964	2147

Table 2(b): XRF values for trace metals in maize (mg/kg)

Tools	K	Mg	Ca
HG	14486	1372	734
WM	11744	505	489
GS	15256	1440	12689
DB	13602	145	590

Results obtained for beans samples ground with the four different tools are presented in Table 3(a) and (b). Cd and Pb were not detected. Si was also not detected in the samples ground with HG, WM and DB. Other heavy metals that were detected were V, Mo, Sn, Sb and W. Similar to the results obtained for wheat and maize, beans ground with GS had the highest concentrations for Al, Si, Mn and Co. The highest concentration for Cr, Fe and Niwere obtained with HG. The very high concentration recorded for Fe from this milling tool could be attributed to attrition of the grinding discs. Samples ground with wooden mortar (WM) had the highest concentrations of Cu and Zn only, while the highest concentrations of Mo and W were obtained using the DB. The highest values for K, Ca and Mg were obtained from samples ground with GS.The trend is GS >HG> DB = MP.

Table 3(a): XRF values for metals in beans (mg/kg)

Tools	Al	Si	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb	V	Mo	Sn	Sb	W
HG	973	-	97	206	29157	47	1005	898	2293	-	-	71	1552	17998	10387	2723
WM	1317	-	25	151	1993	16	832	2449	2496	-	-	65	1501	10184	8743	2730
GS	1927	447	14	203	9221	54	934	1795	2366	-	-	97	1350	9390	7887	1350
DB	1050	-	29	119	1779	22	951	2059	2337	-	-	36	2089	11257	9280	2977

Table 3(b): XRF values for trace metals in beans (mg/kg)

Tools	K	Mg	Ca
HG	28791	315	1583
WM	33776	883	2464
GS	43902	2232	57755
DB	30995	-	2237

Conclusion

XRF technique has been successfully employed in the evaluation of the concentrations of some metals and metalloidsin wheat, maize and beans. From the result obtained in this study, GS had the highest concentrations of most of the metals. Out of the metals investigated, Co, Cd and Pb were not detected. Si was not detected in the samples ground with hand grinder (HG), wooden mortar (WM) and domestic blender (DB) except in the samples ground with grinding stones (GS).The concentration of the metals is of the order of Fe> Zn> Cu> Ni> Al> Si>Mn> Cr> Co.Other heavy metals not included in the study but were detected wereV, Mo, Sn, Sb and W and the trend in concentration is Sn>Sb> W> Mo> V. The trace metals K, Ca and Mg were also found to be present in the wheat, maize and beans samples. The concentration of the metals is of the order of Ca> K> Mg.

Samples processed using the GS and HG had the highest concentration for Fe, Al Cr and Mn. Samples ground with WM and DB had high values for Ni and Cu.Results from all four methods for Zn concentrations are consistent.Concentrations of W in the three grains were high. These concentrations are not acceptable as Cobalt-Tungsten Carbide (in powder or hard metal form) is one of the six substances that have been added as being anticipated to be a human carcinogen. Sn and Sb concentrations were found to be high in all three grains processed using the four tools. These high concentrations of Sn and Sb are a source of concern. Interaction with the traders revealed that these grains were cultivated in Jos, Plateau State and transported to Port Harcourt. It is therefore possible that these two metals might be coming from the soil as reported in other findings and not from the tools of processing.

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