International Journal of Biochemistry Research & Review
12(1): 1-7, 2016, Article no.IJBCRR.21681
ISSN: 2231-086X, NLM ID: 101654445

SCIENCEDOMAIN *international*
www.sciencedomain.org

Effect of Grinding Plates (GUK, Parpela and Premier) on Maize Flour Milled within Samaru, Nigeria

Yashim Zakka Israila[1*] and Suleiman Halima[1]

[1]*Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author YZI designed the study, wrote the protocol, supervised the work and edited the manuscript. Author SH carried out all laboratories work, performed the statistical analysis, wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2016/21681
Editor(s):
(1) Alfonso Clemente, Estación Experimental del Zaidín (EEZ-CSIC), Department of Physiology and Biochemistry of Animal Nutrition c/ProfesorAlbareda, Granada, Spain.
Reviewers:
(1) O. P. Kolawole, Federal University of Technology, Akure, Nigeria.
(2) Marcin Kurek, Warsaw University of Life Sciences, Poland.
(3) Oladeji, Babatunde Stephen, Obafemi Awolowo University, Ile-Ife, Nigeria.
Complete Peer review History: http://sciencedomain.org/review-history/14265

Original Research Article

Received 28th August 2015
Accepted 7th November 2015
Published 20th April 2016

ABSTRACT

This research work was carried out to determine the concentration of Cu, Mn, Pb and Fe in maize flour milled by different types of milling plates in Samaru, Zaria, Nigeria. Three different types of milling plates with the trade names GUK (Gibraltar upgrade kit), Parpela and Premier were identified at different locations where the dry maize grains bought from Samaru market were milled three times to obtain a smooth texture. Sample of the maize was also ground using porcelain mortar and pestle to serve as control. Wet digestion was carried out on the flour samples and the concentration of Cu, Mn, Pb and Fe determined using atomic absorption spectroscopy. The results showed that the concentrations of the metals were higher than those of the control. Using one-way ANOVA, there was a significant difference ($P < 0.05$) between the metal levels in maize flour milled with grinding plate and those ground with mortar and pestle. This implies that the grinding plates have contributed significantly to the heavy metals in the maize flour. Pb and Mn levels from the three milling plates were higher than the recommended limit set by the FAO/WHO, but the Pb level from Premier plate which is foreign was much higher than others which are locally fabricated. This

**Corresponding author: E-mail: ziyashim@abu.edu.ng, zakkayashim@gmail.com;*

could be undoubtedly injurious to the human body. Therefore, the quality of the grinding plates imported or fabricated locally in Nigeria should be checked by the relevant agency such as Standard Organisation of Nigeria (SON).

Keywords: Grinding plates; GUK; parpela premier; maize flour.

1. INTRODUCTION

Heavy metals refer to those metallic elements which have density of above 5 g/cm^3. These metals include arsenic, cadmium, chromium, copper, lead, nickel, zinc, molybdenum and vanadium. However, the main threats to human health from heavy metals are associated with exposure to lead, cadmium, mercury and arsenic.

Absorption of heavy metals through the food has been shown to have a serious consequences on health and thereby economic development, associated with a decline on labour productivity as well as increased direct costs of treating illness- such as kidney diseases, damage to the nervous system, diminished intellectual capacity, heart disease, gastrointestinal diseases, bone fracture, cancer and death [1].

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 [2]. 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 [3]. 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 such as milling process 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 [4].

Maize is an important staple food grown in many parts of the tropics which serves as food for many people and animals. In Nigeria, it is one of the most popular of all grain crops and it is grown all over the country [5]. 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 [6]. 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 nutria-cereal [7]. Maize is processed into corn flour which is used in the preparation of many local foods such as pate, waina, kunu, akamu (pap), kenkey, donkunu, tuwo, zaafi, eko and lots more [8]. Maize is prepared and consumed in a multitude of ways which vary from region to region or from one ethnic group to the other. For instance, maize grains are prepared by boiling or roasting as paste ('eko'), 'abado', and 'elekute' in Nigeria and 'kenke' in Ghana, or as popcorn which is eaten all over West Africa. Traditional methods of preparations and uses of maize are restricted to definite localities or ethnic groups.

The corn mill is the machine used to process cereals, legume, nuts, and spices into flour. It is an indispensible tool in the flour production industry. It can be found in cities, towns and villages across the country due to the dependence on cereal food products by the country folks. It has a pair of circular grinding plates (one a mobile plate and the second a stationary plate) which are made of cast iron. Cast iron is normally used for machinery parts to resist wear and tear. Iron is alloyed with nickel, chromium, copper, molybdenum and silicon to increase the tensile strength [9]. Both surfaces of the plates have small ridges running from edge to center. Grinding takes place when the milling machine is connected to a electricity source thereby causing the mobile plate to rotate against the stationary plate. In the process, grains that pass between the plates are crushed to powder. The sliding process of the plates generates friction which leads to wear and tear. A casual observation of maize processing indicates that worn out metals are been introduced into corn flour.

Foreign grinding plates used by the corn mill operators are, amuda, rex, and premier. But premier is the most commonly used among all. The higher the quality of the grinding plates the longer it takes to wear out and the safer it is because there would be less worn out metals in the corn flour.

However, with the current emphasis on eating more healthy diets which should not contain toxic metals, it is very essential to assess to the chemical composition and heavy metal concentration in maize flour that is popularly consumed by Nigerians. The aim of this study is to determine the concentration of heavy metals (Iron, copper, Manganese and Lead) in maize flour ground by corn mills in Samaru, Zaria, Nigeria using Atomic Absorption Spectroscopy.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Two kilogram of dried maize processed and packaged by Premier seed company in Zaria, Nigeria was bought in the market and divided into four (500 g each) parts in which three parts were milled separately using three different milling machines and the other one pounded using mortar and pestle. The three different milling machines of the model G.U.K, PARPELA and PREMIER were randomly selected at different locations in Samaru, Nigeria for the milling of the corn. Five hundred gram of the dry maize (per milling machine) was milled over and over again three times to obtain a smooth texture. Each round of milling samples were taken into a polyethylene bag and kept for further analysis. The remaining part (500 g) of maize was ground using clean-dried porcelain mortar and pestle in an environment free of dust to serve as the control.

2.2 Sample Analysis

One gram of the corn flour was digested using 20 cm^3 of mixture of concentrated HNO_3 and $HClO_4$ (ratio 4:1). The solution was allowed to cool and filtered through Whatman filter paper No. 42 into a $100cm^3$ standard volumetric flask and made up to the mark with de-ionized water. The concentration of Fe, Cu, Mn and Pb were determined using atomic absorption spectrophotometer model D100XB4J, with the analyses being done in triplicate.

The triplicates of the data obtained were subjected to one-way ANOVA using SPSS v20 software.

3. RESULTS AND DISCUSSION

Table 1 shows the concentrations of the studied metals obtained for the corn flour milled using GUK plate. It was observed that the concentrations of these metals increase as milling is repeated. The values were higher than those obtained from flour milled using mortar and pestle (control). By the third milling the concentration of lead and manganese were higher than the recommended limit set by the Joint Food and Agricultural Organization and the World Health Organization [10]. This is because, samples (maize) that are firstly poured into the machine more friction is needed to break them into smaller pieces. As friction occurs, there is wearing and tearing of the plate which enters into the milling sample. Thus when repeated, the friction continues which causes more wears and tears to the same sample. The level of metals in the flour processed by the pestle and mortar are the true levels of metals in the maize. The metal levels were in the order of Fe > Mn > Cu > Pb. For Parpela plate (Table 2), the metal levels in the corn flour followed the order Fe > Mn > Pb > Cu, while the corn flour from Premier plate (Table 3) showed that Fe > Pb > Mn > Cu.

Comparing the concentration values of heavy metals in the third milling from the three milling plates (Fig. 1), Pb content from Premier plate (32.30±0.02 mg/kg) was greater than that from Parpela (6.40±0.03 mg/kg) which in turn was greater than that from GUK plate (5.80±0.03 mg/kg). For Fe, the concentration from GUK (258.40±0.71 mg/kg) > Parpela (237.20±0.71 mg/kg) > Premier plate (184.00±0.55 mg/kg). The concentration of Cu indicated that the metal level in the corn flour milled with GUK (8.50±0.02 mg/kg) > Parpela (6.20±0.04mg/kg) ≈ Premier plate (6.20±0.02 mg/kg). The Mn levels in the corn flour from the three different plates were GUK (12.00±0.10 mg/kg) > Parpela (7.90±0.10 mg/kg)> Premier (7.50±0.04 mg/kg). The results showed that the heavy metal contents of the different millings were higher than the control values. Using one-way ANOVA, the multiple comparison LSD Post Hoc Tests (Table 4) showed that there was a significant difference ($P < 0.05$) between the metal levels in maize flour milled with different grinding plates and those ground with mortar and pestle. This implies that the grinding plates have contributed significantly to the heavy metals in the maize flour. Also the statistical analysis indicated that there was a significant difference ($P < 0.05$)

between the metal levels in maize flour milled with different grinding plates, but only Cu showed no significant difference (*P > 0.05*) in maize flour milled with Parpela and Premier.

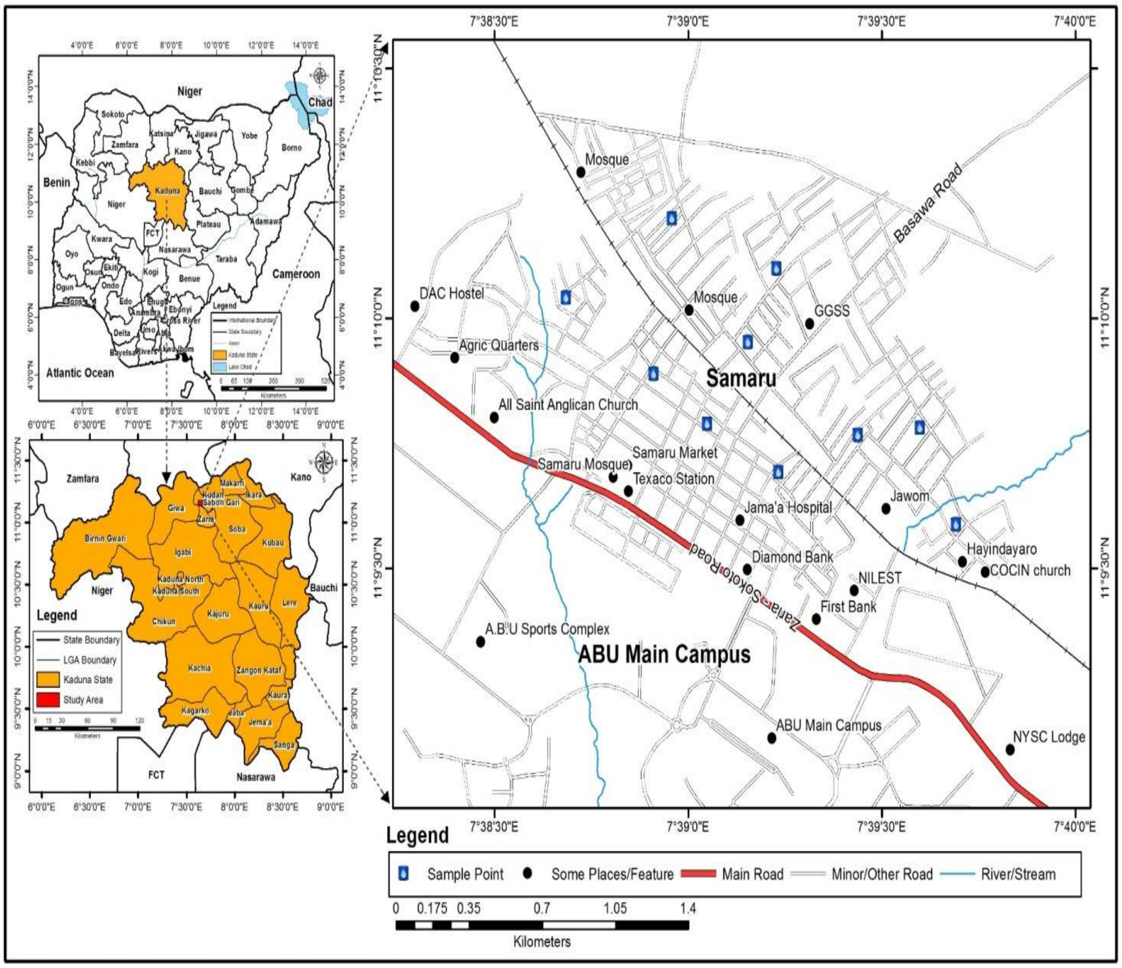

Fig. 1. Map of Samaru-Zaria showing sampling points

Source: Adapted and modified from the dministrative map of Kaduna State/Fieldwork, 2014

Table 1. Mean concentration (mg/kg) ±SD of heavy metals from G.U.K and control

	First milling	Second milling	Third milling	Control	Recommended limit (FAO/WHO)
Lead	1.1±0.01	2.6±0.01	5.8±0.03	ND	5.0
Iron	123.7±0.11	243.8±0.43	258.4±0.71	75.0±0.35	300
Copper	5.6±0.05	6.0±0.04	8.5±0.02	3.5±0.02	40
Manganese	6.2±0.03	6.20±0.04	12.0±0.10	2.6±0.01	5.0

Table 2. Mean concentration (mg/kg) ±SD of heavy metals from Parpela plate and control

	First milling	Second milling	Third milling	Control	Recommended limit (FAO/WHO)
Lead	1.4±0.01	5.3±0.05	6.4±0.03	ND	5.0
Iron	197.2±0.33	231.8±0.23	237.2±0.71	75.0±0.35	300
Copper	5.9±0.11	6.0±0.20	6.2±0.04	3.5±0.02	40
Manganese	7.5±0.05	7.8±0.05	7.9±0.10	2.6±0.01	5.0

Table 3. Mean concentration (mg/kg) ±SD of heavy metals from premier plate and control

	First milling	Second milling	Third milling	Control	Recommended limit (FAO/WHO)
Lead	5.6±0.03	24.2±0.05	32.3±0.02	ND	5.0
Iron	88.1±0.22	177.7±0.43	184.0±0.55	75.0±0.35	300
Copper	5.0±0.02	5.3±0.01	6.2±0.02	3.5±0.02	40
Manganese	6.3±0.03	6.7±0.03	7.5±0.04	2.6±0.01	5.0

Table 4. Showing the analysis of variance

Dependent variable		(I) site	(J) site	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
							Lower bound	Upper bound
Pb	LSD	GUK	Parpela	-0.73333*	0.08518	0.000	-0.9298	-0.5369
			Premier	-26.50000*	.08518	0.000	-26.6964	-26.3036
			Control	5.80000*	0.08518	0.000	5.6036	5.9964
		Parpela	GUK	0.73333*	0.08518	0.000	0.5369	0.9298
			Premier	-25.76667*	0.08518	0.000	-25.9631	-25.5702
			Control	6.53333*	0.08518	0.000	6.3369	6.7298
		Premier	GUK	26.50000*	0.08518	0.000	26.3036	26.6964
			Parpela	25.76667*	0.08518	0.000	25.5702	25.9631
			Control	32.30000*	.08518	0.000	32.1036	32.4964
		Control	GUK	-5.80000*	0.08518	0.000	-5.9964	-5.6036
			Parpela	-6.53333*	0.08518	0.000	-6.7298	-6.3369
			Premier	-32.30000*	0.08518	0.000	-32.4964	-32.1036
Fe	LSD	GUK	Parpela	21.33333*	0.54620	0.000	20.0738	22.5929
			Premier	76.33333*	0.54620	0.000	75.0738	77.5929
			Control	183.03333*	0.54620	0.000	181.7738	184.2929
		Parpela	GUK	-21.33333*	0.54620	0.000	-22.5929	-20.0738
			Premier	55.00000*	0.54620	0.000	53.7405	56.2595
			Control	161.70000*	0.54620	0.000	160.4405	162.9595
		Premier	GUK	-76.33333*	0.54620	0.000	-77.5929	-75.0738
			Parpela	-55.00000*	0.54620	0.000	-56.2595	-53.7405
			Control	106.70000*	0.54620	0.000	105.4405	107.9595
		Control	GUK	-183.03333*	0.54620	0.000	-184.2929	-181.7738
			Parpela	-161.70000*	0.54620	0.000	-162.9595	-160.4405
			Premier	-106.70000*	0.54620	0.000	-107.9595	-105.4405
Cu	LSD	GUK	Parpela	2.30000*	0.02160	0.000	2.2502	2.3498
			Premier	2.30000*	0.02160	0.000	2.2502	2.3498
			Control	5.00000*	0.02160	0.000	4.9502	5.0498
		Parpela	GUK	-2.30000*	0.02160	0.000	-2.3498	-2.2502
			Premier	0.00000	0.02160	1.000	-0.0498	0.0498
			Control	2.70000*	0.02160	0.000	2.6502	2.7498
		Premier	GUK	-2.30000*	0.02160	0.000	-2.3498	-2.2502
			Parpela	0.00000	0.02160	1.000	-0.0498	0.0498
			Control	2.70000*	0.02160	0.000	2.6502	2.7498
		Control	GUK	-5.00000*	0.02160	0.000	-5.0498	-4.9502
			Parpela	-2.70000*	0.02160	0.000	-2.7498	-2.6502
			Premier	-2.70000*	0.02160	0.000	-2.7498	-2.6502
Mn	LSD	GUK	Parpela	4.10000*	0.06014	0.000	3.9613	4.2387
			Premier	4.50000*	0.06014	0.000	4.3613	4.6387
			Control	9.40000*	0.06014	0.000	9.2613	9.5387
		Parpela	GUK	-4.10000*	0.06014	0.000	-4.2387	-3.9613
			Premier	0.40000*	0.06014	0.000	0.2613	0.5387
			Control	5.30000*	0.06014	0.000	5.1613	5.4387
		Premier	GUK	-4.50000*	0.06014	0.000	-4.6387	-4.3613
			Parpela	-0.40000*	0.06014	0.000	-0.5387	-0.2613
			Control	4.90000*	0.06014	0.000	4.7613	5.0387
		Control	GUK	-9.40000*	0.06014	0.000	-9.5387	-9.2613
			Parpela	-5.30000*	0.06014	0.000	-5.4387	-5.1613
			Premier	-4.90000*	0.06014	0.000	-5.0387	-4.7613

**. The mean difference is significant at the 0.05 level; LSD = Least Significant Difference*

Pb content in the maize flour from the three milling plates was higher than the recommended limit (5 ppm), but that of Premier plate which is foreign was much higher than others which are locally fabricated. This could be undoubtedly injurious to the human body. Pb toxicity inhibits enzymes into the brain. It blocks the electrical discharge of the nerve cells which reduces nervous system activity. Kidney dialysis related to lead toxicity causes memory loss, disorientation, loss of coordination and confusion [11,12]. Also it was observed that Mn levels from the three plates were higher than the recommended limit of 5ppm. Manganese is the least toxic of the essential metals and it is toxic to varying degrees, depending on the type of ion and its oxidation state. Growth retardation, non specific anemia, metal fume fever and psychic and neurological disorders are some of the symptoms of manganese intoxication. Chronic Mn toxicity in humans follows chronic exposure through inhalation, ingestion or parental administration to a high concentration of 75 mg/dl [13], results in “Manganism”, a disease of the central nervous system involving psychic and neurological disorder. A peculiar lapping gait, cramps or tremors of the body and extremities, slurred speech, hallucinations, insomnia, and mental confusion are some of the symptoms. Divalent and trivalent Mn act as neurotoxins including degenerative changes in the nervous system. Nephritis, cirrhosis of the liver, anorexia, muscular fatigue, sexual impotence, leucopenia, anaemia and monocytosis are the other observed symtoms of manganism [14,15]. This study showed that lead and manganese are above the recommended limits when Parpela and Premier plates are used. Although copper level was below the recommended limit, the presence of the metal in the flour consumed can lead to its increase in the human body. Whole blood contains about 1 mg/L of copper. The levels can vary considerably especially in women. During pregnancy and after the intake of oral contraceptives, copper can rise to 2 or more mg/L in blood [16].

The corn mill has a pair of circular grinding plates which are made of cast iron. Both surfaces of the plates have small ridges running from edge to center. They are grooved to aid the shearing (cutting and crushing) and grinding of the grain. Different plates, with a range of groove sizes, may be used for the production of meals of varying textures. Grinding is done by power rotating one mobile plate against a stationary plate. The corn mill has a pair of circular grinding plates which are made of cast iron. Both surfaces of the plates have small ridges running from edge to center. They are grooved to aid the shearing (cutting and crushing) and grinding of the grain. Different plates, with a range of groove sizes, may be used for the production of meals of varying textures. Grinding is done by power rotating one mobile plate against a stationary plate. In the process, grains that pass between the plates are crushed to powder. The sliding process of the plates generates friction which leads to wear and tear. The higher the quality of the grinding plates the longer it takes to wear out and the safer it is because there would be less worn out metals in the corn flour. The grain is screw-fed from a conical hopper into the gap between the two plates. This gap may be adjusted to vary the fineness of the ground material. The composition of the grinding plates could also affect the concentration of the metals in the flour [17].

4. CONCLUSION

This study showed that the concentrations of the studied metals in the maize flour milled using milling plates were higher than those from the flour milled using mortar and pestle. This indicated that there is wearing and tearing of the plates which introduced the metals into the maize flour. The Pb and Mn levels from the three milling plates were higher than the recommended limit set by the FAO/WHO, but the Pb level from Premier plate which is foreign was much higher than others which are locally fabricated. The higher the quality of the grinding plates the longer it takes to wear out and the safer it is because there would be less worn out metals in the corn flour. Therefore, the quality of the grinding plates imported or fabricated locally in Nigeria should be checked by the relevant agency such as Standard Organisation of Nigeria (SON). Alloys which contain less amount of potentially toxic metals are recommended for used to fabricate the grinding plates.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Malomo O, Ogunmoyela OAB, Oluwajoba SO, Adekoyeni OO. Evaluation of chemical and heavy metal concentrations in maize

(*Zea mays*) from industrial area of Ogun state, Nigeria; 2012.
2. Akaninwor JO, Onyeike EN, Ifemeje JC. Trace metal levels in raw and heat processed Nigerian stable food from oil producing areas of rivers and Bayelsa States. Journal of Applied Science and Environmental Management. 2006;10(2): 23-27.
3. Nkansan MA, Amoako CO. Heavy metal content of some common species available in markets in the Kumasi metropolis of Ghana. American Journal of Scientific and Research. 2010;19(2):158-163.
4. IOCCC. International Office of Cocoa, Chocolate and Sugar Confectionery. Paper on the position of IOCCC (International Obfuscated C Code Contest) on heavy metal contamination in the confectionery industry. Belgium; 1996.
5. Adebayo GB, Otunola GA, Ajao TA. Physicochemical, microbiological and sensor characteristics of kunu prepared from millet, maize, and guinea corn and stored at selected temperatures advance. Journal of Food Science and Technology. 2010;2(1):41-46.
6. International Institute of Tropical Agriculture. Maize: Research to Nourish Africa. Press Release Bulletin/ PRchecker. Info; 2011.
7. Punita G. Physico-chemical properties, nutritional quality and value addition to quality protein maize (*Zea mays* L.). A thesis for master of home science submitted to the department of food science and nutrition, University of Agricultural Sciences, Dharwad; 2006.
8. Lokko P, Kirkmeyer S, Mattes RD. A crosscultural comparison of appetitive and dietary responses to food challenges. Food Quality and Preference. 2004;15(27): 129–I36.
9. Johnson W. Metallurgy, 5th Edition, U.S.A., Technical Publishers Inc. 1977;269:278-279.
10. FAO/WHO. The Role of food safety in health and development- Summary of Evaluations Performed by the Joint FAO/WHO Expert Committee on Food Additives (JECFA); 2006.

    Available: http://jecfa.ilsi.org/
11. FAO. Food Energy – Methods of analysis and convertion factors. Report of a technical workshop. Rome, 3-6 December; 2002.
12. Food and Agricultural Organisation (FAO). Nasri Chelation and Intergrated Medicine; 2006.

    Available: www.fao.org/publications
13. Dorman CD, Struve MF, Marshell MW, Wong BA. Influence of dietary Mn on the pharmacokinetics of inhaled Mn-sulphate in male CD rats. Toxicology Science. 2001;60:242-251.
14. Beuter A, Mergler D, DueGeoffrey A, Gauthriver S. A study of patients with Parkinson disease and Mn exposed worker. Neurotoxicology. 1994;15:655-664.
15. Ingersoll RT, Montgomery EB, Aposhian HV. Central nervous system toxicity of Mn. Applied Toxicology. 1995;27:106-113.
16. Insaidoo H. Determination of heavy metals in corn in mining and non mining areas. 1999;11-17, 31, 36-37.
17. Abrefah RG, Mensimah E, Sogbadji RBM, Opata NS. The effects of milling on corn flour using instrumental neutron activation analyses: A case study of three selected corn millers within Accra metropolis, Ghana. Elixir Agriculture. 2011;39:5000-5003.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14265