

Original Research Article**EFFECT OF GRINDING PLATES (GUK, PARPELA and PREMIER) ON MAIZE FLOUR MILLED WITHIN SAMARU, NIGERIA****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 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

INTRODUCTION

Heavy metals refer to those metallic elements which have density of above 5g/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 (Malomo *et al.*, 2012).

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 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 (IOCCC, 1996).

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 (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 nutria-cereal (Punita, 2006). 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 (Lokko *et al.*, 2004). 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 indispensable 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 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 (Johnson, 1977). Both surfaces of the plates have small ridges running from edge to center. 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. 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 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 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.

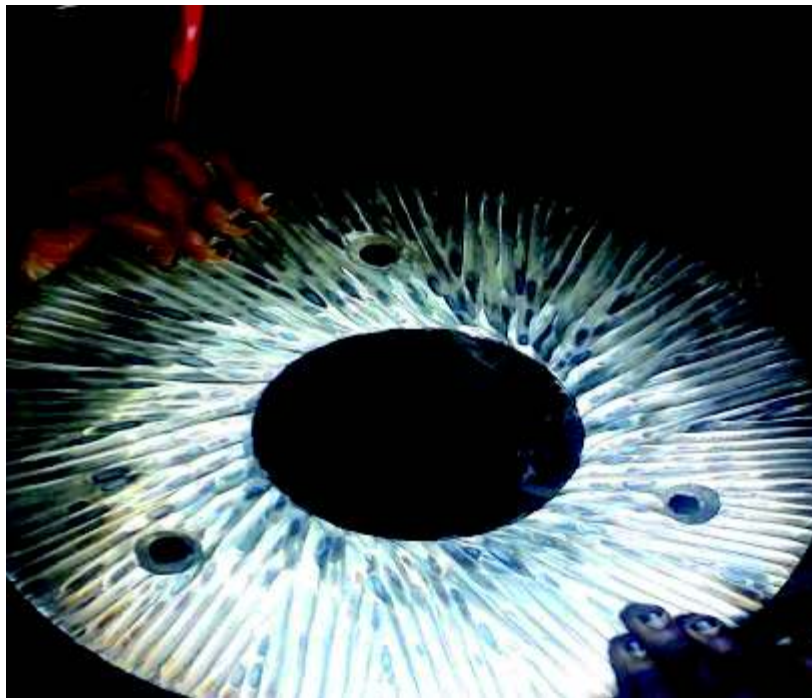
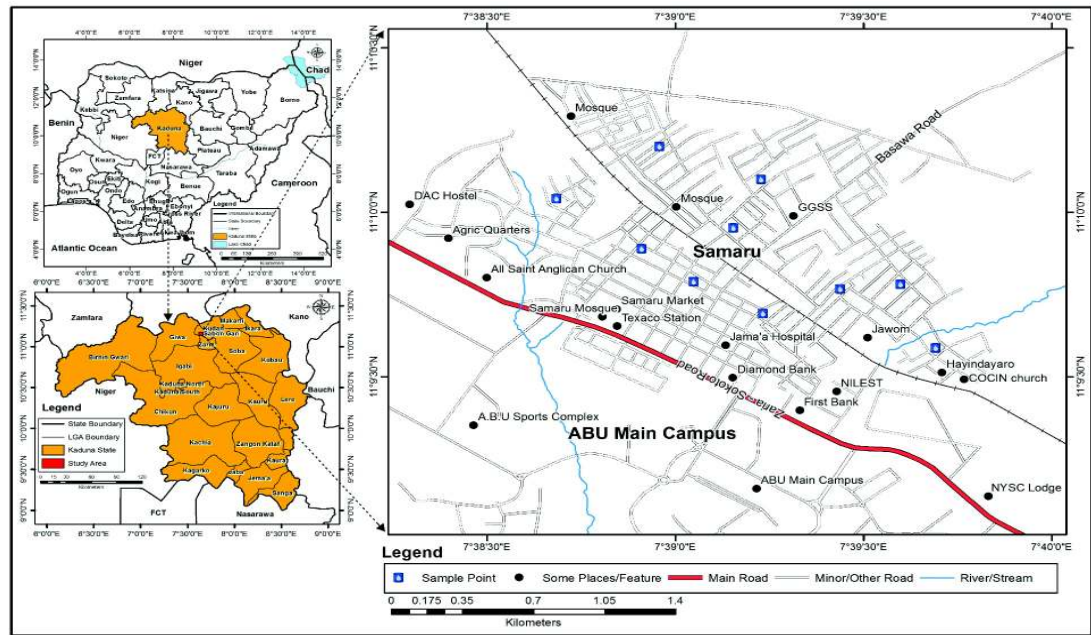


Plate 2.1: photograph showing milling plate



Plate 2.2 : photograph showing “Premier” 127 grinding mill.

MATERIALS AND METHODS

Sample collection and preparation

Two kilogram (2kg) of dried maize was bought in the market and divided into three parts in which two parts was milled and the other one pounded using mortar and pestle. 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 (500g) of the dry maize 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. Sample (50g) of maize was ground using clean-dried porcelain mortar and pestle in an environment free of dust to serve as the control.

Sample analysis

One gram of the corn flour was digested using 20cm³ of mixture of concentrated HNO₃ and HClO₄ (ratio 4:1). The solution was allowed to cool and filtered through Whatman filter paper No. 42 into a 100cm³ 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 D100XB4J, with the analyses being done in triplicate.

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

123 Results and Discussion

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

137 **TABLE 1: Concentration (mg/kg) of heavy metals for each milling 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

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140 **Table 2: concentration (mg/kg) 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

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142 **Table 3: Concentration (mg/kg) 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

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144 Comparing the concentration values of heavy metals in the third milling from the three milling
145 plates (Figure 1), Pb content from Premier plate ($32.30 \pm 0.02 \text{ mg/kg}$) was greater than that from
146 Parpela ($6.40 \pm 0.03 \text{ mg/kg}$) which in turn was greater than that from GUK plate
147 ($5.80 \pm 0.03 \text{ mg/kg}$). For Fe, the concentration from GUK ($258.40 \pm 0.71 \text{ mg/kg}$) > Parpela
148 ($237.20 \pm 0.71 \text{ mg/kg}$) > Premier plate ($184.00 \pm 0.55 \text{ mg/kg}$). The concentration of Cu indicated
149 that the metal level in the corn flour milled with GUK ($8.50 \pm 0.02 \text{ mg/kg}$) > Parpela
150 ($6.20 \pm 0.04 \text{ mg/kg}$) $\approx$ Premier plate ($6.20 \pm 0.02 \text{ mg/kg}$). The Mn levels in the corn flour from the
151 three different plates were GUK ($12.00 \pm 0.10 \text{ mg/kg}$) > Parpela ($7.90 \pm 0.10 \text{ mg/kg}$) > Premier
152 ($7.50 \pm 0.04 \text{ mg/kg}$). Using one-way ANOVA, there was a significant difference ($P < 0.05$)
153 between the metal levels in maize flour milled with grinding plate and those ground with mortar
154 and pestle. This implies that the grinding plates have contributed significantly to the heavy
155 metals in the maize flour.

156 Pb content in the maize flour from the three milling plates was higher than the
157 recommended limit (5ppm), but that of Premier plate which is foreign was much higher than
158 others which are locally fabricated. This could be undoubtedly injurious to the human body. Pb
159 toxicity inhibits enzymes into the brain. It blocks the electrical discharge of the nerve cells which
160 reduces nervous system activity. Kidney dialysis related to lead toxicity causes memory loss,
161 disorientation, loss of coordination and confusion (FAO, 2006). Also it was observed that Mn
162 levels from the three plates were higher than the recommended limit of 5ppm. Manganese is the
163 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 75mg/dl (Dorman *et al.*, 2001), 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 symptoms of manganism (Beuter *et al.*, 1994; Ingersoll *et al.*, 1995). 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 (Insaideo, 1999).

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.

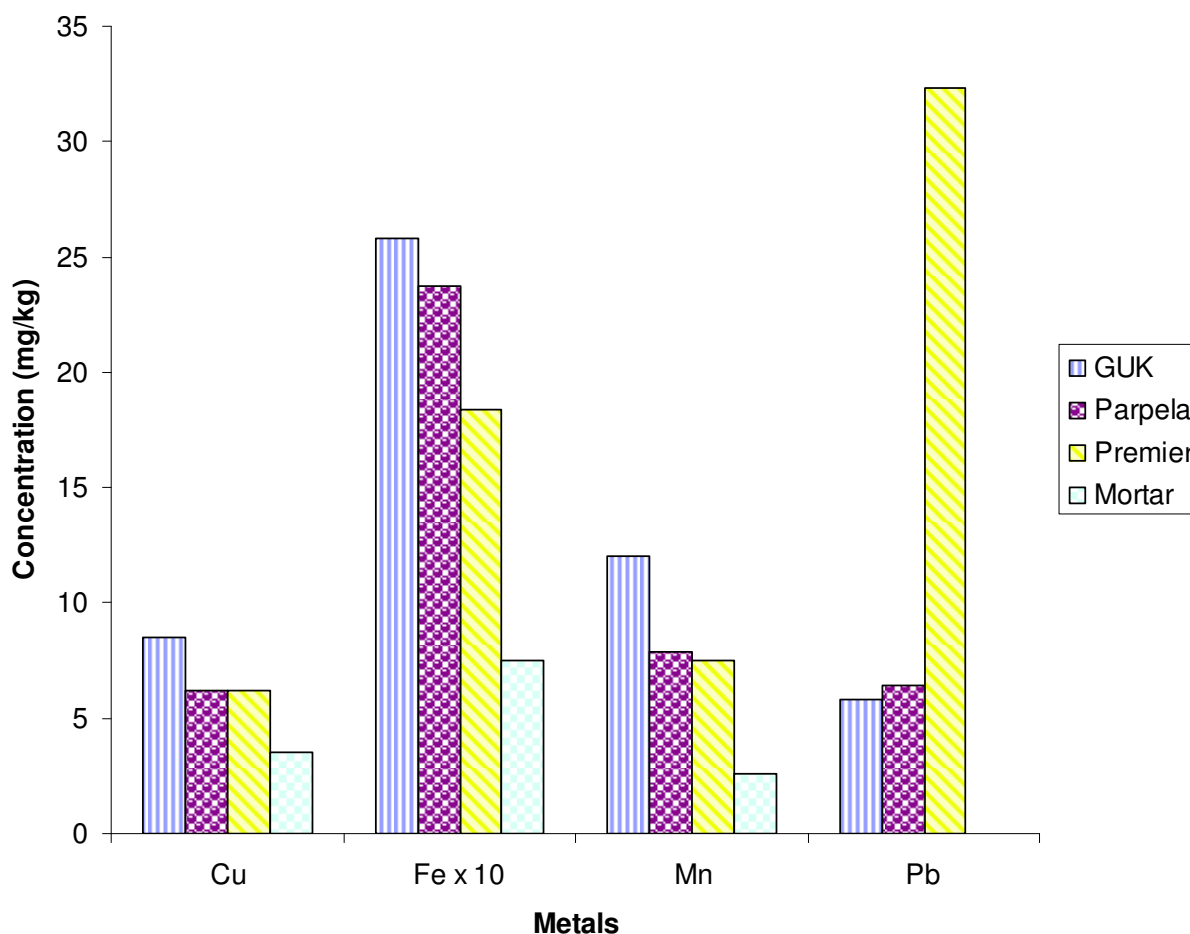


Figure 1: Mean concentration of studied metals in cornflour milled from GUK, Parpela, Premier and Mortar

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 (Abrefah *et al.*, 2011).

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).

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