

DETERMINATION OF HEAVY METALS IN BREAD BAKED IN GOMBE METROPOLIS, USING ATOMIC ABSORPTION SPECTROMETERY TECHNIQUE

BY

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ABSTRACT

Concentrations of heavy metals were determined in some bread samples obtained from some bakeries within Gombe metropolis. The bread samples were digested using nitric (HNO_3) and hydrochloric (HCl) acid in the ratio of 3:1 and analyzed with the help of Atomic Absorption Spectrometer (AAS) to determine heavy metals. The mean concentration for each heavy metal in the analyzed sample was calculated. Concentrations were compared with the permissible levels set by WHO. Results showed that the levels of Copper, Magnesium, and Manganese in the bread samples are $0.075 \pm 0.295 \mu\text{g/g}$, $22.70 \pm 4.130 \mu\text{g/g}$ and $63.42 \pm 10.606 \mu\text{g/g}$ respectively, but lead was not detected in any of the samples. When compared with standards (WHO), heavy metal concentration levels were found to be within safe limit. Only magnesium concentration ($22.7 \mu\text{g/g}$) was greater than the WHO value ($20 \mu\text{g/g}$).

KEYWORDS: Atomic Absorption Spectrometry (AAS), Bread, Heavy metals, Gombe Metropolis.

1.0 INTRODUCTION

Cereal-based diets are of capital importance worldwide. A lot of concern is shown regarding vitamin and mineral deficiency in susceptible individuals such as children with age below five years and women at age of production [1]. Mineral compounds are essential to daily food needs and bread is an important food product that furnishes as much as 50% to 90% of total calorie and protein intakes [2, 3]. The consumption of white in variety of food products made it to be an important source of mineral compounds [1]. The non biodegradability of heavy metals and their potential to cause inappropriate effects made them the most noxious materials [4, 5]. Environmental parameters, mode of production and processing are factors essential for the determination of heavy metals in food [6, 7].

The effect of environmental pollution on contamination of foods and on their safety for human consumption has become an important worldwide issue [8, 9]. Heavy metals

concentrations in foodstuff have been determined by many researchers [10, 11]. Elements like lead (Pb), cadmium (Cd), and nickel (Ni) are non-essential materials for nearly all living creatures. Pb, Cd, and other heavy metals can enter wheat flour and then bread [12].

All types of grain contain trace metals such as iron (Fe), manganese (Mn), magnesium (Mg), copper (Cu), and zinc (Zn), which might be due to weather during cultivation, rain, and levels of contamination. Application of chemical fertilizer and the use of sewage sludge during the cultivation of cereals can substantially increase the levels of Pb, Zn, and Cd. Also, food processing equipment and containers have been long recognized as a source of trace metals such as Fe, Cu, Pb, and chromium (Cr) in processed foods [13].

Heavy metals enter the human body through food, water, and air. Heavy metals are ubiquitous; therefore, they tend to bioaccumulate, thus causing an increase in their concentration in a biological system (human beings). Chronic heavy metal toxicity has been the result of many chronic diseases. The critical issues mentioned above should be avoided by making sure that breads consumed by people are safe and do not contain toxic heavy metals that will be dangerous and lead to human intoxication.

The aim of this study is to determine the heavy metals in some samples of bread within Gombe metropolis, using Atomic Absorption Spectrometer (AAS).

The results obtained can be used by international organizations such as World Health Organization (WHO) and United Children's Fund (UNICEF) as line data for present and future reference.

This work is limited to the determination of heavy metals in bread samples in Gombe metropolis, using Atomic Absorption Spectrometer (AAS).

2.0 MATERIALS AND METHOD

2.1 Study Area

Gombe is a city in north eastern Nigeria. It is the capital city of Gombe state and has an estimated population of more than 261,536 people (2006 census). Gombe metropolitan area has an area of 52 km² and is situated between latitude 9° 30' N and 12° 30' N and longitude 8° 45' E and 11° 45' E of the Greenwich meridian. It has two distinct climates, the dry season (November–March) and the rainy season (April–October) with an average rainfall of 850 mm. Gombe is a confluence of economic activities by its position as the meeting point for business people from the surrounding

States. The States includes: Borno to the north, Yobe to the east, Taraba and Adamawa to the south, and Bauchi to the west. This geographical position has made the state vibrant in all aspects. Numerous banks, filling stations and hotels exist in the town to support the commercial activities.

2.2 Materials

The materials used in this study included: measuring cylinder (100ml), funnel, volumetric flask (500ml), kyeldahl digestion flask (300ml), electro thermal heater, beakers (100ml), filter paper, masking tape, sampling bottles (rubber 100ml), electrical weighing machine and atomic absorption spectrometer.

2.3 Sample collection

The sampling was carried out in the month of July, 2016 and bread samples were collected from five different well known bakeries within Gombe metropolis which are namely: Alheri bread, Abba bakery, Goodness special bread, Trust milk bread, and El-nas bread. These samples were labeled sample A, B, C, D, and E respectively.

2.4 Sample treatment

The samples (10gramseach) were placed in a 100ml beaker for drying in an oven at about 40° -50° c to remove moisture. After which the dry samples were put into a 300ml digestion flask. 20ml of concentrated mixture of hydrochloric and nitric acid (aqua regia) was used in the ratio of 3:1, that is, (3HCL:1HNO₃). The samples were then placed on an electro- thermal heater for heating. The samples were then heated slowly until the samples starts boiling and the aqua regia solution was used to top the solution of the samples to avoid it from drying, this was done to all the five sample until all the bread particles are completely digested. The digested solution of the samples was then allowed to cool and filtered using a funnel and filter paper into a clean100ml beaker. Deionized water was poured into the filtrate to top it to 100ml and it was transferred into sampling bottles (100ml) which were taken for analysis using atomic absorption spectrometry. A blank sample was also prepared and analyzed along with the samples.

2.5 Sample Analysis

The AAS is used to determine the concentration of heavy metals in samples. The technique makes use of the fact that, neutral or ground state atoms of an element can absorb electromagnetic radiation over a series of very narrow, sharply defined wavelengths. The sample solution is aspirated as a fine mist into a flame where it is converted into atomic vapor. Most of the atoms remain in the ground state and are therefore capable of absorbing radiation of a suitable wavelength. This discrete radiation is supplied by a hollow cathode lamp, which is a sharp line source consisting of a cathode, containing the element to be determined along with the tungsten anode. The line characteristic of the element are emitted by the hollow cathode and passes through the flame where they may be absorbed by the atomic vapor, since only the test element can absorb this radiation, the method becomes specific [14].

2.6 Mass fraction

The mass fraction of a particular element in the bread was calculated using the following equation:

$$W_i = \frac{N \times V \times C}{M} \quad (1)$$

where W is the mass fraction of the element in the sediment (mg kg^{-1}); i is the particular element; c is the concentration of the element measured by AAS (mg L^{-1}); n is the dilution ratio; m is the mass of the sample (kg); v is the volume of the sample.

2.7 Agreement

Agreement (AT) is defined as the ratio of the standard deviation (σ) of the concentration of a given element in the sample with respect to the average concentration (\bar{x}) of the element in the sample, expressed as percentage [15]. (AT) is expressed as:

$$AT = (\sigma / \bar{x}) 100\% \quad (2)$$

A large AT is an indication of a large fluctuation of the specific trace element within the sample or vice versa.

2.8 Correlation Analysis

The measure of similarity between paired data is termed correlation analysis. The degree of inter-relation between variables can be estimated with the help of correlation coefficient (r) without any influence by measurement units. Correlation Coefficient being a ratio is a

dimensionless number. Correlation ranges from +1 to -1. A correlation of +1 is an indication of a perfect direct relationship between two variables. While that of -1 indicates that one variable changes inversely in relation to the other. A spectrum of less than perfect relationships lies between the two extremes including zero which indicates the lack of any linear relationship [16]

2.0 RESULT AND DICUSSION

The elements determined and the concentrations of all the trace elements detected from bread samples within Gombe metropolis are given in Table 1.

Table 1: Concentration of all the trace elements detected from bread samples within Gombe Metropolis, in (mg/l)

Sample ID	Sample code	Cu	Mg	Mn	Pb
Alheri bread	Sample A	0.08	2.52	6.57	ND
Abba bread	Sample B	0.10	2.54	7.28	ND
Goodness bread	Sample C	0.07	2.43	6.65	ND
Trust milk bread	Sample D	0.02	2.41	6.93	ND
El-nas bread	Sample E	ND	1.45	4.28	ND

Manganese (Mn) is known as an essential trace element which acts as cofactor for many enzymes. It is less toxic than any other metal. However it can cause neurological disorder, if its concentration exceeds 5 mg/m³, due to continuous exposure to manganese dust and fumes [17](Takeda, 2003). In this study, the concentration of Mn detected is below the recommended value of 64mg/l by WHO. In this work the concentration of Mn ranges from 4.28 to 7.28mg/l, the highest level was observed in the sample B (Abba bread) from Table1.

Lead (Pb) is highly hazardous for plants and animals and micro-organism. Continues application of fertilizers to plants, fuel combustion from automobiles, and sewage sludge from houses are the major reasons leading to escalation in Pb pollution. The bread samples contained

low or no traces or concentration of Pb compared to the permissible limit of 17mg/l defined by (WHO). This finding shows that Pb was not detected in all the five bread samples from Table 1.

Copper (Cu) is one of several trace heavy metals that are essential to humans. Copper deficiency in humans is a rare exception, and would not occur if Cu content were more than 2mg in daily diet. The national accepting limit for Copper is 89.0mg/l [19]. The content of Cu in each sample ranges from (0.02 to 0.1mg/l) the highest level is observed in sample B (Abba bread) and in sample E (El-nas bread) Cu was not detected from Table 1.

Magnesium (Mg) an unequivocal case of magnesium deficiency in human has not been described [18]. Mn may be another trace elements whose important is not manifested under special situations. There are few Mn enzymes they include; arginase, pyruvate carboxylase etc. Perhaps stressing humans so that they have an enhanced need for one of the enzymes will be the situation which will show the nutritional importance of magnesium [19]. In this work the concentration of Mg ranges from 1.45 to 2.54mg/l is low compared to international standard value of 95mg/l. The highest value was obtained in sample B (Abba bread) from Table 1.

It is observed that in Table 1, sample B (Abba bread) has the highest value of the concentration of the metals; Cu (0.1mg/l), Mg (2.54mg/l), Mn (7.28mg/l). However, all the values are below the permissible limit given by WHO.

The mass fraction of a particular element in the bread was calculated using equation (1) and the result is shown in Table 2. The concentrations Cu, Mg, and Mn in the bread samples ranged respectively from 0.2 to 1, from 1.25 to 25.4 and from 4.28 to 72.8 $\mu\text{g/g}$ as shown in Table 2.

It is found that Pb is the element that was not detected from either of the samples while Mn being the largest with $(63.42 \pm 10.6059 \mu\text{g/g})$ and Cu has the lowest value with $(0.675 \pm 0.2945 \mu\text{g/g})$, also sample B has the highest concentration of all the elements detected as shown in figure 1 below. Lastly, all the elements were found to be within the tolerable unit.

The mean concentrations in bread for Cu, Mg and Mn are given in Table 3. Comparison between the elemental mean obtained in this and the world values is given in Table 3. All the trace elements detected are lower than the mean WHO reported by [19], with exception of manganese that showed significant variation as shown in figure 2.

In order to simplify classification, the index *AT* as defined by equation (2) is calculated and the results are shown in Table 3. A large *AT* value indicates a large fluctuation of the specific

trace element within the sample or vice versa [15]. The ATs can roughly be categorized according into three groups: Group 1: $AT < 60$; Group2: $60 < AT < 90$; and Group3: $AT > 90$ [15]. Thus, the trace element Mn, Mg and Cu are in group1 indicating less fluctuation of the element in the samples.

Table 2: Concentration trace elements detected from bread samples within Gombe Metropolis in ($\mu\text{g/g}$).

Sample ID	Sample code	Cu	Mg	Mn	Pb
Alheri bread	Sample A	0.8	25.2	65.7	ND
Abba bread	Sample B	1.0	25.4	72.8	ND
Goodness bread	Sample C	0.7	24.3	66.5	ND
Trustmilk bread	Sample D	0.2	24.1	69.3	ND

Table 3: Coefficient of Variation (%) and Mean concentration of the bread samples compared with WHO values ($\mu\text{g/g}$)

Element	Mean concentration	AT(%)	WHO values [19]
Copper (Cu)	0.675 ± 0.295	43.7	20.00
Magnesium (Mg)	22.7 ± 4.130	18.2	20.00
Manganese (Mn)	63.42 ± 10.606	16.7	900.00
Lead (Pb)	ND	-	17.00

According to the results of these studies, there is a linear relationship between concentrations Mn and Mg; Mn and Cu, Mg and Cu as given by the following equations generated from Figure3a, b, c respectively:

$$Y = 2.755x + 0.349 \quad (3)$$

$$y = -6.317x + 99.93 \quad (4)$$

$$y = -2.44x + 37.17 \quad (5)$$

where y and x are concentrations.

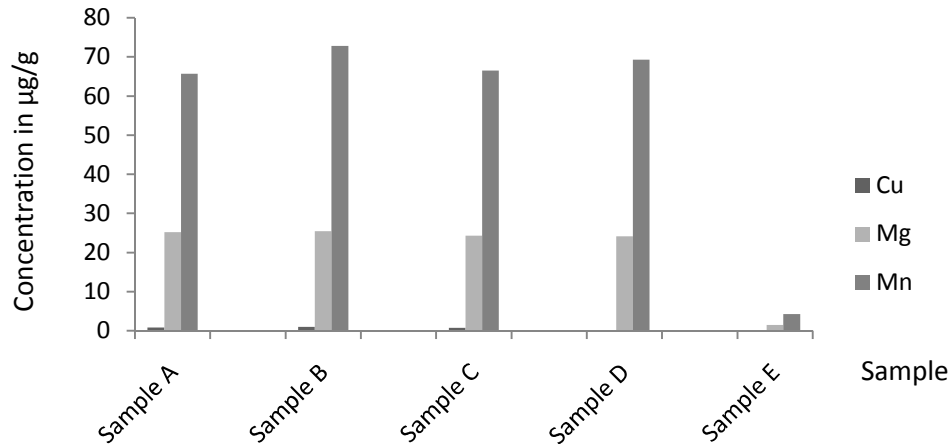


Figure 1: Comparison Concentration of element determined per sample

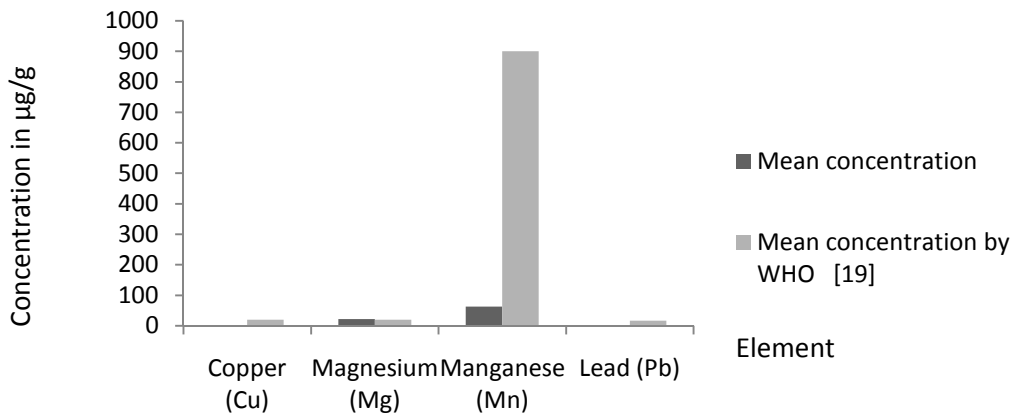


Figure 2: Concentration of elements determined compared with WHO Values

Strong correlation between Mn and Mg was obtained as shown in Figure 3a. The correlation coefficient is of order of 0.991. This shows that the presence of Mn will indicate the presence Mg and vice versa. Very poor correlation exist between Mn and Cu, Mg and Cu this is shown by the poor coefficients of correlation 0.478 and 0.546 as shown in Figure 3b and 3c respectively.

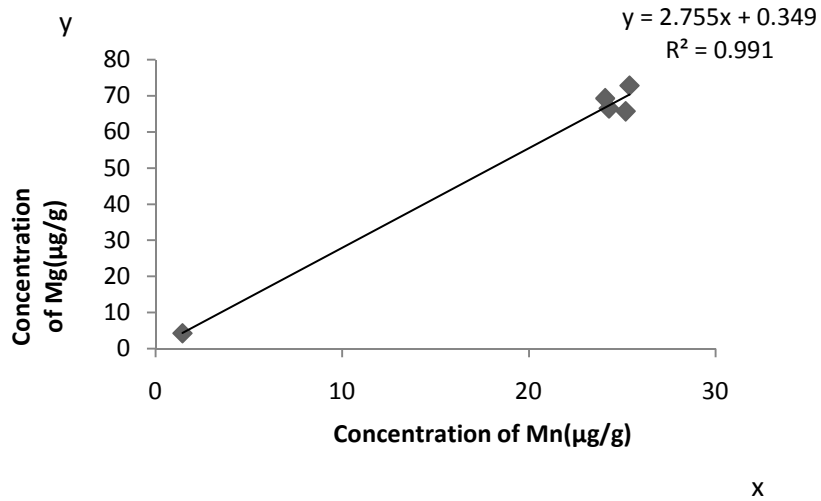


Figure 3a: Correlation between Mg and Mn

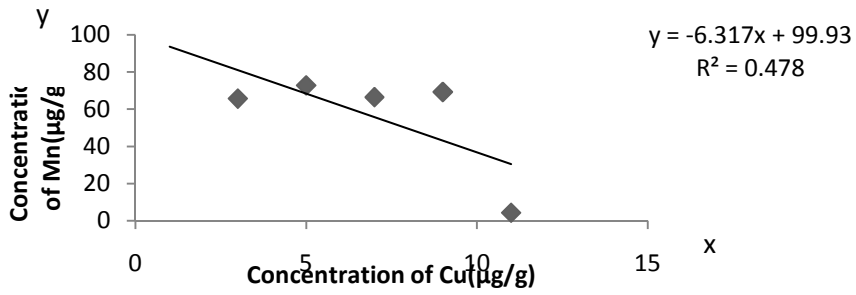


Figure 3b: Correlation between Mn and Cu

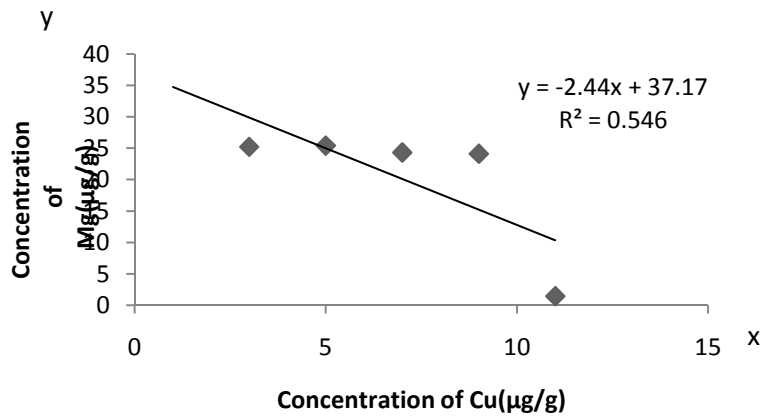


Figure 3c: Correlation between Mg and Cu

4.0 CONCLUSION

The application of atomic absorption spectrometer (AAS) in this work has been successful in the determination of trace elements and their concentrations. The elements detected are; Cu, Mn, and Mg. The mean concentrations of the elements determined are within the permissible limit reported by WHO, except magnesium which shows slight deviation 22.7 µg/g against a WHO value of 20 µg/g. But nothing has been yet reported about the effect of deficiency or excess of magnesium in consumed food.

5.0 RECOMMENDATION

There is need for continuous monitoring of the heavy metals from time to time so that we can always be alerted for any possible contamination of heavy metals in bread.

The use of other techniques such as; Energy Dispersive X-Ray Fluorescence Technique and Neutron Activation Analysis should be recommended in order to fill up the missing gaps in heavy metals analysis.

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