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Research Article

Compliance of commercial bakeries to regulatory safety standards in the Ilorin metropolis

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Abstract: Potassium bromate ($KBrO_3$) becomes important in bread as a flour-enhancing agent which gives fine and uniformly sized pores. However, it has been confirmed by the International Standard Organization that potassium bromate is carcinogenic, hence, its ban for bread production globally. This study was conducted to determine the level of compliance with the banon $KBrO_3$ and the possible heavy metal contamination in bread within the Ilorin metropolis. Thirty (30) different brands of bread were purchased randomly in the rural, peri-urban, and urban areas within the Ilorin metropolis and evaluated for $KBrO_3$ and heavy metals copper (Cu) and lead (Pb) contents, using standard methods. The results revealed that the $KBrO_3$ content ranged from 1.09 - 3.25 mg/kg in rural areas, 1.43 - 3.11 mg/kg in peri-urban areas, and 1.67 - 3.04 mg/kg in urban areas. The copper content is 0.13 - 0.85 mg/kg in the rural area, 0.25 - 0.75 mg/kg in the peri-urban area, and 0.03 - 0.79 mg/kg in the urban area. The lead content of the bread samples ranged between 0.23mg/kg and 0.43 mg/kg in the rural area, 0.29 mg/kg and 0.43 mg/kg in the peri-urban area, and 0.24 - 0.52 mg/kg in the urban area. The potassium bromated content of the bread samples was higher than the United States Food and Drug Agency (UN FDA) and the National Agency for Food and Drug, Administration and Control (NAFDAC) regulatory standard of 0.02 mg/kg, while that of the copper and lead were below the NAFDAC regulatory standard of 1 mg/kg and 1.5 mg/kg respectively. Therefore, the relevant regulatory agencies in Nigeria must establish strict standards for the manufacturing of bread and carry out routine inspections of bakeries to ensure that bakers are not violating the law and that the environment and even the materials they use are free of any contamination for the safety of the consumers.

Keywords: Food safety, Commercial bakeries, Potassium bromate, Heavy metals, Regulatory standards

1. INTRODUCTION

Bread is an important source of food in Nigeria and is consumed extensively in homes, restaurants and hotels. Bread usually contains several ingredients that would help improve its quality. Some of the basic identified ingredients apart from flour are table salt, sugars, flavours, and at least a dough improver, such as potassium bromate ($KBrO_3$), ascorbic acid, and ethylene diamine tetra-acetic acid (EDTA), among others (Vicki, 1997; Airaodion *et al.,* 2019).

Due to its effective oxidising properties, potassium bromate ($KBrO_3$) is a food additive and is frequently used as a flour-enhancing ingredient in Nigeria (Emeje *et al.*, 2010). This is because it converts the gluten protein's sulfhydryl groups in flour into disulphide linkages, strengthening the protein network and making it less extensible and more elastic. As a result, the dough becomes viscoelastic and can hold onto the carbon dioxide gas that the yeast produces (Nakamura*et al.*, 2006).Normal baking at high temperatures transforms poisonous $KBrO_3$ into potassium bromide (KBr) (non-toxic). However, if the dough is ignited for a shorter period or if the operation is not carried out at a high enough temperature, the residual quantum of $KBrO_3$ may be set up. Also, if more than the recommended amount of $KBrO_3$ is used, the final product's texture may be affected (Nakamura*et al.*, 2006). Furthermore, because consumers prefer their bread to seem pleasant to the eye, baking without $KBrO_3$ results in sized holes in the completed product that are small, huge and pleomorphic. Hence, $KBrO_3$ is necessary to produce fine and evenly-sized holes in bread and other baked goods.

The bakers have taken advantage of the $KBrO_3$

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property to increase their profits, thereby disregarding the regulatory limit of 0.02 mg/kg set by the National Agency for Food and Drug Administration and Control (NAFDAC, 2006) and the United State Food and Drug Agency (US FDA) (Emeje *et al.*, 2010) because of the potential health risks. It has been discovered over time that $KBrO_3$ is hazardous and may cause cancer in humans (Kurokawa *et al.*, 1990). The World Health Organization (WHO) discovered in the early 1990s that $KBrO_3$ added to the dough made into bread can result in illnesses like cancer, kidney failure, and various other linked illnesses, which led to its ban in several nations, including Nigeria. Yet, many Nigerian bakers still use it to make bread in spite of the restriction (FAO/WHO, 1999).

Heavy metals, in addition to $KBrO_3$, are another potential factor in human cancer. Because of their universality and toxic effects, even at low concentrations, heavy metals are given special attention worldwide. There have been numerous reports of human illnesses, diseases, organ malfunctions, and malformations brought on by metal toxicity (Jarup, 2003). The dietary channel is the main method by which humans are exposed to heavy metals (Hubbard and Lindsay, 1979). Flour that may have been made from contaminated raw materials has the potential to contaminate bread with heavy metals. The water used to make bread may also be contaminated with heavy metals. According to a research conducted by Ahmed and Fadel (2012), the type of baking fuel used to make bread could also be responsible for heavy metal contamination.

Elements such as Cadmium, Chromium and Lead are considered carcinogenic, while Iron, Copper, Zinc, Nickel, and Manganese are considered essential metals However, if the concentrations of the latter elements are higher than the permissible limits, they may create toxic effects in humans (Gulfrazi *et al.*, 2003). Many researchers have carried out studies on the levels of heavy metals in various foods in many parts of the world (Gulfrazi *et al.*, 2003; Fubara and Christian, 2006; Osuand Odeemelamo, 2007; Onyedika and Nwosu, 2008; Edem *et al.*, 2009; Yebpella *et al.*, 2011). Despite being a major staple food in many homes, there has been little or no information on the levels of heavy metals in loaves of bread produced in the Ilorin metropolis.

This study aims to evaluate the compliance of commercial bread bakers to safety standards in Ilorin metropolis. This is because monitoring compliance with the ban of $KBrO_3$ and the possible presence of heavy metals in bread is necessary for issues of public health concerns.

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2. MATERIALS AND METHODS

A total of thirty brands of bread were used in this study. They were purchased randomly in the rural (Eyenkorin- Latitude 8.4° N, Longitude 4.46667° E), peri-urban (Irewolede- Latitude 8.43333° N, Longitude 4.58333° E) and Urban (Tanke- Latitude 8.4751° N, Longitude 4.6289° E)areas within Ilorin metropolis. About 10g sample was taken from the centre of the loaf of each bread and dried to constant weight in an oven at 55°C. The crust was ground to a fine powder and used for analysis.

2.1 Potassium Bromate Determination

The $KBrO_3$ in the bread samples was qualitatively analysed using previously reported methods (El Harti *et al.,*2011). About 1g of the prepared bread sample was weighed into a test tube, and 10 ml of distilled water was added. The mixture was stirred properly and allowed to stand for 20 min at 28 ± 10°C. A 5 ml volume was decanted from the test tube and 5 ml of freshly prepared 0.5% potassium iodine solution in 0.1N hydrochloric acid was added and colour change was noted. The presence of potassium bromate was indicated by a change in colour from light yellow to purple. The absorbance of the sample was taken at 620 nm in a colourimeter (CAM-Spec. M330). The absorbance of the bread samples was converted to concentration using Beer's calibration curve that was previously constructed for potassium bromate using a standard sample.

2.2 Heavy Metal Determination

Heavy metals were determined using Atomic Absorption Spectrophotometric method as previously described by Awoyale *et al.* (2018). About 1g each of the bread sample was weighed into a 50ml digestion tube and 1ml of H_20, 2ml of HCl, 5ml HNO_2 and $HCLO_4$ (1:1), and 2ml of H_2SO_4were added. The content was heated at 200°C till the solution was clear and transparent. The digest was cooled and filtered using filter paper of 1mm into a standard 50ml volumetric flask, then made to mark with distilled water. A blank digestion solution was also prepared for comparison. The standard for each element was prepared for calibration. Heavy metal measurements were carried out using atomic absorption spectrophotometer (Bosch 752N-VIS). The Hallow Cathode lamp of each metal was used at the specific wavelength of the metal.

2.3 Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 21.0, was used to analyse all the data. One-way analysis of variance (ANOVA) and Duncan's multiple range test were used for the comparison of means. The differences between means were significant at$p<0.05$.

3. RESULTS AND DISCUSSION

3.1 *Potassium Bromate Content*

The findings showed that for rural, peri-urban, and urban locations, the mean values of the KBrO3 in the bread samples are 1.96 mg/kg, 2.15 mg/kg and 2.40 mg/kg. These results are higher than the 0.02 mg/kg regulatory limit set by the National Agency for Food and Drug Administration and Control (NAFDAC) and the United States Food and Drug Agency (Ekop *et al.* 2008).The bread samples that were obtained in the rural area had $KBrO_3$ contents that ranged from 1.09 mg/kg in sample RB007 to 3.25 mg/kg in sample RB005. The KBrO3 level of the peri-urban bread samples ranged from 1.43 mg/kg (PUB001) to 3.11 mg/kg (PUB002). The KBrO3 level of the urban area bread samples ranges from 1.67 to 3.04 mg/kg, with sample UB004, having the highest and UB008, having the lowest value. Bread samples taken from the urban area had significantly greater KBrO3 concentration (p0.05) while those taken from the rural area had lower KBrO3 levels (Figure 1). Due to its dense population, the urban region may be where profit can be maximized. Although in all the bread samples'$KBrO_3$content was higher than the permissible level. Comparable results of high $KBrO_3$content have been reported by other researchers for bread in Gwagwalada, Federal Capital Territory (Alli *et al.*, 2013); Zaria, Kaduna State (Magomya *et al.*, 2013) and Ibadan, Oyo State (Airaodion *et al.*, 2019), Nigeria. Given its harmful consequences, the presence of high quantities of KBrO3 in bread is particularly undesirable. The findings showed that all of the bread samples evaluated from the three research locations had concentrations of $KBrO_3$ at levels over the United State Food and Drug Administration (US-FDA) permitted standard. In addition, this indicates a violation of the NAFDAC's restriction on the use of $KBrO_3$ in bread (NAFDAC, 2006; Ekop *et al.* 2008). This research further showed that bread manufacturers in the Ilorin metropolis are still using KBrO3 despite its ban. So, to protect the health of the consumers, it is necessary for the relevant regulatory bodies in Nigeria to set more stringent requirements for the production of bread and conduct routine inspections of bakeries to make sure that bakers do not break the law and that the environment and even the materials they use are free of any contamination.

Table 1: Potassium Bromate Content(mg/kg)of Bread Sold in the Ilorin Metropolis

Rural Area		Peri-Urban Area		Urban Area	
Bread Samples	Contents	Bread Samples	Contents	Bread Samples	Contents (mg/kg)
RB001	...	PUB001	1.43±0.03f	UB001	2.51±0.27c
RB002	1.61±0.01d	PUB002	3.11±0.05a	UB002	2.79±0.02b
RB003	2.19±0.13c	PUB003	1.85±0.03de	UB003	2.24±0.05d
RB004	1.49±0.02d	PUB004	2.69±0.06b	UB004	3.04±0.04a
RB005	3.25±0.34a	PUB005	1.94±0.11d	UB005	2.53±0.04c
RB006	1.14±0.06e	PUB006	1.72±0.04e	UB006	1.87±0.01e
RB007	1.09±0.03e	PUB007	2.25±0.05c	UB007	2.21±0.02d
RB008	1.41±0.08d	PUB008	2.78±0.26b	UB008	1.67±0.03f
RB009	2.69±0.09b	PUB009	1.51±0.12f	UB009	2.31±0.15d
RB010	2.11±0.05c	PUB010	2.18±0.09c	UB010	2.90±0.12ab
Mean	1.96		2.15		2.40
NAFDAC Std	0.02		0.02		0.02
p level	***		***		***

Means with different letters within the same column are significantly different ($p<0.05$), p***<0.001, NAFDACstd-National Agency for Food and Drug, Administration and Control Standard

3.2 *Copper Content*

High quantities of metals may be caused by non-stainless steel mixing bowls used to knead bread dough. Heavy metal contamination of agricultural produce due to atmospheric deposition from urban and industrial regions is another possibility that could affect the final products (Awoyale *et al.,* 2018). Copper (Cu) is nutritionally an essential metal found naturally in foodstuffs. However, high dietary levels of this metal can cause toxicity because these metals are toxic when consumed in excess of what the body needs for nutrition. The levels of Cu in 30 samples of bread are shown in Table 2. Bread samples from rural, peri-urban, and urban locations had mean Cu content values of 0.57 mg/kg, 0.65 mg/kg, and 0.49 mg/kg, respectively. The sample RB008 in the rural area had the highest value (0.85 mg/kg), whereas sample RB009 had the lowest (0.13 mg/kg). The samples PUB008 and PUB009 in the peri-urban area had the highest concentration of Cu (0.75 mg/kg), while sample PUB001 had the lowest (0.25 mg/kg). The bread samples UB006 and UB007 contained the highest concentration of Cu (0.79 mg/kg), while bread sample UB008 in the urban area contained the lowest concentration (0.03 mg/kg). Bread samples from the peri-urban area had much higher Cu content than those from the urban area, which had significantly lower Cu levels (Figure 1). Perhaps this is because the bakeries in the peri-urban area are closer to industrial pollution sites or their kneading/mixing machine might not be made of stainless steel. The bread samples from Zaria had a Cu level that fell between the values reported in this study (0.13 to 0.66 mg/kg) (Magomya *et al.,* 2013).The Food and Agriculture Organization (FAO) and World Health Organization (WHO) established a maximum limit of 7.3 mg/100 g for Cu in bread, although the Cu levels in the bread samples were below that level (FAO/WHO, 2001). Hence, Cu contamination may be ruled out in the bread samples.

Table 2: Copper Content (mg/kg) of Bread Sold in the Ilorin Metropolis

Rural Area		Peri-urban Area		Urban Area	
Samples	Contents	Samples	Contents	Samples	Contents
RB001	0.75±0.00b	PUB001	0.25±0.01h	UB001	0.70±0.00d
RB002	0.25±0.00f	PUB002	0.69±0.00d	UB002	0.75±0.00b
RB003	0.75±0.01b	PUB003	0.70±0.00c	UB003	0.64±0.00e
RB004	0.35±0.00e	PUB004	0.62±0.01g	UB004	0.70±0.00c
RB005	0.82±0.00b	PUB005	0.64±0.01f	UB005	0.47±0.00f
RB006	0.68±0.00c	PUB006	0.67±0.01e	UB006	0.79±0.00a
RB007	0.45±0.00d	PUB007	0.71±0.00c	UB007	0.79±0.00a
RB008	0.85±0.00a	PUB008	0.75±0.00a	UB008	0.03±0.00i
RB009	0.13±0.00g	PUB009	0.75±0.00a	UB009	0.04±0.00h
RB010	0.65±0.00c	PUB010	0.74±0.00b	UB010	0.05±0.00g
Mean	0.57		0.65		0.49
NAFDAC Std	1.00		1.00		1.00
p level	***		***		***

Means with different letters within the same column are significantly different ($p<0.05$), $p^{***}<0.001$, NAFDACstd-National Agency for Food and Drug, Administration and Control Standard

3.3 *Lead content*

Table 3 shows the concentrations of lead (Pb) in 30 bread samples obtained from three different locations within the Ilorin metropolis. The mean values of the Pb content of bread samples from the rural, peri-urban, and urban areas were 0.31 mg/kg, 0.34 mg/kg, and 0.34 mg/kg respectively. Pb is among the most abundant heavy metals and is particularly toxic (Magomya*et al.*, 2013). The excessive content of this metal in food is associated with several diseases, especially the cardiovascular, renal, nervous, and skeletal systems. This heavy metal is also implicated in carcinogenesis, mutagenesis and teratogenesis (Magomya*et al.*, 2013).

In the rural area, the highest value of Pb in the bread samples was observed in RB009(0.43 mg/kg) and the lowest in the bread sample was RB004(0.23 mg/kg). For the peri-urban area, the highest content of Pb was observed in bread sample PUB009(0.43 mg/kg) while the lowest in bread sample wasPUB002(0.29mg/kg). The urban area has the lowest Pb content in the bread sample UB005(0.24mg/kg) and the highest value in the bread sample UB009(0.51mg/kg). There was no significant difference ($p>0.05$) in the Pb content of the bread samples collected from the peri-urban and urban areas, but that of the rural area was significantly lower ($p<0.05$) (Figure 1).The possible reason behind this may be that the bakery may be closer to premises producing industrial emissions, road traffic with leaded petrol, smoke and dust emissions from coal and gas-fired power stations, and the use of paints and anti-rust agents in the bakery (Emeje *et al.*, 2010).The Pb content in the bread samples was within the range of the value (0.34-3.13mg/kg)reported by Magomya *et al.*(2013) for different bread brands produced in Zaria metropolis of the Northern Nigeria. However, all the bread samples have Pb content below the stipulated regulatory standards of 1.5 mg/kg (NAFDAC, 2006), as well as the 2 mg/kg reported by the Codex Alimentarius Commission (CAC, 2003). Although the Pb contents in all the bread samples were within acceptable limits, they may still have toxic potentials, with detrimental impact becoming apparent after decades of exposure due to possible accumulation in the body.

Table 3: Lead content (mg/kg) of bread sold in the Ilorin metropolis.

Rural Area		Peri-urban Area		Urban Area	
Samples	Content	Samples	Content	Samples	Content
RB001	0.32±0.00c	PUB001	0.32±0.00bc	UB001	0.34±0.02d
RB002	0.26±0.00e	PUB002	0.29±0.00d	UB002	0.24±0.02e
RB003	0.34±0.02c	PUB003	0.34±0.02b	UB003	0.32±0.00d
RB004	0.23±0.00f	PUB004	0.34±0.02b	UB004	0.32±0.00d
RB005	0.29±0.00d	PUB005	0.41±0.02a	UB005	0.24±0.02e
RB006	0.37±0.00b	PUB006	0.32±0.00bc	UB006	0.46±0.00b
RB007	0.28±0.00de	PUB007	0.34±0.02b	UB007	0.32±0.00d
RB008	0.29±0.00d	PUB008	0.34±0.02b	UB008	0.26±0.00e
RB009	0.43±0.00a	PUB009	0.43±0.00a	UB009	0.51±0.03a
RB010	0.29±0.00d	PUB010	0.31±0.02cd	UB010	0.38±0.023c
Mean	0.31		0.34		0.34
NAFDAC Std	1.50		1.50		1.50
p level	***		***		***

Mean ± Standard Deviation (Std); Analysis was done in triplicate, means with different letters within the same column are significantly different ($p>0.05$), p***<0.001, NAFDAC Standard.

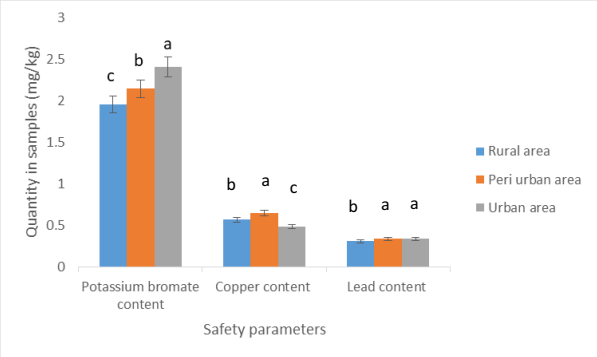

Figure 1. Combined analysis of variance of the potassium bromates, and heavy metal contents of bread sold in Ilorin metropolis.

4. CONCLUSION

The potassium bromate content of all the bread samples in the Ilorin metropolis was higher than the United State Food and Drug Agency (UN FDA) and the National Agency for Food and Drug, Administration and Control (NAFDAC) regulatory standard of 0.02 mg/kg, while that of the copper and lead were below the NAFDAC regulatory standard of 1 mg/kg and 1.5 mg/kg respectively. Thus, the bread consumed in Ilorin may not be safe due to the potassium bromated content, which was higher than the regulatory standard for food. However, the relevant regulatory agencies in Nigeria must establish stricter standards for the manufacturing of bread and carry out routine inspections of bakeries to ensure that bakers are not violating the law and that the environment and even the materials they use are free of any contamination.

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