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Analysis of Potassium Bromate in Bread and Flour Samples Sold in Jalingo Metropolis, Northern Nigeria

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Twenty different bread brands and four wheat flour brands were randomly obtained from bakeries and retail outlets in Jalingo metropolis, North-eastern Nigeria. The samples were analysed for potassium bromate using standard methods. The results obtained revealed the presence of potassium bromate in all the bread and flour samples analysed. The concentration of bromate in the bread samples ranged from 2.51 – 11.52 µg/g while for the flour samples, the concentration ranged from 2.94 – 6.86 µg/g. This study shows that bakers in Jalingo, Nigeria still make use of potassium bromate as bread improver despite its ban in 1993 by the Nigerian National Agency for Food, Drug Administration and Control (NAFDAC). Many studies have established that potassium bromate can cause detrimental health effects in humans. This implies that Consumers of the investigated bread brands sold in Jalingo face potential health risks associated with ingestion of bromate.

Keywords: *Bread, Potassium Bromate, Jalingo, Flour*

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I. Introduction

Potassium bromate, ($KBrO_3$) is an oxidizing agent commonly used by bakers to enhance bread quality. It causes flour maturation and strengthens the gluten network thereby improving gas retention and product volume. $KBrO_3$ acts as a maturing agent and dough conditioner by oxidizing the sulfhydryl groups of the gluten protein in flour into disulphide bridges making it less extensible and more elastic; this makes the dough viscoelastic such that it can retain the carbon dioxide gas produced by the yeast [1]. The overall effect of potassium bromate is improvement in bread texture and increase in loaf volume.

In 1986, the international agency for research on cancer classified potassium bromate $KBrO_3$ as a category 2B carcinogen (possibly carcinogenic to humans) based on sufficient evidence that $KBrO_3$ induces cancer in experimental animals [2]. This finding led to the ban of bromate in flour and bakery products by many countries of the world. The countries that banned the use of potassium bromate include; Argentina, Brazil, Canada, South Korea, UK, Australia, Peru and Uganda [3]. The substance was also banned in Sri Lanka in 2001, Nigeria in 2004 [4], China in 2005 and India in 2016. Countries like the U.S.A did not place a total ban on the use of $KBrO_3$ but rather set maximum limits for its use as food additive. The maximum concentration of potassium bromate allowed in bread by the US Food and Drug Agency (FDA) is 0.02 µg/g(0.02 mg/kg) [4].

The Joint Food and Agricultural Organization (FAO)/World Health Organization Expert Committee on Food Additives (JECFA) had in 1982 recommended a maximum level of 75 ppm (75 µg/g) for treating flour, provided that baked products prepared from such treated flour contain negligible residues of $KBrO_3$ [5]. The understanding that allowed the use of $KBrO_3$ was that bromate gets converted into bromide during the baking process. However, in 1989 the committee changed its position and recommended that "as a general principle, bromate should not be present in food as consumed". As residues of bromate were still detected, the committee further reduced the use limit to 60 ppm. Later in 1992, JECFA concluded that "use of potassium bromate as a flour treatment agent was not appropriate".

Several studies have shown that potassium bromate has many dangerous effects; it exerts nephrotoxic and ototoxic effects in experimental animals as well as in man. It is a carcinogen that has been shown to induce renal cell tumors, mesotheliomas and thyroid follicular cell tumors in rats [6]. Studies have also shown that $KBrO_3$ can induce multiple organ toxicity in humans and experimental animals [7, 8, 9]. $KBrO_3$ is extremely irritating and injurious to tissues especially those of the central nervous system (CNS) and kidneys [10]. Mutagenic effects of $KBrO_3$ have been also reported in experimental animals [11]. Nutritional studies have shown that $KBrO_3$ affects the nutritional quality of bread as it degrades vitamins A2, B1, B2, E and niacin which are the main vitamins available in bread [12].

In Nigeria, the use of potassium bromate in bread and related products was banned in 1993[13]. 27 years after this ban, a search of related literatures shows that compliance is very low in many cities in the country [14, 15, 16, 17, 18, 19, 20]. It is against this background that this study is undertaken to investigate the presence of potassium bromate in bread and flour samples sold in Jalingo metropolis, North eastern Nigeria.

This would help to assess the level of compliance to the bread bromate ban in Nigeria and create awareness to consumers and regulatory authorities.

II. Methodology

2.1 Study Area

Jalingo is the capital city of Taraba State in North-eastern Nigeria. It lies between latitude 08° 43´N and 09° 07´N of the Equator and longitude 10° 50´E and 11° 25´E of the Greenwich meridian, covering an approximate land mass of 59,400 square kilometres. The study area is bounded by three local governments, Lau to the North, Yorro to the East and Ardo-Kola to the south. Jalingo LGA has Tropical Continental type of climate characterised by well-marked wet and dry season. The population of Jalingo as released by the National Population Commission (NPC) in 2006 was 140, 318 people with a projected growth rate of 3.2% annually [21]. Jalingo is a state capital hence the production and consumption of bread is high in the town.

2.2 Sample Collection and Preparation

Twenty different bread brands were purchased randomly from bakeries and retail outlets in Jalingo main town. The samples were selected based on their availability and popularity among consumers. For the flour samples, the four brands of wheat flour available in the market as at the time of this study were used. The twenty bread samples were labelled A – T while the flour samples were labelled as FA, FB, FC and FD. All the samples were dried in the oven at to a constant weight, cooled, ground and stored in air tight containers.

2.3 Qualitative Analysis of potassium bromate

A 1.0 g quantity of sample was weighed out and transferred into a test tube. 10ml of distilled water was added and the mixture was shaken and allowed to stand for 20 minutes .A 5ml volume was decanted from the test tube then 5ml quantity of freshly prepared 1% potassium Iodide solution in 0.1N hydrochloric acid was added. Any color change was noted. The presence of potassium bromate was indicated by a change in color from light yellow to purple.

2.4 Quantitative Analysis of potassium Bromate

For quantitative determination of bromate, the absorbance of the samples prepared in 2.3 was taken at 620nm using a UV-Vis spectrophotometer (model 2550, shimadzu japan) and converted to concentration via a standard calibration graph of Potassium bromate absorbance against concentration [22]. The standard calibration curve was prepared by dissolving 0.25g of Potassium bromate ($KBrO_3$)in 250 ml of distilled water. Different concentrations (0, 10, 20, 30, 40, 50, 60 ppm) were then prepared from the stock solution by serial dilution. A 5ml quantity of freshly prepared 1% of potassium Iodide solution in 0.1N HCl was added to 5ml of each pure sample and the absorbance was taken at 620 nm in accordance with the experimental conditions. The absorbance was plotted against the concentration values. The working graph thus obtained was used to estimate the concentration of bromate in the bread and flour samples.

III. Results and Discussions

The levels of potassium bromate in bread samples analyzed are presented in (Table 1). Values presented are a mean of three replicate determinations. The sample with the least concentration of potassium bromate is sample C (2.51µg/g) while the highest concentration was found in sample A (11.52µg/g). These levels indicate that bakers in Jalingo metropolis do not comply with the 'bromate in bread ban' stipulated by the National agency for drug admistration and control (NAFDAC) in Nigeria. The maximum amount of potassium bromate allowed in bread by the FDA is 0.02 µg/g [3]. Again, all the bread samples analysed contained Bromate in concentrations that far exceeded the FDA permissible limit. Sample C with the lowest bromate concentration (2.51 µg/g) is about 125 times higher than the FDA standard while sample A which had the highest concentration (11.52 µg/g) is over 576 times higher than the FDA safe limit. Such high concentration of bromate in bread is a cause for concern as it implies high risk to the consumers of the bread brands. Some of the deleterious effects that may result from consumption of high levels of bromate are abdominal pain, diarrhea, nausea, vomiting, kidney failure, oligonuria, anuria, deafness, vertigo, hypotension, depression of the central nervous system, and cancer [23, 24]. In addition the nutritional quality of the bread would be affected as potassium bromate is known to degrade essential fatty acids and vitamins such as A2, B1, B2, E and niacin [2, 23]**.** Although the lethal dose of $KBrO_3$ in man has not been accurately established, it is estimated at about 5 to 500 mg/kg body weight [11].

Table 1: Qualitative and Quantitative Determination of Potassium Bromate in Selected Bread Samples Sold In Jalingo, Nigeria

Sample Code	Color Reaction With Potassium Iodide (Qualitative Test)	Concentration Of Potassium Bromate (µg/g)
A	Dark purple	11.52 ± 0.10
B	Light purple	2.86 ± 0.42
C	Light purple	2.51 ± 0.25
D	Light purple	3.94 ± 0.12
E	Dark purple	7.14 ± 0.09
F	Dark purple	6.28 ± 0.74
G	Dark purple	7.64 ± 0.55
H	Dark purple	6.97 ± 0.64
I	Dark purple	5.01 ± 0.80
J	Purple	4.84 ± 0.02
K	Purple	4.59 ± 0.22
L	Purple	5.69 ± 0.72
M	Purple	4.68 ± 0.06
N	Purple	4.50 ± 0.15
O	Purple	4.24 ± 0.35
P	Purple	4.37 ± 0.60
Q	Light purple	3.14 ± 0.17
R	Purple	3.41 ± 0.34
S	Light purple	3.06 ± 0.42
T	Dark purple	10.29 ± 1.02

Values are presented as mean ± Standard deviation (S.D) for three (3) replicate determinations

Figure 1 presents a comparison of the mean Bromate level in this study with the levels that been reported for other cities in Nigeria. The range of values obtained in this study (2.51 – 11.52 µg/g) is comparable to the values (3.6 -9.2 µg/g) reported by Alli *et al*., [1] and 1.24 – 9.31 µg/g reported by Airaodion *et al.,* [14] in studies carried out in Gwagwalada Abuja and Ibadan respectively. A study by Emeje *et al* [15] which analysed bromate levels in bread brands sold in Abuja reported a concentration range of 1.01 – 11.33µg/g. Silimilarly, Magomya *et al.,* [16] reported bromate concentration range of 2.46 – 13.60 µg/g in a study of bread samples sold in Zaria Nigeria. These values are also in close agreement with the values we report in this study. Oyekunle *et al.,* [17] reported higher values than the present study; bromate concentration range of 6.33 – 41.336 µg/g was obtained in their stuidy of bread brands sold in ile ife metropolis of south-western Nigeria. Obunwo *et al.,* [18], Kelle *et al.,* [19] and Ojo *et al* [20] reported 0.12 – 7.28 µg/g, 1.4 – 5.1 µg/g and 0.5 -8.4 µg/g, as the concentration ranges of bromate in bread brands sold in port-harcourt, Asaba and Karu, Nigeria respectively. These values are lower than the values we report in this study. Overall our comparative evaluation (Fig. 1) shows that the bromate levels of bread brands sold in jalingo is similar to the values that have been reported for other cities in Nigeria with the exception of the study carried out in Ibadan which revealed much higher values.

Bromate analysis was carried out on four wheat flour samples from the bakeries in the study area (Jalingo) are likely to have baked their bread brands from. The analysis was done in order to ascertain if the source of the bromate in the bread samples is from the flour producers and not the bakers. The result of the analysis (Table 2) revealed a concentration range of (2.94 – 6.86 µg/g). These values are comparable to the levels obtained for the investigated bread samples with the exception bread samples A and T which had higher bromate levels. While these findings suggest that the producers of the investigated flour brands may have added bromate to their products, it would be wrong to draw such conclusions because bromates can also be introduced into flour from other sources. Bromates are known to be formed when bromine dissolves in water and many foods have a natural content of bromine in the range of 1 -10 mg/kg or more. Flour has natural bromine content of 2.4-7.7 mg/kg [25]. This suggests that the level of bromate (2.94 – 6.86 mg/kg) recorded for the investigated flour samples in this study may not necessarily be an indication that the flour producers also add bromate to their products.

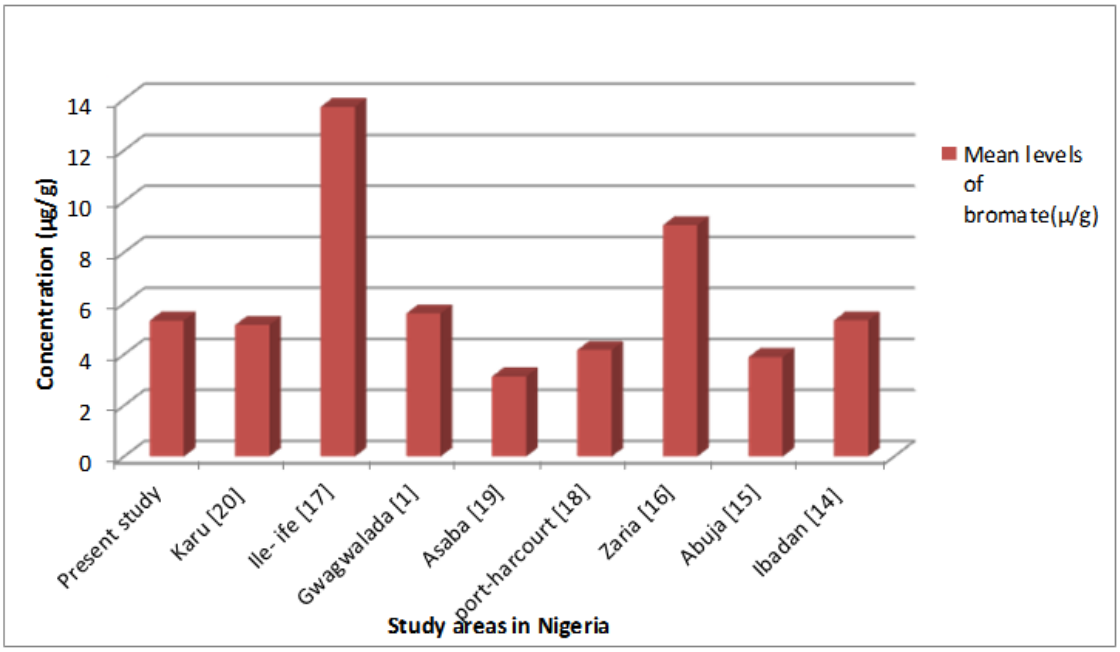

Figure 1: Comparison of mean bromate level in the present study with mean levels that have been reported for other study areas in Nigeria

It has been shown that when potassium bromate is present in flour at levels of 50 mg/kg or less, no residual potassium bromate would be detected in bread prepared from the flour. This is because Potassium bromate is quantitatively converted to a relatively harmless bromide in bread after 20-25 minutes baking. However, if too much of the additive is used, or the bread is not baked long enough or at a high enough temperature, then a residual amount will remain. On this basis, regulatory agencies in some countries are not strict on the prohibition of bromate as an additive in flour however most countries are definite on the need to have no bromate or minimal quantities in bread.

Table 2: Concentration of Potassium Bromate in Wheat Flour Samples Sold In Jalingo, Nigeria

Sample Code	Color Reaction With Potassium Iodide (Qualitative Test)	concentration of potassium bromate (µg/g)
FA	Light purple	2.94 ± 0.14
FB	purple	4.03 ± 0.09
FC	Light purple	2.94 ± 0.44
FD	Dark purple	6.86 ± 1.04

Values are presented as mean ± Standard deviation (S.D) for three (3) replicate determinations

IV. Conclusion

It is clear that potassium bromate is still widely used as bread improver by bakers in Nigeria. This study revealed the presence of bromate in all the bread and flour samples analysed. The main reason for the preference of $KBrO_3$ over other alternatives is likely because it is a cheap and very efficient oxidizing agent which produces high quality of bread. There is need for regulatory bodies in Nigeria to carry out regular monitoring and enforcement of the bromate in bread ban. Apart from enforcing the ban, it is important to also sensitize bakers on safer alternatives. There are several other improvers and flour treatment agents which are considered as safer alternatives health wise. For example, ascorbic acid is considered as a healthy alternative by experts. Glucose oxidase is also another safer alternative known to perform similar functions as potassium bromate. There are several other improvers and flour treatment additives approved by law in many countries; they include ammonium persulphate, ammonium chloride and amylases. Bakers should be encouraged to use these alternatives in order to safe guard human health.

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