

# QUANTITATIVE AND QUALITATIVE ASSESSMENT OF POTASSIUM BROMATE IN COMMERCIAL BREAD SOLD IN ENUGU METROPOLIS

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## Abstract

Potassium bromate ( $\text{KBrO}_3$ ) is an additive and flour improver widely used in the baking industry to enhance dough elasticity, loaf volume, and texture. However, due to its carcinogenic and nephrotoxic properties, its use in food products has been banned in many countries, including Nigeria. This study evaluated the presence and concentration of potassium bromate in commercially available bread sold within Enugu Metropolis, Enugu state, Nigeria. Fifteen bread brands obtained from various retail outlets and bakeries within Enugu Metropolis were analyzed by spectrophotometric method at an absorbance wavelength of 515 nm. This is based on the redox reaction between potassium bromate and promethazine hydrochloride in acidic medium. Qualitative determination was achieved through colorimetric observation where the intensity of pink coloration observed correlated positively with bromate concentration. Results revealed potassium bromate concentrations ranging from 0.01 to 0.47  $\mu\text{g/g}$ . 10 bread samples out of the fifteen samples analyzed, exceeded the permissible limit of 0.02  $\mu\text{g/g}$  recommended by the United States Food and Drug Administration (FDA). The findings indicate poor compliance with regulatory restrictions on potassium bromate use in bread production and suggest potential public health risks associated with chronic dietary exposure. Continuous surveillance, stricter enforcement of food safety regulations, and adoption of safer alternatives such as ascorbic acid and enzyme improvers are strongly recommended.

**Keywords:** Potassium bromate, Bread, Spectrophotometry, Food safety, Enugu Metropolis, Carcinogenicity, Bakery products

## Introduction

Bread is a carbohydrate food source prepared from mixed yeast and leavened dough obtained from flour made from cassava or wheat with bromate or phosphate as enhancer in the presence of *Saccharomyces cerevisiae* (yeast). Bread is one of the widely consumed staple foods and a major component of the daily diet globally, including Nigeria. It is widely consumed by people of all classes, religion, region, race and sex. It is easily and readily prepared in most homes and in almost all communities. Though the cost of bread has increased over the years, the consumption has not decreased (Oyibo *et al.*, 2025). Bread is easy to prepare, usually comes ready to eat, easy to carry about, with appreciable storage quality and shelf life. It is rich in carbohydrate, a major source of energy and contains other nutrients-proteins, fats, minerals and

vitamins- depending on the source of flour and other additives during preparation(Oyibo *et al.*, 2025).

To improve bread texture, elasticity, and shelf stability, bakery industries often employ oxidizing agents during dough preparation. Among these agents, potassium bromate ( $\text{KBrO}_3$ ) has historically been favored because of its efficiency in strengthening dough and increasing loaf volume (Diachenko and Warner, 2002). Despite these technological advantages, potassium bromate has attracted considerable scientific and regulatory concern due to its toxicological effects. Potassium bromate is a strong oxidizing agent commonly used in flour treatment and dough conditioning. During baking, bromate is expected to be reduced to potassium bromide, a less harmful compound. However, incomplete reduction due to excessive use or insufficient baking temperatures may result in residual bromate in finished bread products (Diachenko and Warner, 2002; Etinosa and Raimo, 2023).

Several studies have documented the toxicological implications of bromate exposure. Kurokawa and colleagues (1990) and Giesecke, A. G. and S. A. Taillie. (2000) reported that potassium bromate induces renal carcinogenicity in experimental animals. Similarly, National Agency for Food and Drug Administration and Control banned the use of potassium bromate in bread production due to associated health risks.

Studies have demonstrated that potassium bromate possesses nephrotoxic, neurotoxic, ototoxic, mutagenic, and carcinogenic properties. Experimental investigations have linked prolonged exposure to renal cell tumors and oxidative tissue damage (Kurokawa *et al.*, 1990). Consequently, regulatory authorities such as the National Agency for Food and Drug Administration and Control (NAFDAC) (2003) in Nigeria and the United States Food and Drug Administration (FDA) have prohibited or restricted its use in bakery products.

Despite these bans, reports continue to indicate the presence of potassium bromate in commercially produced bread across several Nigerian cities. The persistence of its use may be attributed to inadequate monitoring, lack of awareness among bakers, and the low cost of bromate compared to safer alternatives. Since bread is consumed daily by individuals of all age groups and socioeconomic backgrounds, the continued presence of potassium bromate in bread represents a significant public health concern.

Research conducted in various parts of Nigeria revealed varying concentrations of potassium bromate in commercial bread samples. Previously, Emejeet *et al.*, (2010) reported bromate concentrations ranging between 1.2 and 10.4  $\mu\text{g/g}$  in bread samples analyzed in Eastern Nigeria. Comparable findings were also reported in Kaduna Metropolis, indicating widespread non-compliance with food safety regulations. The evaluation carried out in Awka Metropolis revealed the level of bromate in the bread samples ranged between 5.309+0.023ppm to 9.136+0.024ppm and results from the toxicological study showed a significant increases( $p<0.05$ ) in the ALT and AST activities of the animal groups tested (Okafor *et al.*,

2013). In southwest Nigeria around Ile Ife Bromate levels in the analyzed bread samples ranged from  $2.051 \pm 0.011 \mu\text{g/g}$  to  $66.224 \pm 0.014 \mu\text{g/g}$  (Oyekunle *et al.*, 2014).

Alternative bread improvers such as ascorbic acid and enzyme preparations have been proposed as safer substitutes for potassium bromate. These alternatives improve dough characteristics without producing toxic residues.

This study aimed to determine the qualitative and quantitative presence of potassium bromate in selected bread brands sold within Enugu Metropolis, Enugu state, Nigeria, using a UV-visible spectrophotometric method.

## **Materials and Methods**

### **Study Area**

The study was conducted within Enugu Metropolis, Enugu state located in southeastern Nigeria. Bread samples were obtained from supermarkets, retail outlets, and bakeries situated in different parts of the Enugu metropolis.

### **Sample Collection**

Fifteen different brands of bread were randomly purchased from various commercial locations including Ogui Road, Presidential Road, GRA, Asata, New Haven, UNEC, and Agbani road areas of Enugu State.

### **Chemicals and Reagents**

Analytical-grade reagents were used in this study and were obtained from Sigma Chemical, USA. They included:

- Potassium bromate standard
- Promethazine hydrochloride
- Hydrochloric acid (12 M)
- Distilled water

### **Quantitative analysis**

#### **Preparation of Standard Solution**

Aliquots of potassium bromate stock solution (100–1000  $\mu\text{L}$ ) were transferred into 20 mL test tubes. One milliliter of 0.01 M promethazine hydrochloride was added, and the solutions were diluted to 10 mL using distilled water. Subsequently, 0.2 mL of 12 M hydrochloric acid was added, and the mixtures were shaken thoroughly for one minute. Absorbance measurements were taken at 515 nm using a UV-visible spectrophotometer to construct the calibration curve (El. Harti *et al.*, 2011).

### Preparation and Analysis of Bread Samples

Ten grams of bread from the center of each loaf were dried at 75°C for one hour and pulverized into powder form. One gram of each powdered sample was mixed with 20 mL distilled water and filtered using Whatman No. 1 filter paper. Eight milliliters of filtrate were transferred into a volumetric tube, mixed with 1 mL promethazine hydrochloride and 0.2 mL hydrochloric acid, and analyzed spectrophotometrically at 515 nm (El. Harti *et al.*, 2011).

### Qualitative Analysis

The qualitative determination involved direct addition of promethazine hydrochloride and hydrochloric acid to portions of bread samples. Development of a pink coloration indicated the presence of potassium bromate.

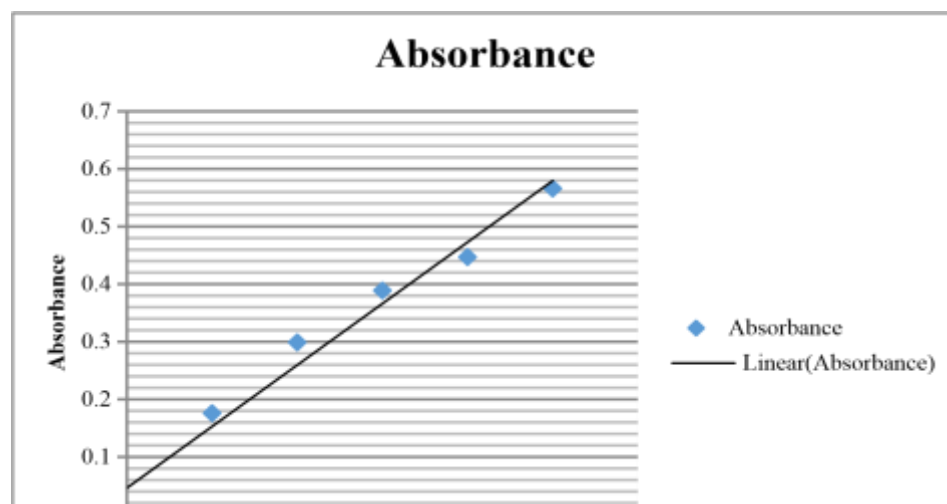
### Statistical Analysis

Data obtained were analyzed descriptively and presented in tables and figures. Bromate concentrations were compared with the FDA permissible limit of 0.02 µg/g.

### Results

**Table 1: CALIBRATION CURVE: ABSORBANCE AT 515 NM USING A UV-VISIBLE SPECTROPHOTOMETER**

| Concentration | Absorbance |
|---------------|------------|
| Blank (0)     | 0          |
| 5             | 0.176      |
| 10            | 0.299      |
| 15            | 0.389      |
| 20            | 0.447      |
| 25            | 0.566      |



**Table 2: RESULTS OF QUALITATIVE ANALYSIS OF POTASSIUM BROMATE IN SOME BRANDS OF BREAD SOLD IN ENUGU METROPOLIS**

| S/N | BREAD<br>SAMPLES | MANUFACTURE<br>LOCATION       | QUALITATIVE<br>TEST | COLOUR CHANGE<br>(QUALITATIVE TEST) |
|-----|------------------|-------------------------------|---------------------|-------------------------------------|
| 1   | A                | Four Market Days Ogui Rd      | —                   | Black                               |
| 2   | B                | Kilamanjaro Ogui Road         | —                   | Black                               |
| 3   | C                | Citi Chef Emene               | +                   | Pink                                |
| 4   | D                | Market Square Ogui Rd         | +                   | Pink                                |
| 5   | E                | Crunches Presidential Rd      | —                   | Black                               |
| 6   | F                | Shop Rite GRA, Polo Park mall | —                   | Black                               |
| 7   | G                | Chimex, Asata                 | +                   | Pink                                |
| 8   | H                | Roban Stores Trans Ekulu      | —                   | Black                               |
| 9   | I                | Timeless, New Haven           | +                   | Pink                                |
| 10  | J                | Spar Presidential Rd          | —                   | Black                               |
| 11  | K                | Genesis Zik Avenue            | +                   | Pink                                |
| 12  | L                | Chicken Republic Agbani Rd    | +                   | Pink                                |
| 13  | M                | Kumac UNEC                    | +                   | Pink                                |
| 14  | N                | Sky Limit Shopping Centre     | +                   | Pink                                |
| 15  | O                | Grand Master Stores           | +                   | Pink                                |

**Table 3: RESULTS OF QUANTITATIVE ANALYSIS OF POTASSIUM BROMATE IN SOME BRANDS OF BREAD SOLD IN ENUGU METROPOLIS**

| <b>S/N</b> | <b>BREAD SAMPLES</b> | <b>MANUFACTURE LOCATION</b> | <b>QUANTITY OF Potassium bromate (KBrO<sub>3</sub>) (µg/g)</b> | <b>US FOOD AND DRUG AGENCY(FDA) PERMISSIBLELIMITS</b> |
|------------|----------------------|-----------------------------|----------------------------------------------------------------|-------------------------------------------------------|
| <b>1</b>   | <b>A</b>             | Four market days Ogui Rd    | 0.02                                                           | 0.02ug/g                                              |
| <b>2</b>   | <b>B</b>             | KilamanjaroOgui Road        | 0.01                                                           | 0.02ug/g                                              |
| <b>3</b>   | <b>C</b>             | Citi ChefEmene              | 0.2                                                            | 0.02ug/g                                              |
| <b>4</b>   | <b>D</b>             | Market Square OguiRoad      | 0.18                                                           | 0.02ug/g                                              |
| <b>5</b>   | <b>E</b>             | CrunchesPresidential Road   | 0.015                                                          | 0.02ug/g                                              |
| <b>6</b>   | <b>F</b>             | Shop RiteGRA, PoloPark mall | 0.017                                                          | 0.02ug/g                                              |
| <b>7</b>   | <b>G</b>             | Chimex, Asata               | 0.29                                                           | 0.02ug/g                                              |
| <b>8</b>   | <b>H</b>             | Roban Stores, Trans Ekulu   | 0.019                                                          | 0.02ug/g                                              |
| <b>9</b>   | <b>I</b>             | Timeless, New Haven         | 0.13                                                           | 0.02ug/g                                              |
| <b>10</b>  | <b>J</b>             | SparPresidentialRoad        | 0.015                                                          | 0.02ug/g                                              |
| <b>11</b>  | <b>K</b>             | GenesisZik Avenue           | 0.38                                                           | 0.02ug/g                                              |
| <b>12</b>  | <b>L</b>             | ChickenRepublicAgbani Rd    | 0.47                                                           | 0.02ug/g                                              |
| <b>13</b>  | <b>M</b>             | KumacUNEC                   | 0.22                                                           | 0.02ug/g                                              |
| <b>14</b>  | <b>N</b>             | Sky LimitShopping Centre    | 0.32                                                           | 0.02ug/g                                              |
| <b>15</b>  | <b>O</b>             | Grand MasterStores          | 0.18                                                           | 0.02ug/g                                              |

## Discussion

Potassium bromate is used widely in the baking industry, as an oxidizing agent, an additive and perfects the rheological properties of the final product. However, studies have shown numerous toxic to carcinogenic effects of potassium bromate which negates all its numerous benefits.

The results from this study revealed the presence of potassium bromate in all bread samples analyzed, with concentrations ranging from 0.01 to 0.47 µg/g. 10 (ten) of the fifteen samples contained bromate levels above the permissible NAFDAC (2003) and FAO/WHO(1992) limit (0.025ppm of potassium bromate), indicating substantial non-compliance with food safety regulations. The positive correlation observed between the intensity of pink coloration and bromate concentration validates the effectiveness of the qualitative screening method employed (El Harti *et al.* 2011). Results obtained are consistent with previous results, (Emejeet *et al.*, 2010) reported in Eastern Nigeria of bromate concentrations ranging between 1.2 and 10.4 µg/g in bread samples analyzed. Also with studies in three local government areas of Kano metropolis, Kano state, Nigeria, ranging from 0.07ppm to 9.53ppm (Oyibo *et al.*, 2025). In Jos Metropolis quality assessment revealed that, all the Bread samples brands contained potassium bromate in a quantity that exceeded the minimum allowed by the FDA (0.020 ppm) and WHO (0.025 ppm) (Ogah *et al.*, 2021). Also, previous reports from other Nigerian cities, suggesting that the illegal use of potassium bromate remains prevalent in the Nigerian baking industry. The chronic consumption of bromate-contaminated bread may expose consumers to serious health risks including kidney damage, neurological disorders, hearing impairment, and carcinogenicity. Bakery workers may also be exposed through inhalation of bromate-containing flour dust during processing (Kurokawa *et al.*, 1990). The persistence of bromate use may be attributed to its low cost, availability, and effectiveness as a dough improver (Etinosa and Raimo, 2023). However, safer alternatives such as ascorbic acid, hemi-cellulases, glutathione oxidase, and exo-peptidases are available and capable of improving bread quality without adverse health consequences.

## Conclusion

This study confirmed the heavy and widespread presence of potassium bromate in commercially available bread sold in Enugu Metropolis, Enugu state, Nigeria. Although some samples complied with permissible safety limits, majority exceeded the recommended standards, thereby posing potential health risks to consumers, particularly the vulnerable population-Children, women and the elderly. Bread is a staple food consumed on a regular basis by residents in Enugu metropolis irrespective of their socio economic status, and calls for public health concern on the high dietary exposure of residents living within the study area to potassium bromate through bread consumption. The bakers and other bakery workers are also exposed to additional risk from inhaled bromate. Consequently there may be future occurrence of carcinogenicity and other symptoms associated with chronic exposure to high level of potassium bromate in the community. The findings emphasize the need for stronger regulatory enforcement, continuous surveillance, and increased public awareness regarding the dangers associated with potassium bromate consumption.

## Recommendations

It is therefore recommended that Regulatory agencies such as National Agency for Food and Drug Administration (NAFDAC) and Standards Organization of Nigeria (SON) should intensify routine inspection and monitoring of bakeries, as well as sponsor public awareness campaigns to educate consumers on the dangers of potassium bromate. Also, strict penalties should be imposed on manufacturers violating the potassium bromate bans. In addition, bakers should adopt safer alternatives such as ascorbic acid and enzyme improvers. Finally, further studies on this involving larger sample sizes using advanced analytical techniques and studies into organic and local sourced raw materials are recommended.

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