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Investigation of Potassium Bromate and Iodate Concentrations in Breads in Eket Metropolis

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ABSTRACT
The concentrations of potassium bromate and potassium iodate additives in bread consumed within Eket metropolis, Nigeria were investigated using spectrometric and iodometric titration methods respectively. Bread samples from ten bakeries were assessed. Bromate was detected in bread samples from four bakeries, while samples from three bakeries had iodate. Both additives were present in bread samples from two bakeries, but iodate alone was detected in samples from only one bakery. Neither bromate nor iodate was detected in bread samples from five bakeries. It is possible that bread samples from those five bakeries did not contain the additives or they contained concentrations lower than the detection limits of the methods used in this study.The concentration of potassium bromate detected in the bread samples ranged from 1.45 ± 0.63- 4.48 ± 0.25(µg/g), while potassium iodate ranged from 2.43 ± 0.22 - 5.71± 1.66(µg/g); however, the allowable maximum limits of potassium bromate in bread according to NAFDAC and FDA is 0.02µg/g. In those bread samples that contained bromate, the additive concentrations exceeded these stipulated regulatory limits and therefore poses health risk to consumers within the study area who depend on these products as one of the most commercially available staple foods. Although potassium iodate is approved to be use as a dough strengthener at a maximum concentration of 0.0075% per weight of flour, unhealthy ingestion may result in dysfunctions associated with the thyroid gland. This behooves on NAFDAC to further enlighten bakers and bread consumers regarding the risks with use of these additives above recommended regulatory limits.

Keywords: **Potassium Bromate, Potassium Iodate, Bread, Bakeries, food additives.**

INTRODUCTION

Bread is one of the oldest staple food items consumed right from ancient times. In Nigeria it is consumed by people regardless of their ethnic or socio-economic status. Potassium bromate ($KBrO_3$) is a food additive that functions as an oxidizing agent and used in baking industry to enhance bread quality. It causes flour maturation, strengthens gluten network, improve gas retention in dough and increase bread volume (Magomya *et al.,* 2020). The substance is very efficient in increasing dough size and profit yield for bakers (Emeje *et al,* 2010).

Inhalation and ingestion are common ways through which people consume potassium bromate. Many factory workers have limited safety knowledge thus; they get exposed to unsafe doses of the toxic chemical during baking process. Oloyede and Sunmonu (2009) added that bakery workers inhale bromate which can result in hepatotoxic and nephrotoxic effects. Painful eyes, cough, diarrhea, and sore throat are the most recurrent symptoms of toxicity, while the least of all symptoms often experienced by bakers is kidney disorder. Also, consumers get poisoned with potassium bromate by ingestion when they eat from bread meals. When baking is done at sufficient high temperature and time, potassium bromate is converted to a harmless bromide. However, if the baking is done with large quantity of bromate or with shorter baking time and/or at low baking temperatures, then the unconverted residual bromate which remains in the bread becomes toxic to consumers' health (Etukudo *et al,* 2024). This has prompted regulatory agencies in different countries to ban, regulate and set the permissible limit at 0.02 µg/g of potassium bromate in bread (Omotoso, 2021). The optimum level of iodate to use in baking is recommended to be between 10-20 mg/kg of dought (Wieser, 2003).

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Atkins (1993) pointed that potassium bromate induce adverse effects in humans; causes cough and sore throat when inhaled. Abdominal pains, diarrhea, nausea, vomiting, kidney failure, hearing loss, bronchial and ocular problems. Due to the negative implications on human health it has been banned in many countries.

Human nutrition is sometimes deficient of certain essential nutrients such as iodine both in the developing and developed countries of the world. Iodine is known to be one of many critical nutrients world-wide with about two billion people having inadequate iodine nutrition on a global scale (Winger *et al.* 2008). Lack or inadequate supply of iodine in human nutrition has been linked to some health problems including mental retardation, goiter, cretinism and childhood mortality. Thus, iodine deficiency disorder is not only a nutrition and public health concern; but it is also seen to be a major problem to human and economic development (Chavasit*et al.,* 2002).

The FDA establishes US food regulations and policies while the Codex Alimentarius (Codex), develops international food standards and guidelines through FAO and the WHO. As an example FDA and Codex call insist on labeling of table salt to indicate fortification with iodine, voluntary labeling of iodine on foods and a Daily Value of 150 µg for iodine (Trumbo, 2016). Calcium iodateand potassium iodate is permitted to be use as a dough strengthener during the manufacture of bread at a maximum concentration of 0.0075% per weight of flour.

Potassium iodate may be used in a food to supply iodine, as long as the maximum intake of the food will not result in daily ingestion of iodine beyond 225 µg for foods labeled without reference to age or physiologic state or, when age or physiologic state (pregnancy or lactation) are specified, in excess of 45 µg for infants, 105 µg for children aged less than 4 years, 225 µg for adults or children aged greater than 4 years, and 300 µg for pregnant or lactating women (Trumbo, 2016). This implies that excess ingestion of iodide will depend on the size of the food consumed by the individual.

One of the recommended ways to prevent iodine deficiency in food is by the fortification of edible salts with iodine, either in the form of iodide or iodate. Since potassium iodate has greater stability than potassium iodide, especially in the presence of impurities, humidity, and porous packing, iodate is the recommended form in tropical countries and those with low grade salt (Zimmermann, 2009).

Bakery products are also potential channels for enrichment of essential nutrients since they are consumed often by many people as ready to eat foods. Potassium iodate can also be used in baking industry to improve the quality of bakery products (Špačková *et al.,* 2001).

The use of both potassium bromate and potassium iodate is banned in several countries due to their ill effects on health, but in some countries, they are use under permissible limits (Duvvuri *et al.,* 2016). In Nigeria the use of potassium bromate in flour milling and baking has been banned by NAFDAC since 1993 (Akunyili, 2004).

JECFA (1965) opined that potassium iodate should not be used in flour treatment to avoid excessive intake of iodine due to its high physiological significance and potency. Its use may result in a daily intake of iodine that is over five fold higher than the recommended 100-200 µg (Scientific Opinion on Dietary Reference Values for iodine, 2016).

CSE (2016) pointed that excessive iodine intakes may accelerate the development of sub-clinical thyroid disorders of hypothyroidism or hyperthyroidism, increase the incidence of autoimmune thyroiditis and increase the risk of thyroid cancer.

In India, the Food Safety and Standards Regulations stipulated that the maximum level of potassium bromate and/or iodate in bread is 50 mg/Kg (CSE, 2016). While in flour for bakery potassium bromate is permitted with the maximum level of use at 20 mg/Kg (CSE, 2016). In Canada the health agency disallows potassium bromate use but allows potassium iodate as maturing or dough conditioning agent in bread and other bakery products (CSE, 2016). The United States Food and Drug Administration permits the use of potassium bromate, calcium bromate, potassium iodate, calcium iodate, calcium peroxide, or any combination of two or more of these if the total quantity in any bromated flour used, is not more than 0.0075 part for each 100 parts by weight of flour used (CSE, 2016).

Ascorbic acid, alongside a suitable enzyme (glutathione oxidase, glucose oxidase or hemicellulases) is an alternative to toxic potassium bromate in bread production. Omotoso (2021) suggested potassium iodate (KIO_3) as alternatives to bromate in bread making.

Eket is highly populated and regarded as the second most developed urban city, after Uyo, in Akwa Ibom State, Nigeria. There are several bakeries sited within Eket metropolis. This necessitates the assessment for the presence and concentrations of potassium potassium bromate/iodate in bread from bakeries in this region so as to inform the level of compliance with NAFDAC directives.

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MATERIALS AND METHODS

Ultra-violet spectrophotometric method, adapted from Etukudo and Ekott (2022), was used for potassium bromate assessment, while iodometric titration method, adapted from Ekott and Etukudo (2019), was used to assess potassium iodate. The bread samples were randomly selected from bakeries, weekly and within a period of two months, then safely taken to the laboratory for analyses.

Qualitative and Quantitative Assessment of Potassium Bromate:

A 25g portion of bread loaf was kept to air dry for three days in the laboratory at room temperature out of sunlight. The dried bread crust was pulverized, and then 1.0g was transferred to a beaker. 20 ml of distilled water was added to the beaker, and kept for 30 minutes to completely dissolve the bread. Thereafter, the solution was decanted into a 15ml centrifuge tubes and centrifuged at 3000 rpm for 10 minutes. The filtrate was separated from the residue using a Whatman no: 1 filter paper. 5ml of the filtrate transferred to a test tube. 5ml of freshly prepared 0.5 % potassium iodide solution in 0.1M hydrochloric acid was added to the test tube. The color change was observed for 5 minutes. The process was repeated for the other bread samples.A spectrophotometer (model: SP721E) was used to record the absorbance of the standards and the sample at 540 nm, which is the maximum absorption wavelength for potassium bromate. The absorbances were converted to concentrations from a previously constructed calibration curve that pure potassium bromate was used.

Qualitative and Quantitative Assessment of Potassium Iodate:

10g of the pulverized bread was transferred into a 250mL conical flask. 50mL distilled water was added to the flask and kept for 30 minutes tocompletely dissolve it, then filtered to collect the filtrate. To liberate free iodine from the dissolved bread sample 1.0mL of freshly prepared H_2SO_4 was added to the filtrate. The liberated free iodine was made soluble in water by adding 5mL of 10% KI to the flask. The solution turned yellow indicating the presence of iodine. To prevent photochemical reactions that could oxidize iodide ions to iodine, the flask was sealed immediately and kept in a dark drawer. After at least 10 minutes, the content of the flask was titrated with 0.005M $Na_2S_20_3$ until the solution turned pale yellow. Few drop of starch indicator solution was added; this produced a dark-purple color complex with iodine. The titration continued until the solution became pink and finally colorless. The average volume of sodium thiosulfate ($Na_2S_2O_3$) consumed and the corresponding iodine concentration is calculated and presented in table1.

RESULTS AND DISCUSSION

Table 1: Content of Potassium Bromate and Iodate in Bread Sample.

Bread Sample	**Potassium Bromte**		**Potassium Iodate**	
	Colour Change	**$KBrO_3$Content** (µg/g)	**Colour Change**	**KIO_3Content** (µg/g)
A	Light Purple (+)	3.65 ± 0.67	Light Purple (+)	2.43 ± 0.22
B	Light Purple (+)	4.48 ± 0.25	Light Purple (+)	2.73 ± 0.35
C	Light Purple (+)	1.57 ± 0.34	No visible colour change (-)	-
D	Light Purple (+)	1.45 ± 0.63	No visible colour change (-)	-
E	No visible colour change	-	Light Purple (+)	5.71± 1.66
F	No visible colour change	-	No visible colour change	-
G	No visible colour change	-	No visible colour change	-
H	No visible colour change	-	No visible colour change	-
I	No visible colour change	-	No visible colour change	-
J	No visible colour change	-	No visible colour change	-

Values represent mean ± SD of 3 replicate determinations

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DISCUSSION

Bread samples from ten bakeries were considered in this study within a period of two months. Table 1 presents the results of potassium bromated/iodate concentrations in the studied bread samples in Eket. It indicates the presence of bromate in bread samples from four bakeries, while potassium iodate was present in bread samples from three bakeries. Both bromate and iodate were detected in bread samples from two bakeries, bromate alone was present in samples from two bakeries, while iodate alone was detected for bread from one bakery.

Bread samples from bakeries A and B had high concentrations of both bromated and iodate, while samples C and D had lower concentrations of bromate. Bread sample E had no trace of bromate but iodate was observed. In these bakeries, concentrations of bromated and iodate however were observed to be present in amounts that exceeds limits set by regulatory authorities. This raises concerns of the subtle rising risks associated with consumption of these products.

From the ten bakeries assessed, bromate was detected in only four. The absence of detectable bromate in the other six bakeries could be due to the possibility that the samples contained concentrations below the detection limits of the method used or due to the increasing awareness that bakers and consumers have concerning the health risks associated with consumption of bromated bread. Some of the deleterious effects that may result from consumption of high concentrations of bromate are abdominal pain, diarrhea, nausea, vomiting, kidney failure, oligonuria, anuria, deafness, vertigo, hypotension, depression of the central nervous system, and cancer (Johnson *et al,* 2013).

Bakeries employ the use of bromate in their formulation because of economic gain, often capitalizing on poor enlightenment and enforcement. Though NAFDAC had banned potassium bromate as food additives, some bakeries, especially those sited in rural communities still use bromate in baking bread (Etukudo *et al,* 2024). The effects of bromate is cumulative, thus its continual ingestion over a period of time is detrimental to health. Regulatory agencies need to engage inpost-marketing surveillance, on the spot analysis, effective monitoring and enforcement, stringent regulations, and sustained routine and surveillance inspections to reduce or eliminate bromate use as bread enhancer (Mode *et al.,* 2023).

Human nutrition is often deficient of some essential nutrients such as iodine. Bread offers a good channel for its enrichment with iodine, which will help increase the daily intake of iodine and reduce iodine deficiency disorders which are now considered a public health concern (Chavasit*et al.,* 2002).

CONCLUSION

A good knowledge of the health consequences of any dough improver is important. This will not only give bakers multiple choice of improving agents to select from, but will reduce the incidence of health challenges. Maintenance of good health and prevention of diseases is essential for food consumers, thus the need for healthier bread products free from banned substances. (Mode *et al.,* 2023).

Information regarding the quality of bread in Eket in terms of bromate concentrations have not been previously reported. With this study, it is indicative that the health risks associated with bromate consumption could subtly be on the rise owing to the presence of bromate in quantity higher than acceptable limits in 40% of bread samples examined. Therefore, there is need for routine monitoring of potassium bromate in commercial breads in this region so as to curb the health risks associated with its consumption.

Potassium iodate which remains a good source of iodine in human diet should however be used with caution as it is a strong oxidizer and may leave residual iodine in the final product if not properly incorporated into dough. Other available bread improvers should be explored by bakers for proper and safe use while remaining compliant to regulatory limits.

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