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High Potassium Bromate Levels in Bread Brands marketed in Mwanza and Kagera regions of Tanzania: A Cross-Sectional Study

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Bread production often involves the addition of potassium bromate to enhance product quality. The study analyzed potassium bromate levels in bread brands from Mwanza and Kagera regions, Tanzania. This analysis was conducted due to the carcinogenic risks associated with potassium bromate when it exceeds the US-FDA's permissible concentration of 0.02 mg/kg. Twenty-one bread samples were randomly collected from the study areas and analyzed for potassium bromate content using David Pearson's qualitative and quantitative methods at the Tanzania Bureau of Standards laboratories. The results obtained showed that all samples contained potassium bromate, with concentrations ranging from 1.02 - 4.85 µg/g, which is significantly above the permissible limit. Consequently, all brands tested are unsafe for human consumption due to excessive bromate levels. This indicates a significant public health risk and underscores the need for stricter regulatory enforcement to ensure adherence to food safety standards.

Keywords: Potassium bromate, bread production, spectrophotometry, carcinogen.

INTRODUCTION

Bread is an important food product worldwide. It usually contains several ingredients including potassium bromate ($KBrO_3$) that help improve its quality. Potassium bromate is a white crystal, granule or powder, which is colourless, odorless, and tasteless.[1] It is a strong oxidizing agent and is used in the bakery industry as a quality-improving reagent for wheat flour as it strengthens the dough and increases the elasticity of bread during baking.[2] The use of $KBrO_3$ common among flour millers and bakers worldwide because it is cheap and probably the most efficient oxidizing agent. As a result, many bakeries use $KBrO_3$ to produce an appealing texture in the finished product.[3,4]

The potassium bromate added must be completely used up during the bread making because if too much is applied or bread is not completely cooked to an appropriate temperature, traces may remain in the final product. The maximum amount of $KBrO_3$ allowed in bread by the United States Food and Drug Administration (US-FDA) is 0.02 µg/g (w/w).[3,5] There are two ways by which humans may be poisoned with potassium bromate namely, by ingestion when it is present in food such as bread and by inhalation. Potassium bromate is linked to kidney, thyroid, and gastrointestinal cancers in experimental animals.[6] Numerous studies have also revealed the potential of potassium bromate to degrade some potential essential fatty acids as well as vitamins in bread such as retinol, thiamine, riboflavin and niacin. Potassium bromate can also cause cough, sore throat (when inhaled), abdominal pain, nausea, vomiting, kidney failure, hearing loss, and ocular problems.[7]

Due to these harmful effects observed in experimental animals relating to high residual

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potassium bromate after bread baking, some countries such as the United Kingdom (1990), Canada (1994), and Nigeria (1993) have banned the use of potassium bromate in bakery.[3] However, in many developing countries including Tanzania, $KBrO_3$ is still being used in bakeries, therefore, posing health risks to the manufacturers and consumers. There is limited data on the magnitude of this problem in Tanzania. The current study was designed to determine the amount of potassium bromate in bread brands consumed in Mwanza and Kagera regions, Tanzania.

MATERIALS AND METHODS

Study area

Mwanza and Kagera are among the thirty-one administrative regions in Tanzania. They constitute about 10% of the country's population.[8] Samples were collected from these two regions and transferred to the Tanzania Bureau of Standards (TBS) laboratory in Dar es Salaam, Tanzania for analysis.

Sample collection

Bread samples were purchased randomly from 10 bakeries in Mwanza region and 11 bakeries in Kagera region. From each bakery, one bread brand was available, therefore, 21 bread brands were selected for analysis. Four loaves of each bread were collected for analysis of potassium bromate content. A visual inspection was conducted to ensure that the samples were not spoiled due to storage conditions. Information regarding the brand code, sampling area, country of origin as well as manufacturing and expiry dates of the bread brands is provided in Table 1.

Materials and reagents

Methanol (HPLC grade), potassium iodide AR (≥ 99.0%) and hydrochloric acid AR (Sigma-Aldrich, St. Louis, MO, USA) were used for the experiments. Milli-Q water (MilliporeSigma, Burlington, MA, USA) was employment as solvent.

Equipment

A 6850 JENWAY UV-VIS Spectrophotometer (Vernon Hills, Chicago, IL, U.S.) was used for $KBrO_3$ quantification. For this purpose, solutions were placed in quartz UV-cuvettes (Hellma Analytics, Müllheim, Germany) for absorbance readings.

Qualitative analysis

One gram of each powdered sample was weighed and transferred into a test tube. This was followed by the addition of 10 ml distilled water with shaking and the mixture allowed to stand for 20 minutes. The resulting solution was filtered to remove insoluble particles. Afterwards, 5 ml of each filtrate was transferred to a labelled test tube, followed by the addition of 5 ml potassium iodide (1% w/v) solution in 0.1N HCl. A color change from light yellow to purple indicated the presence of potassium bromate.[9]

Quantitation of potassium bromate

A calibration curve for potassium bromate quantitation was constructed through serial dilution of a 100 mg/l stock solution to yield standard solutions of concentration range 1 - 10 mg/l. This concentration range was chosen based on reported levels of potassium bromate in bread samples in prior studies. The linear regression equations obtained were: $y = 0.3116x + 0.0119$ ($r^2 = 0.9993$) and $y = 0.1284x + 0.0058$ ($r^2 = 0.998$), for Mwanza and Kagera samples, respectively.

The concentration of potassium bromate in the bread samples was determined using the spectrophotometric method described by Pearson (1976).[9,10] Each test tube that tested positive for $KBrO_3$ was diluted to 50 ml with distilled water, mixed thoroughly, an aliquot transferred into a cuvette and the optical density measured at 620 nm using a UV-Vis spectrophotometer. The absorbances of the samples were converted to concentrations with reference to Beer-Lambert’s calibration curve previously constructed using potassium bromate standard.

Statistical analysis

The statistical analysis of data obtained was conducted using STATA (StataCorp LLC, College Station, TX, USA). Descriptive statistics were employed to summarize the statistical parameters, including mean and standard deviation.

Table 1: Product information of commercial bread brands analyzed in the study.

Study Area	Brand Code	Sampling Area	Country of Origin	Manufacturing Date	Expiry Date
Mwanza Region	M-01	Mwanza City	Tanzania	5 Jul 2020	11 Jul 2020
	M-02	Mwanza City	Tanzania	4 Jul 2020	10 Jul 2020
	M-03	Mwanza City	Tanzania	5 Jul 2020	11 Jul 2020
	M-04	Mwanza City	Tanzania	3 Jul 2020	9 Jul 2020
	M-05	Mwanza City	Tanzania	4 Jul 2020	10 Jul 2020
	M-06	Mwanza City	Tanzania	5 Jul 2020	11 Jul 2020
	M-07	Mwanza City	Tanzania	4 Jul 2020	10 Jul 2020
	M-08	Mwanza City	Tanzania	5 Jul 2020	11 Jul 2020
	M-09	Mwanza City	Tanzania	5 Jul 2020	11 Jul 2020
	M-10	Mwanza City	Tanzania	4 Jul 2020	10 Jul 2020
Kagera Region	K-01	Bukoba Urban	Tanzania	13 May 2021	19 May 2021
	K-02	Bukoba Urban	Tanzania	13 May 2021	19 May 2021
	K-03	Bukoba Rural	Tanzania	12 May 2021	18 May 2021
	K-04	Bukoba Rural	Tanzania	13 May 2021	19 May 2021
	K-05	Bukoba Rural	Tanzania	12 May 2021	18 May 2021
	K-06	Bukoba Rural	Tanzania	12 May 2021	18 May 2021
	K-07	Bukoba Urban	Tanzania	13 May 2021	19 May 2021
	K-08	Bukoba Urban	Tanzania	13 May 2021	19 May 2021
	K-09	Bukoba Rural	Tanzania	12 May 2021	18 May 2021
	K-10	Bukoba Urban	Tanzania	13 May 2021	19 May 2021
	K-11	Bukoba Rural	Tanzania	12 May 2021	18 May 2021

RESULTS

The colour changes due to the presence of $KBrO_3$ in bread samples and its levels in bread samples are presented in Table 2. The concentration values presented in the tables are the mean of four replicate determinations. The $KBrO_3$ concentration in the bread brands from Mwanza was in the range of 1.02 – 2.01 µg/g while those from Kagera were ranged 2.50 – 4.85 µg/g (Table **2**). These results show that all bread samples tested positive for potassium bromate with levels exceeding the specified limit (0.02µg/g).

Table 2: Qualitative and quantitative $KBrO_3$ data on bread samples sold in Mwanza and Kagera, Tanzania.

Sample Code	Colour change with 1% KI	Mean Absorbance (A)	$KBrO_3$ concentration (µg/g)
M01	Light Purple	0.37	1.14
M02	Light Purple	0.44	1.38
M03	Light Purple	0.44	1.39
M04	Light Purple	0.33	1.02
M05	Light Purple	0.39	1.21
M06	Purple	0.64	2.01
M07	Purple	0.51	1.60
M08	Purple	0.50	1.57
M09	Purple	0.49	1.53
M10	Light Purple	0.44	1.37
K01	Purple	0.37	2.85
K02	Purple	0.45	3.44
K03	Light Purple	0.45	3.46
K04	Light Purple	0.37	2.80
K05	Light Purple	0.33	2.50
K06	Purple	0.52	3.96
K07	Purple	0.63	4.85
K08	Purple	0.49	3.83
K09	Light Purple	0.37	2.83
K10	Light Purple	0.37	2.87
K11	Light Purple	0.40	3.09

The mean ± SD concentrations of potassium bromate in breads from Mwanza and Kagera regions were 1.422 ± 0.265 µg/g and 3.316 ± 0.654 µg/g, respectively. A t-test revealed a significant difference in the mean concentrations of potassium bromate between the two regions, with a p-value of 0.0000.

DISCUSSION

In the qualitative analysis for $KBrO_3$ in the bread samples, the compound reacts with potassium iodide and hydrochloric acid to produce iodine, which appears as a purple colour, according to the equation below.[3,10,11]

$$6KI + KBrO_3 + 6HCl \rightarrow 3I_2 + KBr + 6KCl + 3H_2O$$

Some of the bread samples analyzed showed a light purple colouration which corresponds to the levels of potassium bromate present.[11] All the bread samples displayed a colour change, which confirmed the presence of potassium bromate.

The potassium bromate concentration values ranged from 1.02µg/g to 4.85µg/g thus demonstrating that all the bread brand samples analyzed exceeded the accepted US-FDA permissible limit of 0.02µg/g.[3,5] The sample with the lowest potassium bromate concentration (1.02µg/g) was 51 times higher than the stated US-FDA limit while that with the highest concentration (4.85µg/g) was 243 fold. This demonstrates that none of the bread brands sampled from Mwanza and Kagera regions are safe for human consumption due to the potential carcinogenic effects of potassium bromate.[6] The primary exposure routes of potassium bromate are oral and inhalation pathways. These elevated levels of potassium bromate found in the bread samples raise significant health concerns due to the widespread consumption of bread as an integral part of the menu in Tanzania.

Potassium bromate is valued for its ability to consistently improve the quality of bread.[4] Despite the known health risks, some manufacturers might continue using potassium bromate due to its cost-effectiveness and the technical benefits it provides in the baking process. Strengthening the monitoring and enforcement activities by regulatory authorities in Tanzania is crucial to ensure compliance with established safety standards among bread manufacturers. Furthermore, public awareness campaigns are essential to educate consumers about the risks associated with potassium bromate and to promote demand for safer bread alternatives.

The t-test results for mean concentrations of potassium bromate in the bread brands from the two regions indicated a significant difference. This could suggest the variations in bread production practices among bakeries in the two regions. Furthermore, environmental factors, such as humidity or temperature during storage, could impact the concentration of potassium bromate in the bread samples.[2,11,12] This underlines the importance of comprehensive sampling to accurately assess the potassium bromate levels as well as true variability in the market.

Although the sampling strategy employed in the study may not capture all possible variations, it provides a significant overview of current practices and potential risks. Manufacturers adhering to good manufacturing practices (GMP) guidelines can use these findings to strengthen their quality assurance systems. Regulatory bodies should also consider these results when formulating or updating safety standards and monitoring protocols.

CONCLUSION

This study revealed the presence of potassium bromate at unacceptable levels in all the bread brands analyzed. Reported $KBrO_3$ concentration values ranged from 1.02µg/g to 4.85µg/g, which exceeded the US-FDA safe limit (0.02µg/g). Therefore, the manufacturers and the consumers of breads in Mwanza and Kagera regions of Tanzania are at potential risk of the deleterious effects of potassium bromate. Potassium bromate is still widely used as a bread improver by bakeries in Tanzania. Hence, regulatory agencies should monitor its levels in bread for consumer safety or prohibit use of this reagent in bakery. Other safer flour improvers such as ascorbic acid and glucose oxidase may be used as an alternative to potassium bromate.[13] Bakeries require dedicated quality control laboratories to ensure appropriate levels of $KBrO_3$ in bread products. By implementing these proactive measures, bakeries not only prioritize consumer safety but also align with industry best practices, ultimately fostering confidence in the quality and compliance of their bread products.

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