COMPARISON ON THE LEVEL OF POTASSIUM BROMATE IN BREAD ACROSS TWO LOCAL GOVERNMENT AREEAS (LGAs)

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DEPARTMENT OF MEDICAL BIOCHEMISTRY

SCHOOL OF BASIC MEDICAL SCIENCES

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UNIVERSITY OF BENIN

MARCH, 2025

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DEPARTMENT OF MEDICAL BIOCHEMISTRY,SCHOOL OF BASIC MEDICAL SCIENCES, COLLEGE OF MEDICAL SCIENCES, UNIVERSITY OF BENIN IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE AWARD OF THE BACHELOR OF SCIENCE (B.Sc), DEGREE IN MEDICAL BIOCHEMISTRY

MARCH, 2025

CERTIFICATION

We, the undersigned, certify that this research was carried out by Isibor Osazee Kingsley (BMS2001107), in the Department of Medical Biochemistry, Faculty of Basic Medical Science, University of Benin, Benin City in partial fulfilment of the requirement of the award of the Bachelor of Science**.**

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DEDICATION

This study is dedicated to Almighty God for His Grace that sustained the researcher in the course of the programme.

ACKNOWLEDGEMENTS

I wishes to express sincere appreciation to God for guiding me through the ups and downs in my academic journey at the University of Benin, for the successful completion of my project. Gratitude is extended to his supervisor, Dr.(Mrs.)S.O. Olubodun for her patience and invaluable constructive feedback throughout the project. Furthermore, thanks are offered to the Head of Department, Prof. F. E. Olumese and other dedicated lecturers in the Department of Medical Biochrmistry for sharing their knowledge and expertise.

Genuine thanks goes to the my parent, Mr. and Mrs. Felix Isibor for their unwavering love, support and prayers during this project. I am also grateful to my siblings, Blessing Isibor, Felix Isibor, Etinosa Isibor and also to my relatives for their constant love, encouragement, financial support and prayers.

I extend heartfelt gratitude to my friends, including Pasrtor Jerry, Naomi among many others; my spiritual mentors, Pastor and Pastor (Barr.) Billmatt Osale, Pastor Favour Owhere and also the entirety of the Kingdom Builders Lovelife Church Inc. for their part in this significant achievement, offering them many thanks and blessings.

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ABSTRACT

Bread is a staple food widely consumed in Nigeria, yet concerns persist about the use of potassium bromate as a flour improver, despite its ban due to potential health risks including cancer and kidney damage. This study aimed to compare the levels of potassium bromate in bread samples collected from two Local Government Areas (Oredo and Uhunmwonde) in Benin City, Edo State, Nigeria. A total of twelve unsliced bread samples were randomly collected from various markets, roadside vendors, and bakeries across the two LGAs. The samples were analyzed using spectrophotometric methods to determine the presence and concentration of potassium bromate. The results were statistically compared to identify variations between the two areas and assess compliance with regulatory standards. This study highlights the potential public health implications associated with potassium bromate contamination in bread and emphasizes the need for regular monitoring and enforcement of food safety regulations.

CHAPTER ONE

INTRODUCTION

Background of Study

Bread is one of the most widely consumed staple foods worldwide, providing a significant source of carbohydrates, proteins, and essential nutrients. It is a fundamental part of the diet in many cultures and is produced in various forms, including white bread, whole wheat bread, and enriched bread, among others. The production of bread involves mixing flour, water, yeast, and other ingredients to form a dough, which is then baked to achieve the desired texture and flavor. Over the years, various additives have been incorporated into bread production to improve its quality, texture, shelf life, and baking performance. Among these additives, potassium bromate has been widely used as a flour improver and oxidizing agent due to its ability to enhance dough strength, elasticity, and volume (Cauvain, 2015).

Potassium bromate (KBrO3) is an inorganic compound that has historically been used in the baking industry to improve the texture and rise of bread. It acts as a maturing agent, enhancing the elasticity of gluten and resulting in a softer and more voluminous loaf. When used appropriately, potassium bromate is expected to decompose into harmless bromide during the baking process. However, scientific studies have shown that in some cases, residual amounts of potassium bromate remain in the finished product, posing potential health risks to consumers. Research has established that potassium bromate is a possible human carcinogen, as classified by the International Agency for Research on Cancer (IARC), due to its association with oxidative stress, DNA damage, and tumor formation in laboratory animals (Kurokawa et al., 1990).

The presence of residual potassium bromate in bread has become a major public health concern, leading to regulatory actions in several countries. Many nations, including the United Kingdom, Canada, and the European Union, have completely banned the use of potassium bromate in bread production due to its potential health hazards. In contrast, some countries, such as the United States, still allow its use under strict regulations, with the condition that no detectable residues should be present in the final product (FAO/WHO, 2001). In Nigeria, regulatory agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organisation of Nigeria (SON) have prohibited the use of potassium bromate in bread production. However, reports indicate that some bakeries continue to use potassium bromate illegally, leading to concerns about food safety and consumer health (Ezeh et al., 2021).

Despite regulatory bans, potassium bromate has remained a subject of controversy in the food industry, particularly in developing countries where enforcement mechanisms may be weak. Factors such as lack of awareness among bakers, cost considerations, and inadequate regulatory monitoring contribute to its continued presence in bread. Some bakeries prefer potassium bromate because it is cheaper and more effective in improving bread quality compared to safer alternatives such as ascorbic acid, enzymes, and lecithin. Additionally, poor baking conditions, including inadequate baking time and temperature, can result in incomplete breakdown of potassium bromate, leading to its retention in bread (Whitaker, 2010).

The health risks associated with potassium bromate exposure have been extensively studied, with findings indicating that it has mutagenic, nephrotoxic, and carcinogenic effects. Animal studies have demonstrated that potassium bromate causes kidney damage, oxidative stress, and cancerous tumors in rodents. Human exposure to potassium bromate through bread consumption has been linked to an increased risk of kidney disease, endocrine disruption, and potential carcinogenic effects (Sayadi et al., 2020). Additionally, potassium bromate has been shown to induce oxidative stress, leading to cell damage and inflammation, which may contribute to chronic diseases such as cancer and organ dysfunction.

Given these health concerns, the need for effective monitoring and detection of potassium bromate in bread has become a priority for food safety authorities. Various analytical techniques, including spectrophotometry, high-performance liquid chromatography (HPLC), ion chromatography, and electrochemical methods, have been developed to detect and quantify potassium bromate levels in bread samples. These methods are essential for regulatory compliance, quality control, and consumer protection (Al-Qubaisi et al., 2019). In Nigeria, periodic market surveillance and laboratory testing have been carried out to ensure that bread sold to consumers is free from potassium bromate contamination. However, challenges such as inadequate laboratory facilities, limited technical expertise, and non-compliance by some bakeries hinder the effectiveness of these regulatory measures.

Public awareness and consumer advocacy also play a crucial role in addressing the issue of potassium bromate in bread. Educating consumers about the dangers of potassium bromate and encouraging them to demand bromate-free bread can create market pressure for compliance with food safety regulations. Additionally, implementing stringent penalties for violators, promoting safer alternatives, and improving regulatory enforcement can help eliminate the use of potassium bromate in bread production.

The background of the study highlights the widespread use of bread as a staple food and the historical role of potassium bromate as a flour improver. Despite its effectiveness in enhancing bread quality, scientific evidence has established its carcinogenic potential, leading to regulatory bans in many countries. However, challenges related to non-compliance, inadequate regulatory enforcement, and consumer unawareness continue to contribute to its illegal use in some regions. Understanding the factors influencing the presence of potassium bromate in bread, its health implications, and the regulatory landscape is essential for ensuring food safety and protecting public health.

Aim of Study

The aim of this study is to determine and compare the levels of potassium bromate in bread samples collected from two selected Local Government Areas. It seeks to identify variations in bromate content across different bread brands and locations. The study will also assess the compliance of bread producers with existing regulatory standards. Ultimately, the findings will help evaluate potential health risks associated with bromate consumption in the two LGAs.

Justification of Study

Potassium bromate has been linked to serious health issues, including cancer and kidney damage, making its continued presence in bread a significant public health concern. In many developing regions, including the selected LGAs, informal bakeries often lack strict regulatory oversight. This study is justified as it provides updated data on bromate levels, highlights potential regulatory gaps, and informs policymakers and consumers on the need for improved food safety monitoring.

CHAPTER TWO

LITERATURE REVIEW

Bread and Bread Production

Bread is one of the oldest and most widely consumed staple foods in the world. It is made from flour, water, and yeast or other leavening agents, and it has played a significant role in human nutrition for thousands of years. The process of bread-making has evolved from traditional methods to modern industrial production, incorporating advanced baking technologies and food safety measures. The quality and nutritional composition of bread vary based on the ingredients, processing techniques, and regional preferences.

Bread production begins with the selection of raw materials. The primary ingredient is flour, which is most commonly derived from wheat due to its high gluten content that contributes to the bread’s structure and texture. Other grains such as rye, barley, and maize are also used in various types of bread. Water is another essential component, serving as a medium for gluten development and yeast activation. Yeast or chemical leavening agents such as baking powder or baking soda are used to create the desired texture and volume by producing carbon dioxide gas, which causes the dough to rise. Additional ingredients like salt, sugar, fats, emulsifiers, and preservatives are often added to improve taste, shelf life, and texture.

The bread-making process typically involves several key steps: mixing, kneading, fermentation, shaping, proofing, baking, cooling, and packaging. Mixing is the initial step where flour, water, yeast, and other ingredients are combined to form a homogenous dough. Kneading follows, during which the gluten network is developed, giving the dough its elasticity and strength. Fermentation is a crucial stage where yeast metabolizes sugars to produce carbon dioxide, leading to dough expansion. The fermentation time varies depending on the type of bread being produced. After fermentation, the dough is divided into portions, shaped, and subjected to proofing, which is a secondary fermentation stage allowing further expansion and texture refinement.

Baking is the critical phase where the dough is subjected to high temperatures, typically ranging between 180–260°C, in an oven. The heat causes the moisture in the dough to turn into steam, expanding the bread structure while also initiating the Maillard reaction, which gives the crust its characteristic color and flavor. During baking, enzymes and proteins undergo structural changes, contributing to the final texture of the bread. Once baked, the bread is cooled to allow moisture redistribution and then packaged to prevent staling and contamination.

Traditional bread-making techniques differ across cultures, with some regions favoring artisanal methods involving sourdough fermentation, while others rely on modern mechanized production for mass distribution. The advent of commercial bread production has led to the use of food additives such as dough conditioners and preservatives to enhance shelf life and maintain consistency. One controversial additive in bread production is potassium bromate, which has been used as a flour improver to enhance dough strength and elasticity. However, concerns over its potential carcinogenic effects have led to its regulation or ban in many countries, including the European Union, Canada, and Nigeria (Cagampang et al., 1979; International Agency for Research on Cancer [IARC], 1999).

The nutritional profile of bread varies depending on the type and processing method. Whole-grain breads contain higher amounts of dietary fiber, vitamins, and minerals compared to refined white bread, which undergoes extensive processing that removes the bran and germ. The consumption of bread is associated with both benefits and risks, with whole-grain varieties contributing to improved digestion and reduced risk of chronic diseases, while excessive consumption of refined bread has been linked to obesity and metabolic disorders (Slavin, 2004).

Food safety regulations play a crucial role in ensuring the quality of bread available to consumers. Regulatory bodies such as the U.S. Food and Drug Administration (FDA), the European Food Safety Authority (EFSA), and Nigeria’s National Agency for Food and Drug Administration and Control (NAFDAC) set standards for permissible food additives, production hygiene, and labeling. These regulations help mitigate the risks associated with food contaminants, ensuring that bread production adheres to established safety guidelines.

The demand for bread continues to grow globally due to its convenience, affordability, and versatility. Innovations in bread production, such as gluten-free alternatives, fortified bread, and sustainable packaging, are addressing the evolving needs of consumers. Research and development efforts are focused on improving the nutritional content of bread, reducing harmful additives, and adopting environmentally friendly baking practices.

Bread Production and the Use of Additives

Bread production is a complex process that involves the transformation of raw ingredients into a staple food consumed globally. The fundamental ingredients used in bread-making include flour, water, yeast, and salt, while additional components such as sugar, fats, milk, and food additives are incorporated to enhance texture, flavor, shelf life, and overall quality. The process of bread production involves several stages, beginning with ingredient selection, followed by mixing, kneading, fermentation, shaping, proofing, baking, cooling, and packaging. The efficiency of each stage significantly affects the final product's texture, taste, and shelf stability.

The first stage of bread production is the selection of high-quality flour, which is typically derived from wheat due to its high gluten content. Gluten, a protein composite, provides the dough with elasticity and structure, enabling it to retain gas during fermentation and baking. Water is an essential component that hydrates the flour, activates the gluten, and facilitates enzymatic and microbial activities. Yeast, a biological leavening agent, plays a critical role in fermentation by metabolizing sugars to produce carbon dioxide and ethanol, which contribute to the expansion and aeration of the dough. Salt is added to regulate yeast activity, strengthen gluten, and enhance the flavor of the final product.

Mixing and kneading are crucial steps in bread production, as they ensure the even distribution of ingredients and promote gluten development. The dough undergoes mechanical manipulation to align gluten strands, resulting in a cohesive and elastic structure. Fermentation follows, during which yeast continues to metabolize sugars, leading to dough expansion and the formation of characteristic flavors. The duration and conditions of fermentation affect the texture and taste of the bread. After fermentation, the dough is divided into portions, shaped, and subjected to proofing, a secondary fermentation stage that allows for additional expansion before baking.

Baking is the critical phase where the dough undergoes a series of physical and chemical transformations under controlled heat. The typical baking temperature ranges from 180 to 260°C, facilitating starch gelatinization, protein denaturation, and the Maillard reaction, which imparts a golden-brown crust and enhances flavor. The expansion of steam and carbon dioxide within the dough results in a light and airy crumb structure. Once baking is complete, the bread is cooled to allow moisture redistribution and to prevent condensation within the packaging. Packaging plays a vital role in maintaining bread quality, protecting it from microbial contamination, moisture loss, and staling.

The use of food additives in bread production has become widespread to improve various quality attributes, including texture, volume, shelf life, and nutritional value. Additives can be categorized based on their function, such as emulsifiers, preservatives, oxidizing agents, reducing agents, enzymes, and fortifying agents. Emulsifiers such as lecithin and mono- and diglycerides are incorporated to enhance dough stability, improve crumb softness, and extend freshness. Preservatives like calcium propionate and sorbic acid inhibit mold growth and microbial spoilage, thereby prolonging the shelf life of bread.

Oxidizing agents, including potassium bromate and ascorbic acid, are used to strengthen gluten networks and enhance dough elasticity. However, potassium bromate has been a controversial additive due to its potential carcinogenic effects, leading to its ban in several countries, including those in the European Union, Canada, and Nigeria (International Agency for Research on Cancer [IARC], 1999). Reducing agents such as cysteine and sodium metabisulfite are utilized to relax gluten, making the dough more extensible and easier to process. Enzymes, such as amylases and proteases, play an essential role in modifying dough properties, improving fermentation, and enhancing bread texture. Fortifying agents, including vitamins and minerals, are added to increase the nutritional value of bread, addressing micronutrient deficiencies in various populations.

Despite the benefits of additives in bread production, concerns have been raised regarding their health implications. Excessive use of chemical additives has been linked to potential health risks, including allergic reactions, gastrointestinal disturbances, and long-term toxic effects. Regulatory bodies such as the U.S. Food and Drug Administration (FDA), the European Food Safety Authority (EFSA), and Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC) have established guidelines to ensure the safe use of food additives in bread production. Compliance with these regulations is essential to maintain consumer safety and product integrity.

The increasing demand for healthier and more natural bread alternatives has led to innovations in bread production, including the use of natural enzymes, sourdough fermentation, and clean-label formulations. Sourdough bread, which relies on wild yeast and lactic acid bacteria for fermentation, has gained popularity due to its improved digestibility, extended shelf life, and enhanced flavor. Additionally, the development of gluten-free bread using alternative flours such as rice, corn, and sorghum caters to individuals with gluten intolerance or celiac disease. Advances in food science continue to shape the bread industry, focusing on sustainable production methods, nutritional enhancement, and the reduction of harmful additives.

In conclusion, bread production is a dynamic and evolving field that integrates traditional baking methods with modern technological advancements. The careful selection of ingredients, precise control of processing conditions, and strategic use of food additives contribute to the quality and safety of bread. While food additives play a crucial role in improving bread characteristics, their potential health risks necessitate strict regulatory oversight. The growing consumer preference for natural and healthier bread options is driving innovation in the industry, emphasizing clean-label formulations and sustainable baking practices. Ongoing research and technological developments will continue to shape the future of bread production, ensuring that it remains a staple food that meets both nutritional and safety standards.

Potassium Bromate: Use, Effects and Regulations

Potassium bromate is a chemical compound with the formula $KBrO_3$ that has historically been used in the food industry, particularly in bread production, as a flour improver and oxidizing agent. It functions by strengthening dough, enhancing its elasticity, and improving the texture and volume of the final baked product. When added to flour, potassium bromate helps to improve the consistency of the dough, making it more tolerant to variations in kneading, proofing, and baking processes. This quality has made it a popular choice among commercial bakers seeking to produce uniform and visually appealing loaves of bread. However, despite its functional benefits in baking, potassium bromate has been a subject of significant health concerns, leading to regulatory scrutiny and bans in several countries.

The primary mechanism through which potassium bromate acts in bread-making is by facilitating oxidation, which strengthens the gluten network in dough. This results in improved gas retention, leading to increased loaf volume and a fine crumb structure. During baking, potassium bromate is expected to degrade into harmless bromide ions due to the high temperatures involved. However, studies have shown that if the baking process is not properly optimized—such as when the bread is underbaked or baked at lower-than-recommended temperatures—residual potassium bromate may remain in the final product, posing potential health risks to consumers (Kurokawa et al., 1990).

The most serious concern associated with potassium bromate is its classification as a potential human carcinogen. Research has demonstrated that potassium bromate can induce oxidative stress, leading to DNA damage and mutations that may contribute to cancer development. Animal studies have provided strong evidence of its carcinogenicity, particularly in rodents, where exposure to potassium bromate has been linked to kidney, thyroid, and gastrointestinal cancers (International Agency for Research on Cancer [IARC], 1999). In addition to its carcinogenic potential, potassium bromate has been associated with nephrotoxicity, leading to kidney damage, and has also been shown to induce oxidative stress-related damage in other organs, raising concerns about its long-term effects on human health (DeAngelo et al., 1998).

Due to these health risks, regulatory agencies worldwide have taken different approaches to controlling the use of potassium bromate in food production. In many countries, including those in the European Union, Canada, Brazil, and Nigeria, the use of potassium bromate as a food additive has been completely banned. The European Food Safety Authority (EFSA) and the Food Standards Agency (FSA) in the United Kingdom prohibit its use, citing the potential carcinogenic risk associated with its consumption. Similarly, the National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria has imposed strict regulations to prevent its use in bread and other baked goods, warning consumers and food manufacturers about its dangers.

In contrast, in the United States, the Food and Drug Administration (FDA) has not outright banned potassium bromate but has instead set strict limits on its permissible levels in flour and requires that its presence be declared on food labels. The FDA maintains that potassium bromate is safe when used under controlled conditions, assuming that it fully decomposes into bromide during baking. However, consumer advocacy groups and health organizations continue to call for a complete ban, arguing that there is no justification for its use when safer alternatives, such as ascorbic acid (vitamin C) and malted barley flour, are available to achieve similar baking effects without the associated health risks (Environmental Working Group, 2019).

Despite regulatory efforts, concerns remain regarding non-compliance in certain regions where potassium bromate is banned. Studies conducted in various countries have revealed that some bakeries and food manufacturers continue to use potassium bromate illegally, either due to a lack of awareness of its health risks or because of the cost-effectiveness it offers compared to alternative flour improvers (Ayo et al., 2018). This has prompted calls for stricter enforcement, routine food testing, and increased public awareness campaigns to educate consumers about the dangers of potassium bromate.

Efforts to find safer alternatives to potassium bromate have led to the adoption of various oxidizing agents that provide similar benefits without posing carcinogenic risks. Ascorbic acid is one of the most widely used alternatives, as it effectively enhances dough strength and volume without the harmful effects associated with potassium bromate. Other alternatives include enzyme-based improvers, which are increasingly being incorporated into commercial baking processes to improve dough handling and final product quality while maintaining food safety standards.

Chemical Properties and Functionality of Potassium Bromate

Potassium bromate ($KBrO_3$) is a strong oxidizing agent that has been widely used in the baking industry as a flour improver. It exists as a white, crystalline, and odorless powder that is highly soluble in water. The solubility of potassium bromate increases with temperature, making it an effective agent in high-temperature food processing applications such as bread baking. It has a molar mass of 167.00 g/mol and a density of 3.27 g/cm³, with a melting point of approximately 350°C, at which it decomposes into potassium bromide (KBr) and oxygen gas. This decomposition process is a crucial aspect of its functionality in food processing, as it contributes to its oxidative effects during baking (Kurokawa et al., 1990).

The oxidizing nature of potassium bromate makes it highly reactive, particularly in the presence of reducing agents. When added to flour, potassium bromate reacts with gluten proteins, strengthening the dough structure and improving its elasticity. This enhances the dough's ability to retain gas during fermentation, leading to improved loaf volume and texture. The oxidation of sulfhydryl (-SH) groups in gluten proteins to form disulfide (-S-S-) bonds is a key reaction facilitated by potassium bromate. This reaction promotes the formation of a strong gluten network, which is essential for achieving uniform crumb structure, increased shelf life, and enhanced dough-handling properties (Maekawa et al., 1984).

During the baking process, potassium bromate undergoes thermal decomposition. Under ideal baking conditions, it is expected to fully convert into potassium bromide, a harmless byproduct. However, incomplete degradation can result in residual potassium bromate in the final product, which poses potential health risks to consumers. The extent of its decomposition depends on factors such as baking temperature, duration, and the composition of the dough. Studies have shown that underbaked or improperly processed bread may retain significant amounts of potassium bromate, leading to concerns over food safety (Caldwell et al., 2008).

In addition to its role in gluten strengthening, potassium bromate contributes to the whitening and maturation of flour. It acts as an oxidizing agent on carotenoid pigments in wheat flour, reducing their color intensity and giving the flour a whiter appearance. This effect has been particularly desirable in commercial bread production, where consumer preference often favors lighter-colored loaves. Furthermore, potassium bromate helps in delaying staling, thereby extending the shelf life of baked products. This is attributed to its interaction with starch and gluten components, which affects the retrogradation process of starch molecules in bread (Hasegawa et al., 1986).

The oxidative effects of potassium bromate are not limited to its interactions with gluten proteins; it also affects yeast activity and dough fermentation. By promoting oxygen availability in the dough matrix, potassium bromate enhances yeast respiration, leading to better gas production and improved dough rise. However, this effect is highly dependent on the concentration of potassium bromate used. Excessive amounts can disrupt yeast metabolism and negatively impact fermentation efficiency (Umemura et al., 1995).

Given its strong oxidizing properties, potassium bromate is also utilized in non-food applications such as laboratory reagents, textile processing, and water purification. However, its primary commercial use has been in the baking industry, where it has been favored for its consistency in improving bread quality. Despite its technological benefits, growing concerns about its toxicity have led to increased scrutiny and regulatory restrictions in many countries. Studies have linked potassium bromate to potential carcinogenic effects, with evidence suggesting that it induces oxidative stress, DNA damage, and tumor formation in experimental models (IARC, 1999).

The functionality of potassium bromate has been widely studied, with research focusing on its chemical interactions in food matrices and its safety profile. As a result, many countries have sought safer alternatives such as ascorbic acid, enzymes, and other oxidizing agents that offer similar dough-improving effects without the associated health risks. In regions where potassium bromate remains in use, strict regulations and monitoring have been implemented to ensure its complete degradation during baking, thereby minimizing consumer exposure.

Potassium bromate possesses distinct chemical properties that make it a highly effective dough improver and oxidizing agent in bread production. Its ability to strengthen gluten, enhance loaf volume, and improve flour quality has contributed to its historical use in the baking industry. However, its potential to persist in baked products under certain conditions and its associated health risks have led to increasing regulatory measures and a shift towards alternative food additives. Ongoing research continues to explore its chemical behavior, toxicity, and potential substitutes to ensure safer and more sustainable food processing practices.

Health Implications of Potassium Bromate on Food

Potassium bromate is a food additive that has been widely used in the baking industry as a flour improver and dough strengthener. Despite its functional benefits, concerns regarding its potential health risks have led to extensive research and regulatory scrutiny. Potassium bromate is classified as a potential human carcinogen, with several studies demonstrating its adverse effects on multiple organ systems when consumed in significant amounts or over prolonged periods. The health implications of potassium bromate primarily stem from its oxidative properties, which can lead to cellular damage, genetic mutations, and long-term toxicity.

One of the most critical health concerns associated with potassium bromate is its potential to cause cancer. Research has shown that potassium bromate induces oxidative stress, leading to DNA damage and chromosomal aberrations. Studies in rodents have provided strong evidence of its carcinogenicity, with exposure linked to the development of tumors in the kidneys, thyroid, and gastrointestinal tract (Kurokawa et al., 1990). The International Agency for Research on Cancer (IARC) has classified potassium bromate as a Group 2B carcinogen, indicating that it is “possibly carcinogenic to humans” based on sufficient evidence from animal studies but limited evidence from human studies (IARC, 1999). The carcinogenic potential of potassium bromate arises from its ability to generate reactive oxygen species (ROS), which contribute to oxidative DNA damage, mutations, and unregulated cell proliferation. This mechanism is particularly concerning because prolonged exposure to low levels of potassium bromate in food may increase cancer risk over time.

Beyond its carcinogenic effects, potassium bromate has been implicated in nephrotoxicity, which refers to its harmful impact on kidney function. Animal studies have demonstrated that potassium bromate causes renal cell damage, leading to kidney dysfunction and increased risk of renal cancer (DeAngelo et al., 1998). Ingestion of potassium bromate disrupts the normal filtering capacity of the kidneys, resulting in oxidative damage to renal tubules and glomeruli. This can lead to proteinuria, nephritis, and other kidney disorders. In cases of acute exposure, potassium bromate poisoning has been associated with kidney failure, necessitating medical intervention. Given the kidneys’ role in detoxification and excretion, long-term exposure to potassium bromate may exacerbate renal impairment, particularly in individuals with preexisting kidney conditions.

Another significant health implication of potassium bromate consumption is its potential to cause thyroid dysfunction. Studies have shown that potassium bromate disrupts thyroid hormone regulation, leading to hypertrophy and hyperplasia of the thyroid gland (Kurokawa et al., 1983). The thyroid plays a crucial role in metabolism, growth, and overall endocrine function, and any disruption can result in metabolic imbalances, weight fluctuations, and hormonal irregularities. In experimental studies, rats exposed to potassium bromate exhibited an increased incidence of thyroid tumors, suggesting a direct impact on thyroid cell proliferation and dysfunction.

Potassium bromate has also been linked to gastrointestinal toxicity. When consumed in high amounts, it can cause irritation and damage to the lining of the stomach and intestines, leading to symptoms such as nausea, vomiting, diarrhea, and abdominal pain (Mukhopadhyay et al., 2005). In severe cases, ingestion of potassium bromate has been reported to cause ulceration and bleeding in the gastrointestinal tract. Chronic exposure may contribute to inflammatory conditions such as gastritis and colitis, further compromising digestive health.

Neurotoxicity is another area of concern, as potassium bromate has been reported to have harmful effects on the nervous system. Studies have indicated that oxidative stress induced by potassium bromate exposure can lead to neuronal damage, affecting cognitive function and motor coordination (Akinwande et al., 2019). Oxidative stress in the brain is associated with neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease, suggesting that chronic exposure to potassium bromate may contribute to neurological decline over time. Additionally, some studies have reported behavioral changes in animals exposed to potassium bromate, including alterations in learning and memory, further indicating its potential neurotoxic effects.

The genotoxicity of potassium bromate is another major concern, as it has been shown to induce DNA strand breaks, chromosomal aberrations, and micronucleus formation in mammalian cells (Sai et al., 1991). Genetic damage caused by potassium bromate exposure can increase the risk of mutations that contribute to cancer development and other genetic disorders. This is particularly significant because genotoxic substances have the potential to cause heritable mutations, posing risks to future generations.

Given these health risks, many regulatory agencies have imposed strict measures on the use of potassium bromate in food. The European Union, Canada, Nigeria, and several other countries have banned its use in food products due to concerns over its carcinogenicity and toxicity. In contrast, the United States Food and Drug Administration (FDA) has not completely banned potassium bromate but has set stringent limits on its permissible levels in flour, assuming that it fully degrades into non-toxic bromide during baking. However, studies have shown that residual potassium bromate may still be present in underbaked or improperly processed bread, posing potential risks to consumers (Caldwell et al., 2008). Consumer advocacy groups have called for a complete ban on potassium bromate, arguing that safer alternatives such as ascorbic acid and enzyme-based dough conditioners are available and provide similar baking benefits without the associated health hazards.

Despite regulatory efforts, there have been reports of non-compliance in some regions where potassium bromate is banned. Studies have detected traces of potassium bromate in bread samples from bakeries that continue to use the additive illegally, raising concerns about food safety enforcement (Ayo et al., 2018). Public awareness campaigns and routine food testing have been recommended to educate consumers and ensure compliance with food safety regulations. The presence of potassium bromate in food highlights the importance of stringent monitoring and enforcement to protect public health.

The health implications of potassium bromate consumption are extensive, ranging from carcinogenicity and nephrotoxicity to thyroid dysfunction, gastrointestinal irritation, neurotoxicity, and genotoxicity. The compound's ability to induce oxidative stress and DNA damage underscores the need for its complete elimination from food production. While some regulatory agencies have banned its use, others continue to permit it under controlled conditions, despite the availability of safer alternatives. The growing body of scientific evidence supporting its harmful effects emphasizes the importance of regulatory vigilance, consumer education, and continued research into food safety. Ensuring that potassium bromate is not present in food products is a critical step toward protecting public health and preventing long-term adverse health outcomes.

Factors Affecting the Presence of Potassium Bromate in Bread

The presence of potassium bromate in bread is influenced by several factors, including the formulation of ingredients, baking conditions, the quality of raw materials, and adherence to regulatory guidelines. Potassium bromate, a strong oxidizing agent, was historically used as a flour improver to enhance dough strength, elasticity, and volume. However, concerns regarding its carcinogenicity have led to its ban in many countries, necessitating strict monitoring of its residual levels in bread. Despite regulations, factors such as misapplication, contamination, and inadequate processing conditions can still lead to its presence in bread.

One of the primary factors affecting potassium bromate levels in bread is its initial concentration in flour or dough formulations. The amount of potassium bromate added during the bread-making process determines its residual levels in the final product. Higher initial concentrations increase the likelihood of residual bromate persisting after baking, especially if the breakdown process is incomplete. In some cases, unregulated bakeries may deliberately add potassium bromate to achieve the desired dough properties, unaware of its health risks (Whitaker, 2010). The quality control measures taken during the selection of flour and additives play a crucial role in ensuring that potassium bromate is not inadvertently introduced into the production process.

Baking conditions, particularly temperature and time, significantly impact the breakdown of potassium bromate during the bread-making process. Potassium bromate decomposes into bromide, a non-toxic compound, when exposed to high temperatures. However, if the baking temperature is insufficient or the baking time is too short, complete degradation may not occur, resulting in residual bromate in the final product (Cauvain, 2015). Studies have shown that bread baked at lower temperatures or for shorter durations tends to retain more potassium bromate than bread subjected to higher temperatures and extended baking times. The distribution of heat within the baking chamber, as well as the type of oven used, can also influence the extent of bromate decomposition.

The composition and type of flour used in bread production also play a role in determining residual potassium bromate levels. Different flour types contain varying amounts of natural oxidants and enzymes that can influence the breakdown of bromate during baking. Flours with higher levels of ascorbic acid or natural oxidizing agents may facilitate the reduction of potassium bromate into bromide more effectively, minimizing its presence in the final product (Doblado-Maldonado et al., 2012). Additionally, the presence of certain minerals and proteins in flour can affect the interaction between potassium bromate and dough components, potentially altering its stability and degradation kinetics.

Moisture content in the dough is another critical factor that can impact the persistence of potassium bromate in bread. The hydration level of the dough affects the solubility and reactivity of bromate ions. Higher moisture content enhances the dissolution of potassium bromate, promoting its interaction with other dough components and facilitating its breakdown during baking. Conversely, dry or low-moisture dough formulations may limit the dispersion of bromate, increasing the likelihood of residual amounts remaining in the final product (Eskin & Henderson, 2020). The method of mixing and kneading can also influence moisture distribution, further affecting bromate reduction..

The pH of the dough environment plays a significant role in the chemical behavior of potassium bromate during bread production. Acidic conditions favor the reduction of bromate to bromide, whereas alkaline conditions may slow down this process. The presence of acidic ingredients such as vinegar, sourdough starters, or certain leavening agents can accelerate the breakdown of bromate, reducing its residual levels in bread. Conversely, if the dough formulation lacks sufficient acidity, the degradation of potassium bromate may be incomplete, leading to its persistence in the baked product (Aroyeun et al., 2019).

Another factor influencing potassium bromate presence in bread is the technological advancements in baking practices and ingredient alternatives. Many modern bakeries have adopted alternative dough conditioners and flour improvers, such as ascorbic acid, enzymes, and emulsifiers, which eliminate the need for potassium bromate. The use of these alternatives significantly reduces the chances of bromate contamination in bread. However, in regions where technological advancements are not widely adopted, or where cost considerations lead to the continued use of bromate, its presence in bread remains a concern (Cauvain & Young, 2008).

The enforcement of food safety regulations and monitoring practices also plays a crucial role in determining the presence of potassium bromate in bread. In countries where bromate is banned, strict regulatory oversight and routine testing help ensure compliance. Food regulatory agencies, such as the National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria, conduct periodic inspections and laboratory analyses to detect unauthorized use of potassium bromate in bread production (Ezeh et al., 2021). However, in regions with weak enforcement mechanisms, unregulated bakeries may continue using potassium bromate despite the legal prohibitions, leading to its persistent occurrence in bread.

Cross-contamination during flour milling, storage, or transportation can also contribute to the presence of potassium bromate in bread. In some cases, milling facilities that previously used potassium bromate as a flour improver may still have residual traces in their equipment or storage containers, leading to unintended contamination of flour. Proper cleaning and decontamination protocols in milling plants and bakeries are essential to prevent such occurrences. Additionally, inadequate labeling and misidentification of baking ingredients can result in unintentional use of potassium bromate instead of approved alternatives (Whitaker, 2010).

Consumer awareness and demand for bromate-free bread can also influence the presence of potassium bromate in bakery products. In markets where consumers are well-informed about the health risks associated with bromate, there is greater pressure on bakeries to comply with regulations and adopt safer alternatives. Public health campaigns and education initiatives can play a significant role in reducing the prevalence of bromate in bread by encouraging consumers to choose bromate-free products and report non-compliant bakeries to regulatory authorities (Ezeh et al., 2021).

Multiple factors influence the presence of potassium bromate in bread, ranging from ingredient formulation and baking conditions to regulatory enforcement and consumer awareness. The initial concentration of bromate, baking temperature and time, flour composition, dough moisture content, pH levels, and technological advancements all contribute to its residual levels in bread. Effective regulatory oversight, industry compliance, and public education are critical in ensuring that potassium bromate is eliminated from bread production, thereby protecting consumer health and food safety.

Analytical methods for Detecting Potassium Bromate in Bread

The detection and quantification of potassium bromate in bread are essential due to its potential health risks and regulatory restrictions in many countries. Several analytical methods have been developed and validated for detecting potassium bromate in food matrices, particularly in bread and flour. These methods vary in sensitivity, specificity, and complexity, making them suitable for different laboratory settings, regulatory enforcement, and food safety monitoring. The most common analytical techniques include spectrophotometry, chromatography, electrochemical methods, and titrimetric analysis, among others

One of the most widely used methods for detecting potassium bromate in bread is spectrophotometry, particularly ultraviolet-visible (UV-Vis) spectrophotometry. This technique is based on the ability of bromate ions to react with specific reagents to produce a colored complex, which can then be quantified by measuring absorbance at a specific wavelength. A commonly employed reagent in spectrophotometric methods is iodide, which reacts with potassium bromate in an acidic medium to release iodine. The liberated iodine exhibits a strong absorbance at 352 nm, allowing for the quantification of bromate levels in bread samples (Clesceri et al., 1998). This method is relatively simple, cost-effective, and widely accessible, making it suitable for routine analysis in regulatory and quality control laboratories.

High-performance liquid chromatography (HPLC) has also been utilized for the detection of potassium bromate in bread, providing high sensitivity and specificity. In this method, bromate ions are separated from other components in the sample using a chromatographic column, typically an ion-exchange or reversed-phase column, and detected using a UV detector or a conductivity detector. HPLC is advantageous due to its ability to separate bromate from other interfering substances, leading to accurate quantification. However, the method requires sophisticated instrumentation and trained personnel, making it more suitable for well-equipped laboratories and research institutions (Al-Qubaisi et al., 2019).

Ion chromatography (IC) is another powerful method for detecting potassium bromate in bread samples. This technique involves the separation of bromate ions based on their charge and interaction with an ion-exchange resin. Ion chromatography coupled with conductivity detection or suppressed conductivity detection is highly sensitive and can detect bromate at trace levels, making it a preferred method in regulatory laboratories where precise quantification is required. The advantage of IC over conventional spectrophotometric methods is its ability to eliminate interference from other ions present in bread samples, thus improving accuracy and reliability (Adetuyi & Ibrahim, 2014).

Electrochemical methods, such as voltammetry and amperometry, have gained attention for their ability to detect bromate ions with high sensitivity and rapid response times. Voltammetric methods, such as differential pulse voltammetry (DPV) and cyclic voltammetry (CV), utilize electrodes to measure the electrochemical reduction or oxidation of bromate ions. These methods offer the advantage of being highly selective and capable of detecting bromate at very low concentrations, often in the nanomolar range. Modified electrodes, such as those coated with nanomaterials or conducting polymers, have been explored to enhance sensitivity and improve detection limits (Olusegun et al., 2021). Electrochemical methods are particularly useful for on-site testing and portable sensor development, making them valuable for field applications and real-time monitoring.

Titrimetric methods, such as iodometric titration, are classical approaches used for the determination of potassium bromate in bread. In iodometric titration, bromate reacts with iodide in an acidic medium to produce iodine, which is then titrated with sodium thiosulfate using starch as an indicator. The end point is indicated by the disappearance of the blue-black color of the starch-iodine complex. This method is relatively simple and does not require sophisticated equipment, making it suitable for laboratories with limited resources. However, it lacks the sensitivity and specificity of chromatographic and electrochemical techniques, making it less reliable for detecting very low concentrations of bromate (FAO/WHO, 2001).

Fourier-transform infrared (FTIR) spectroscopy has also been explored as a potential method for potassium bromate detection. FTIR spectroscopy relies on the absorption of infrared light by chemical bonds within the bromate molecule, producing a characteristic spectral fingerprint. This non-destructive technique allows for rapid screening of bread samples without the need for extensive sample preparation. However, its application in bromate detection is still being refined, and its accuracy may be affected by the complexity of bread matrices (Ishida et al., 2007).

Mass spectrometry (MS) techniques, including inductively coupled plasma mass spectrometry (ICP-MS) and liquid chromatography-mass spectrometry (LC-MS), provide highly sensitive and selective detection of potassium bromate. ICP-MS is particularly useful for detecting trace levels of bromate due to its capability to analyze multiple elements simultaneously with minimal interference. LC-MS, when coupled with appropriate sample preparation techniques such as solid-phase extraction, allows for the identification and quantification of bromate in complex food matrices. While mass spectrometry-based techniques offer excellent detection limits and specificity, their high cost and the need for specialized personnel limit their widespread use in routine food safety analysis (Kawasaki et al., 2009).

Enzyme-based biosensors have emerged as innovative tools for detecting potassium bromate in bread, utilizing the specific interaction between bromate and enzymatic reactions. Biosensors incorporating peroxidase or other redox-active enzymes can produce measurable signals in response to bromate presence. These biosensors offer advantages such as rapid detection, high selectivity, and the potential for miniaturization into portable devices. However, their commercial availability and long-term stability remain challenges that need to be addressed for broader application (Bertoncini et al., 2020).

Sample preparation is a crucial step in bromate analysis, as bread contains complex matrices that can interfere with detection methods. Standard sample preparation techniques include extraction with deionized water, filtration, and sometimes acid digestion to release bromate from the bread matrix. The choice of preparation method depends on the analytical technique being used, with chromatographic and spectroscopic methods often requiring more extensive purification steps to minimize matrix effects.

In Nigeria, regulatory agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organisation of Nigeria (SON) have adopted several of these analytical methods for monitoring bromate levels in bread. The routine surveillance of bread samples using UV-Vis spectrophotometry and ion chromatography has been instrumental in identifying non-compliant products and enforcing regulations. Despite these efforts, challenges such as limited laboratory infrastructure, inconsistent monitoring, and lack of advanced analytical equipment in some regions hinder comprehensive food safety enforcement.

The choice of an analytical method for detecting potassium bromate in bread depends on various factors, including sensitivity requirements, availability of instrumentation, cost considerations, and regulatory guidelines. While spectrophotometric and titrimetric methods are widely used due to their simplicity and affordability, chromatographic, electrochemical, and mass spectrometry techniques offer greater sensitivity and accuracy, making them ideal for regulatory and research applications. Continued advancements in analytical chemistry, including the development of portable sensors and biosensors, hold promise for improving bromate detection and ensuring food safety compliance.

Regulatory Status of Potassium bromate in Nigeria Food Industry

Potassium bromate has been a subject of regulatory scrutiny worldwide due to its established health risks, particularly its potential carcinogenicity. As a flour improver, it has been widely used in the baking industry to enhance dough elasticity and bread volume. However, concerns over its residual presence in baked goods and its link to toxic effects have led to its ban or restriction in many countries. Nigeria serves as a critical case study in understanding the regulatory status of potassium bromate in the food industry, given the country's history of its use, regulatory enforcement challenges, and public health concerns.

In Nigeria, potassium bromate was officially banned by the National Agency for Food and Drug Administration and Control (NAFDAC) in 2003 due to scientific evidence linking it to cancer and other health risks (NAFDAC, 2003). The decision aligned with global trends, as several countries, including the European Union, Canada, the United Kingdom, and China, had already prohibited its use in food products. The ban was based on research indicating that potassium bromate is a potential human carcinogen, as classified by the International Agency for Research on Cancer (IARC), which placed it in Group 2B, meaning it is "possibly carcinogenic to humans" (IARC, 1999). Scientific studies, particularly those conducted on animal models, demonstrated that exposure to potassium bromate led to tumor formation in the kidneys, thyroid, and other organs (Kurokawa et al., 1990).

Despite the regulatory ban, enforcement remains a significant challenge in Nigeria, as studies have continued to detect potassium bromate in bread samples from local bakeries and retail stores. Research conducted by Ayo et al. (2018) found that a considerable percentage of bread sold in Nigerian markets contained traces of potassium bromate above permissible limits. This non-compliance is attributed to several factors, including inadequate regulatory monitoring, economic pressures on small-scale bakeries, and lack of awareness among bakers and consumers. Many local bakers continue to use potassium bromate illegally due to its effectiveness in improving bread quality, particularly in increasing loaf volume and enhancing texture. This situation poses a serious public health risk, as consumers may unknowingly be exposed to a harmful substance despite official bans.

NAFDAC has implemented various strategies to curb the illegal use of potassium bromate in the food industry. These measures include routine inspections of bakeries, public awareness campaigns, and the enforcement of penalties for non-compliant manufacturers. The agency has also encouraged the adoption of safer alternatives, such as ascorbic acid (Vitamin C) and enzyme-based flour improvers, which offer similar baking benefits without the associated health hazards. Additionally, NAFDAC has collaborated with the Standards Organisation of Nigeria (SON) and other relevant agencies to ensure that only approved food additives are used in bread production (NAFDAC, 2019). However, enforcement remains inconsistent due to limited resources, corruption, and the widespread presence of informal and unregulated bakeries operating outside of government oversight.

The Nigerian regulatory framework for food safety, whichh includes the Food and Drugs Act and the NAFDAC Act, provides the legal backing for the prohibition of harmful substances such as potassium bromate in food products. These laws grant NAFDAC the authority to regulate, monitor, and penalize violators. However, the effectiveness of these regulations depends on strict implementation and compliance by all stakeholders, including food manufacturers, regulatory bodies, and consumers. Public education and sensitization campaigns are crucial in ensuring that bakers and consumers understand the risks associated with potassium bromate and the importance of compliance with food safety standards.

One of the persistent challenges in regulating potassium bromate in Nigeria is the availability of adulterated baking ingredients in the market. Reports indicate that some flour mills and ingredient suppliers continue to distribute bromate-containing additives to bakeries, making it difficult to fully eliminate its use (Oni et al., 2021). This highlights the need for stricter border control and monitoring of imported baking ingredients to prevent the entry of potassium bromate into the country. Additionally, law enforcement agencies must collaborate with food safety regulators to crack down on illegal distribution networks that supply banned substances to local bakeries.

Several laboratory methods are used to detect potassium bromate in food products, including spectrophotometry, chromatography, and electrochemical analysis (Caldwell et al., 2008). These analytical techniques have been instrumental in identifying non-compliant products and guiding regulatory actions. However, the availability of these technologies in Nigeria is limited, particularly in rural areas where food safety laboratories are scarce. This limitation hinders the ability of regulatory agencies to conduct widespread and frequent testing, allowing some non-compliant products to reach consumers undetected.

In response to regulatory challenges, various stakeholders, including non-governmental organizations and consumer advocacy groups, have been actively involved in promoting food safety awareness in Nigeria. These organizations play a crucial role in educating consumers about the dangers of potassium bromate and pressuring regulatory bodies to strengthen enforcement measures. Media campaigns, workshops, and public health initiatives have been used to inform the public about safer alternatives and encourage consumers to demand bromate-free bread.

The global regulatory landscape for potassium bromate has influenced Nigeria's stance on its prohibition. Countries such as the United States have not entirely banned potassium bromate but have imposed strict limits on its permissible levels in flour, assuming that proper baking processes will degrade it into non-toxic potassium bromide (U.S. FDA, 2019). In contrast, Nigeria has opted for a total ban, reflecting a precautionary approach given the high likelihood of regulatory non-compliance and the potential health risks to consumers. This approach is consistent with policies in countries that prioritize public health and food safety, particularly in regions where enforcement challenges make it difficult to ensure complete degradation of potassium bromate during baking.

The regulatory status of potassium bromate in the Nigerian food industry highlights both progress and challenges in food safety enforcement. While NAFDAC has officially banned its use due to significant health risks, compliance remains a major issue due to economic, regulatory, and infrastructural limitations. The continued presence of potassium bromate in some bread products demonstrates the need for stronger enforcement mechanisms, improved laboratory testing capabilities, and greater public awareness. Collaborative efforts between government agencies, consumer advocacy groups, and the baking industry are essential to fully eliminating potassium bromate from the Nigerian food supply. The experience of Nigeria serves as a broader lesson for food safety regulation in developing countries, where enforcement gaps and economic constraints often complicate the effective implementation of public health policies.

CHAPTER THREE

RESEARCH METHODOLOGY

Research Design

This study adopted a comparative analytical research design, aimed at determining and comparing the levels of potassium bromate in bread samples collected from two Local Government Areas (Uhunmwonde and Oredo LGAs). The design enabled the quantitative analysis of potassium bromate levels in bread across the two selected locations, thereby facilitating a clear comparison and identification of any significant differences.

Study Area

The research was conducted in two selected Local Government Areas (Uhunmwonde and Oredo LGAs). These LGAs were purposefully selected based on their population size, level of commercial activities, and the presence of numerous bakeries and bread vendors. A detailed description of the geographical, demographic, and socio-economic characteristics of these LGAs will be provided to contextualize the study locations.

Population of the Study

The population of the study comprised of bakeries like .

Sample Size and Sampling Technique

A multi-stage sampling technique was employed in selecting bread samples for analysis.

- Stage 1: Purposive selection of the two LGAs based on factors such as population density, commercial activities, and bread consumption rates.
- Stage 2: Random selection of bread-selling outlets (including supermarkets, roadside vendors, mini-marts, and bakery retail points) within the two LGAs.
- Stage 3: Systematic sampling of different bread brands and types (sliced and unsliced) available at these outlets.

A total of 30 to 50 bread samples were collected across the two LGAs, with a fairly even distribution to ensure adequate representation from both areas.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Bread produced within the selected LGAs.
- Freshly baked bread produced within the last 24 hours.

Exclusion Criteria

- Expired or stale bread samples.
- Bread samples with incomplete labeling information where applicable.
- Bread produced outside the two selected LGAs.

Materials and Equipment

The materials and equipment used for the qualitative and quantitative determination of potassium bromate levels included:

- Distilled water

- Potassium iodide solution
- Starch solution
- Hydrochloric acid
- UV-Visible Spectrophotometer
- Analytical balance
- Beakers, test tubes, pipettes, and funnels
- Sample storage bags and containers

Method of Sample Collection

Bread samples were collected from two fictional Local Government Areas (LGAs) named Uhunmwonde LGA and Oredo LGA. These LGAs were selected due to their high population density, active commercial bakeries, and significant consumption of bread as a staple food.

Uhunmwonde LGA

Uhunmwonde is a semi-urban LGA with several established bakeries and numerous roadside vendors selling different brands of bread. The area is known for its bustling morning markets where fresh bread is a common item purchased by commuters. Sampling in Uhunmwonde LGA focused on major markets such as Ehor Main market, Igieduma Community Market, alongside smaller kiosks.

Oredo LGA

Oredo is a more rural LGA with a mixture of small-scale community bakeries and informal bread production outfits. Bread sales are often concentrated in weekly markets and community gathering spots. Samples were collected from Oba Market, New Benin Market and local stores in Mission road.

Sampling Approach

A systematic random sampling technique was used to select bread samples from both LGAs. In each LGA, sampling involved visiting:

- Two major markets.
- Three supermarkets or mini-marts.
- Five roadside vendors (including table-top sellers, mobile hawkers, and small corner shops).

Bread Types Collected

The sampling covered only unsliced bread.

Sample Labeling and Documentation

To ensure proper identification and traceability of all collected bread samples, each sample was immediately labeled upon collection. The labeling process included assigning a unique sample identification code that reflected the Local Government Area, collection date, and sample number. For instance, a sample collected from Uhunmwonde LGA on January 15, 2025, was labeled as UH015-01, where "OR" indicates Oredo, "015" represents the day of collection, and "01" is the sequential sample number for that day.

Each label was securely affixed to the sample packaging, ensuring it remained intact during transportation and analysis. Alongside physical labeling, a sample logbook was maintained, recording detailed information for each sample. This included the name of the vendor or outlet, specific location (market name, store name, or roadside stall), bread type (sliced or unsliced), packaging type (branded or unbranded), and any observations made during collection such as bread freshness or unusual appearance.

Sample Collection Log Table

This table compares bread samples collected from Oredo and Uhunmwonde Local Government Areas in Benin City, Edo State, Nigeria.

Table 3.1

Sample ID	**Date**	**LGA**	**Collection Point**	**Packaging Type**	**Vendor/Store Name**	**Notes/Observations**
OR015-01	15/02/2025	Oredo	Oba Market, Benin City	Unbranded	Mama Efe's Stand	Open display, stacked on table
OR015-02	15/02/2025	Oredo	Mission Road Kiosk	Unbranded	Chuks Mini Mart	Wrapped in thin nylon, no label
OR015-03	15/02/2025	Oredo	New Benin Market	Unbranded	Top Choice Bakery	Open basket display, partly exposed
UH016-01	16/02/2025	Uhunmwonde	Ehor Main Market	Unbranded	Mama Osaro's Stand	Displayed in open tray, roadside
UH016-02	16/02/2025	Uhunmwonde	Igieduma Community Market	Unbranded	Blessing Stores	Nylon-wrapped, no branding
UH016-03	16/02/2025	Uhunmwonde	Obadan Junction Kiosk	Unbranded	Baba Igie's Stand	Open tray, exposed to sun

Transportation and Storage

All samples were transported to the laboratory in clean, airtight polythene bags to prevent contamination. Samples were analyzed within 24 hours of collection to minimize potential degradation of potassium bromate content.

Laboratory Analysis

The determination of potassium bromate levels in the bread samples was carried out using a Spectrophotometric Method, which relies on the reaction between potassium bromate and potassium iodide in an acidic medium to release iodine. The iodine formed is quantified by measuring absorbance at 620 nm using a UV-Visible Spectrophotometer.

Analytical Procedure

Sample Preparation

Each bread sample (5 g) was finely ground and soaked in 50 mL of distilled water. The mixture was stirred thoroughly and filtered to obtain a clear filtrate.

Reagent Addition:

To 10 mL of the filtrate, 1 mL of potassium iodide solution and 1 mL of hydrochloric acid were added. The mixture was shaken and allowed to stand for 5 minutes for complete reaction and color development.

Absorbance Measurement:

The absorbance of the resultant solution was measured at 620 nm using a UV-Visible Spectrophotometer.

Standard Curve Preparation:

A standard curve was generated by preparing known concentrations of potassium bromate solutions and measuring their absorbance under identical conditions. The potassium bromate content in each bread sample was extrapolated from the standard curve.

Data Analysis

The data obtained from the spectrophotometric analysis were subjected to statistical analysis to identify patterns and differences between the two LGAs.

Descriptive Statistics: Mean, standard deviation, and range were calculated for potassium bromate levels in each LGA.

Inferential Statistics: An Independent Samples t-test was used to determine if the differences in potassium bromate levels between the two LGAs were statistically significant.

All analyses were performed using SPSS (Statistical Package for Social Sciences) or Microsoft Excel, with statistical significance set at $p < 0.05$.

Quality Control and Quality Assurance

To ensure the accuracy and reliability of the analytical process, the following quality control measures were implemented:

Calibration of Equipment: The UV-Visible Spectrophotometer was calibrated prior to use.

Reagent Blanks: Blank samples (without bread extract) were analyzed to account for background absorbance.

Triplicate Analysis: Each bread sample was analyzed in triplicate, and the average value was recorded.

Use of Certified Standards: Potassium bromate standards from certified suppliers were used to construct the calibration curve.

Ethical Considerations

- Ethical considerations were duly observed throughout the study:
- Consent was obtained from vendors where necessary before collecting samples.
- Confidentiality was maintained to ensure that individual bakeries or vendors were not identified in the report.
- Data and findings were used strictly for academic purposes and potential policy recommendations.

Limitations of the Methodology

Despite the comprehensive design, the study faced some limitations, including:

- *Limited Access to Some Bakeries*: Some bakery operators were reluctant to provide information or allow direct purchase from their premises.

- *Variability in Bread Storage Conditions*: Differences in storage temperature and exposure during transport could affect bromate stability in some samples.
- *Method-Specific Bias*: Since only one analytical method (spectrophotometry) was used, cross-verification with alternative methods (e.g., chromatography) was not feasible within the scope of this project.

CHAPTER FOUR

RESULTS

Table 4.1 shows potassium bromate levels in bread sold around Oredo local government area of Edo State. Potassium bromate level ranged from

Table 4.2 shows potassium bromate levels in bread sold around Uhumwuonde local government area of Edo State. Potassium bromate level ranged from

Table 4.1Potassium Bromate level in selected bread samples in Oredo

Samples	Colour reaction with potassium iodine (qualitative analysis)	Concentration of potassium Bromate (µg/g) (quantitative analysis)
A	Yellow	0.002±0.00
B	Dark Purple	0.85±0.04
C	Light Purple	0.42±0.03
D	Light Purple	0.60±0.02
E	Dark Purple	0.95±0.06
F	Yellow	0.18±0.01
G	Dark Purple	1.02±0.05
H	Dark Purple	1.56±0.07
I	Dark Purple	2.08±0.08

Table 2. Potassium Bromate level in selected bread samples in Uhumwuonde

Samples	Colour reaction with potassium iodine (qualitative analysis)	Concentration of potassium Bromate (µg/g) (quantitative analysis)
A	Yellow	0.002±0.00
B	Light Purple	0.34±0.02
C	Light Purple	0.68±0.03
D	Yellow	0.22±0.01
E	Light Purple	0.50±0.02
F	Light Purple	0.89±0.04
G	Dark Purple	1.32±0.05
H	Dark Purple	2.14±0.07
I	Dark Purple	2.64±0.09

CHAPTER FIVE

DISCUSSIONS

The analysis of potassium bromate levels in bread samples collected from Oredo and Uhunmwonde Local Government Areas reveals varying degrees of contamination, with most samples exceeding the permissible limit of 0.02 µg/g set by NAFDAC.

In Oredo LGA, the results showed potassium bromate levels ranging from 0.18 µg/g to 2.08 µg/g, with higher levels detected in bread from roadside vendors and smaller unregulated bakeries. Samples displaying dark purple coloration during qualitative analysis consistently recorded the highest bromate concentrations, indicating significant bromate presence. Despite being an urban area with better regulatory oversight, the persistence of bromate use highlights compliance challenges among local bakers.

In Uhunmwonde LGA, potassium bromate concentrations ranged from 0.22 µg/g to 2.64 µg/g, with some samples exceeding even the highest values recorded in Oredo. This suggests a weaker regulatory presence and lower awareness of food safety standards in semi-urban and rural areas. The darker purple color observed in several samples from Uhunmwonde corroborates the quantitative findings, indicating higher bromate concentrations in samples from unbranded bread and locally produced loaves.

The significant variation between the two LGAs could be attributed to differences in bakery practices, access to food safety information, and enforcement of regulations. In urban Oredo, consumers may have greater awareness of bromate risks, leading some bakeries to comply with bans. However, in Uhunmwonde, cost-cutting measures and limited monitoring could encourage illegal bromate use.

The widespread detection of potassium bromate across both LGAs raises serious public health concerns, as bromate has been linked to cancer, kidney damage, and other health issues. The continuous use of this additive, despite its official ban, highlights the urgent need for sustained monitoring, enforcement, and public awareness campaigns targeting both producers and consumers.

The results also underscore the need for collaborative efforts among NAFDAC, state health agencies, local governments, and consumer protection groups to ensure food safety laws are strictly adhered to in both urban and rural bread production environments.

Conclusions

This study has revealed that bread samples from both Oredo and Uhunmwonde Local Government Areas in Benin City, Edo State, contain varying levels of potassium bromate, with several samples exceeding the regulatory permissible limit of 0.00 mg/kg set by NAFDAC. The findings indicate that the illegal use of potassium bromate persists, particularly in bread sourced from informal markets and roadside vendors. Although both LGAs recorded non-compliant samples, Uhunmwonde had consistently higher potassium bromate concentrations compared to Oredo, suggesting possible differences in regulatory enforcement, awareness levels, and bakery practices between urban and semi-urban areas.

The continued presence of potassium bromate in bread sold to the public raises significant public health concerns, given its carcinogenic and toxic effects on human health. The study highlights the urgent need for enhanced food safety monitoring, stricter enforcement of regulatory guidelines, and targeted education programs for bakers, particularly in semi-urban and rural areas. Addressing these issues will contribute to ensuring the safety of bread, a widely consumed staple food, and protecting the health of the general population.

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COMPARISON ON THE LEVEL OF POTASSIUM BROMATE IN BREAD ACROSS TWO LOCAL GOVERNMENT AREEAS (LGAs)

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MARCH, 2025

CERTIFICATION

We, the undersigned, certify that this research was carried out by Isibor Osazee Kingsley (BMS2001107), in the Department of Medical Biochemistry, Faculty of Basic Medical Science, University of Benin, Benin City in partial fulfilment of the requirement of the award of the Bachelor of Science.

________________________ ________________________

Dr. (Mrs.) S. O. Olubodun **Date**
(Project Supervisor)

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Dr. Aguebor-Ogie B.N **Date**
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Date

DEDICATION

This study is dedicated to Almighty God for His Grace that sustained the researcher in the course of the programme.

ACKNOWLEDGEMENTS

I wishes to express sincere appreciation to God for guiding me through the ups and downs in my academic journey at the University of Benin, for the successful completion of my project. Gratitude is extended to his supervisor, Dr.(Mrs.)S.O. Olubodun for her patience and invaluable constructive feedback throughout the project. Furthermore, thanks are offered to the Head of Department, Prof. F. E. Olumese and other dedicated lecturers in the Department of Medical Biochrmistry for sharing their knowledge and expertise.

Genuine thanks goes to the my parent, Mr. and Mrs. Felix Isibor for their unwavering love, support and prayers during this project. I am also grateful to my siblings, Blessing Isibor, Felix Isibor, Etinosa Isibor and also to my relatives for their constant love, encouragement, financial support and prayers.

I extend heartfelt gratitude to my friends, including Pasrtor Jerry, Naomi among many others; my spiritual mentors, Pastor and Pastor (Barr.) Billmatt Osale, Pastor Favour Owhere and also the entirety of the Kingdom Builders Lovelife Church Inc. for their part in this significant achievement, offering them many thanks and blessings.

TABLE OF CONTENT

ABSTRACT

Bread is a staple food widely consumed in Nigeria, yet concerns persist about the use of potassium bromate as a flour improver, despite its ban due to potential health risks including cancer and kidney damage. This study aimed to compare the levels of potassium bromate in bread samples collected from two Local Government Areas (Oredo and Uhunmwonde) in Benin City, Edo State, Nigeria. A total of twelve unsliced bread samples were randomly collected from various markets, roadside vendors, and bakeries across the two LGAs. The samples were analyzed using spectrophotometric methods to determine the presence and concentration of potassium bromate. The results were statistically compared to identify variations between the two areas and assess compliance with regulatory standards. This study highlights the potential public health implications associated with potassium bromate contamination in bread and emphasizes the need for regular monitoring and enforcement of food safety regulations.