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Original article

Evaluation of Potassium Bromate Levels in Bread Products Marketed in Ghemines City

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Abstract
Bread is a staple food that is indispensable throughout Libya for all Social and economic groups. Potassium bromate (KBrO3) is a white crystal/powder that is colorless, odorless, and tasteless and is used as a food additive in the pastry industry to improve the function of dough as an oxidizing and bleaching agent. After several long-term studies, the International Agency for Research on Cancer (IARC) classified potassium bromate as a possible carcinogen (Group 2B), and in 2012 the Codex Alimentarius Commission officially withdrew the specification for potassium bromate as an additive. The study aims to verify that Libyan bread, especially Ghemines city bread, is free of potassium bromate. Different bread samples were randomly collected from 19 bakeries in Ghemines. The samples were then analyzed using a spectrophotometric method. This method is based on the reaction of bromate ions with iodide ions in an acidic medium to produce iodine. This substance has been found at a concentration significantly above the permissible level of potassium bromate set by the USFDA and Libyan National Standard Regulation in bread. Therefore, bread consumers and bakers are at risk of exposure to potassium bromate.
Keywords. Potassium Bromate, Bread, Food Additives, Food Safety, UV-VIS Spectrophotometer, Residual Contaminants.

Introduction

Food additives are substances deliberately incorporated into food products to maintain flavor, improve taste or appearance, and extend shelf life or enhance technological characteristics. Their use is regulated by health authorities due to possible effects on human health. Chemically, these additives range from basic inorganic salts to complex organic compounds, with their functions varying based on the intended sensory or technological purpose [1]. Food additives are generally classified into several categories: preservatives, antioxidants, coloring agents, flavor enhancers, emulsifiers, stabilizers, thickeners, and leavening agents. Preservatives prevent the growth of microorganisms like bacteria, yeasts, and molds, helping to prolong the shelf life of food products. Common examples include sodium benzoate (C_6H_5COONa), which is effective in acidic foods, and nitrites or nitrates, which are widely used in preserving meats [2].

Potassium sorbate ($C_6H_7KO_2$) is another widely used antimicrobial agent that inhibits molds and yeasts in dairy and bakery products [3]. Antioxidants are compound protect food from oxidative damage, which can cause rancidity and reduce nutritional value. Common antioxidants include butylated hydroxytoluene (BHT, $C_{15}H_{24}O$) and ascorbic acid ($C_6H_8O_6$) [4]. They function by neutralizing free radicals and interrupting the chain reactions responsible for lipid oxidation [5]. Coloring Agents are additives used to restore or enhance the color of food products. They may be derived from natural sources, such as carotenoids and anthocyanins, or produced synthetically, like tartrazine ($C_{16}H_9N_4Na_3O_9S_2$).

Due to concerns about potential allergenic and toxic effects, the use of many synthetic colorants is strictly regulated [6]. Flavor enhancer compounds such as monosodium glutamate (MSG, $C_5H_8NO_4Na$) enhance the overall taste of food without adding a distinct flavor of their own. They work by stimulating glutamate receptors on the tongue, thereby intensifying the perception of umami [7]. Emulsifiers, Stabilizers, and Thickeners, are additives used to alter the texture and visual appeal of food. Emulsifiers, such as lecithin ($C_{24}H_{80}NO_8P$), facilitate the mixing of immiscible liquids like oil and water. Thickeners like xanthan gum enhance viscosity, while stabilizers help maintain a consistent distribution of ingredients within the food matrix [8]. Leavening agents release gases that cause dough to rise and become light and airy; they are mainly used in baked goods.

Ammonium bicarbonate (NH_4HCO_3) and sodium bicarbonate ($NaHCO_3$) are typical examples. Additionally, potassium bromate ($KBrO_3$), a potent oxidizing agent, has long been used to improve baking quality and strengthen dough. Food Additives' Advantages are Enhanced Visual Quality and aesthetic appeal, better microbial safety, and Shelf Stability. In contemporary food processing, food additives are frequently used to boost flavor, increase shelf life, and improve texture and appearance. Concerns regarding the possible long-term health effects of consumption have been raised by an increasing body of scientific research [11]. Artificial colorants are a significant cause for concern because they have been connected to behavioral problems in kids, especially hyperactivity. Certain synthetic dyes may exacerbate hyperactive behavior in children from the general population, according to a well-known randomized controlled trial published in The Lancet [12]. Particularly when meats are cooked at high temperatures, preservatives like sodium nitrite, which are commonly used in processed meats, can result in the formation of nitrosamines - compounds known for their potential to cause cancer [13].

Artificial sweeteners such as aspartame and saccharin, commonly used as sugar substitutes in diet products, have faced scrutiny due to potential metabolic impacts and possible associations with cancer. While human studies have yielded mixed findings, animal research has raised concerns, including a higher incidence of tumors [14]. Emulsifiers, which are

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used to stabilize food structure and prolong shelf life, may have adverse effects on gut microbiota. A study published in Nature involving mice indicated that these substances could contribute to low-grade inflammation and metabolic syndrome by disrupting the microbiome [15]. Potential hazards to human health [16]. The International Agency for Research on Cancer (IARC) has identified potassium bromate, an oxidizing agent used to fortify dough and improve baking quality, as a potential human carcinogen. As a result, it has been outlawed in many nations, though some areas continue to use it [17]. Lastly, phosphate additives, which are frequently found in processed meats, baked goods, and sodas, can disrupt the metabolism of minerals and have been connected to kidney and cardiovascular problems, particularly in people who already have renal problems [18].

The bromate ion (BrO_3^-) is responsible for the strong oxidizing properties and white crystalline powder form of potassium bromate ($KBrO_3$), an inorganic compound [19]. It has been widely used as a flour improver in the baking industry, where it oxidizes sulfhydryl groups in gluten-forming proteins to strengthen dough and encourage greater rise [17]. This substance increases the bread dough's elasticity and stability, resulting in a finer crumb texture and a larger loaf [20]. Potassium (K^+) and bromate (BrO_3^-) ions make up potassium bromate, a salt with a molecular weight of 167.00 g/mol [21]. The bromine atom in the +5-oxidation state gives it strong oxidizing power, which makes it a useful electron acceptor in chemical reactions [22]. $KBrO_3$ is commonly used in baking at concentrations of roughly 10–75 mg per kilogram of flour; during the baking process, it should ideally be completely reduced to the non-toxic bromide ion (Br^-) [23]. When baking conditions are not ideal, residual potassium bromate may still be present in the final product if this reduction is not complete. This poses serious safety risks [24]. Potassium bromate's potential to cause cancer is one of the main issues surrounding it. In vitro and in vivo studies have shown that $KBrO_3$ can cause oxidative stress, damage DNA, and have clastogenic effects [25]. Potassium bromate is "possibly carcinogenic to humans" according to the International Agency for Research on Cancer's (IARC) Group 2B carcinogen classification [26].

Methods

Concentrations of potassium bromate were determined by a UV-visible double-beam spectrophotometer CECIL 1000 S). The measurements were performed in the visible region using a 1 cm cuvette. A total of nineteen samples of bread were collected randomly from 19 different bakeries in the city of Ghemines. The central portion of each sample was taken and dried in an oven for an hour at a temperature of 70ºC. The dried crusts of the same baked product samples were powdered and well mixed to get a homogeneous representative sample of each selected product. The samples were given different code numbers such as A1 to A19. These samples were stored in well-closed plastic packaging till further analysis. A 1.0 g well-prepared sample was weighed out from each bread sample on an electronic weighing balance and transferred into a test tube [28]. 10 mL of distilled water was added; the mixture was shaken well and allowed to stand for 20 minutes at room temperature. A 1.5 mL volume was filtered from the test tube. A 1.5 mL quantity of freshly prepared 0.5 % potassium iodide solution in 0.1N hydrochloric acid was added; the absorbance of the sample was taken at 520 nm in a UV-visible spectrophotometer. The Analysis was done on three replicates for each of the representative samples. The amount of potassium bromate (μg/mL) in each sample was calculated using the corresponding regression equation of the calibration curve prepared from the standard solutions of potassium bromate. Then, the concentration of potassium bromate (μg/g) in each sample was calculated using equation {1}.

Con. $KBrO_3$ (μg/g) = ($KBrO_3$ μg/mL/ sample (g) X dilution factor) … Eq. (1)

Result and Discussion

In this study, the concentration of potassium bromate in the collected baked samples was determined by the spectrophotometric method. This method is based on the reaction of bromate ions with iodide ions in acid medium to produce iodine, according to the equation. The produced Iodine formed blue color complex in the presence of starch from baked products [29].

$$BrO_3^- + 6I^- + 6H^+ \rightarrow 3I_2 + 3H_2O + Br^-$$

As shown in (Figure 1), the absorbance at 520 nm increased linearly with the bromate ion concentration in the range from 0.25 to 15.0 μg/ml, with a correlation coefficient of 0.994. The corresponding regression equation was A=0.061C+0.009, where A and C were the absorbance and potassium bromate concentration, respectively.

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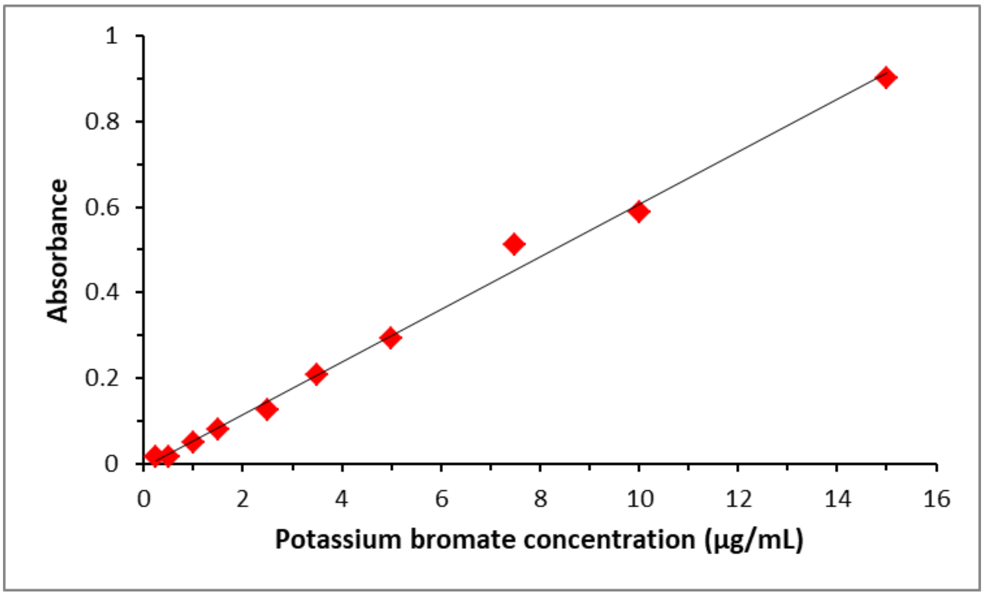

Figure (1). The standard curve of potassium bromate (0.25-16 µg/ml) using potassium iodide solution. The absorbance is measured at 520 nm. The linear regression equation is A = 0.061C + 0.009, (R^2 = 0.994).

The results of potassium bromate in bread samples collected from different bakeries located in Ghemines city are shown in (Table 1).

Table 1. Potassium bromates concentrations in some bread samples collected from different bakeries in Ghemines city

Samples	Absorbance Avg	Concentration (µg/ml)	Concentration (µg/g)
A1	0.3360	5.37	0.027
A2	0.4020	6.45	0.032
A3	0.3460	5.52	0.028
A4	0.5380	8.66	0.043
A5	0.4650	7.48	0.037
A6	0.2960	4.70	0.024
A7	0.3137	5.00	0.025
A8	0.4233	6.79	0.034
A9	0.4067	6.52	0.033
A10	0.5490	8.85	0.044
A11	0.5867	9.46	0.047
A12	0.5713	9.22	0.046
A13	0.5603	9.05	0.045
A14	0.6153	9.95	0.050
A15	0.5087	8.20	0.041
A16	0.6780	10.96	0.055
A17	0.5927	9.57	0.048
A18	0.5203	8.37	0.042
A19	0.8910	14.47	0.072

In bread samples, the mean concentration of potassium bromate ranged between 0.024 and 0.072 µg/g. The highest bromate level was detected in sample A19 (0.072 µg/g), whereas the lowest level was detected in sample A6 (0.024 µg/g). These quantities of potassium bromate in bread and baked product samples collected from bakeries in Ghemines may be due to low baking temperature, baking time, and large quantities of potassium bromate used in flour. Therefore, consumers and bakers of these products are at risk of exposure to potassium bromate due to bioaccumulation over time [30].

Figure 2 show that the concentrations of potassium bromate in all baked samples were well above the permissible safe levels of 0.020 (µg/g), recommended by the US-FDA and WHO for bread products [17].

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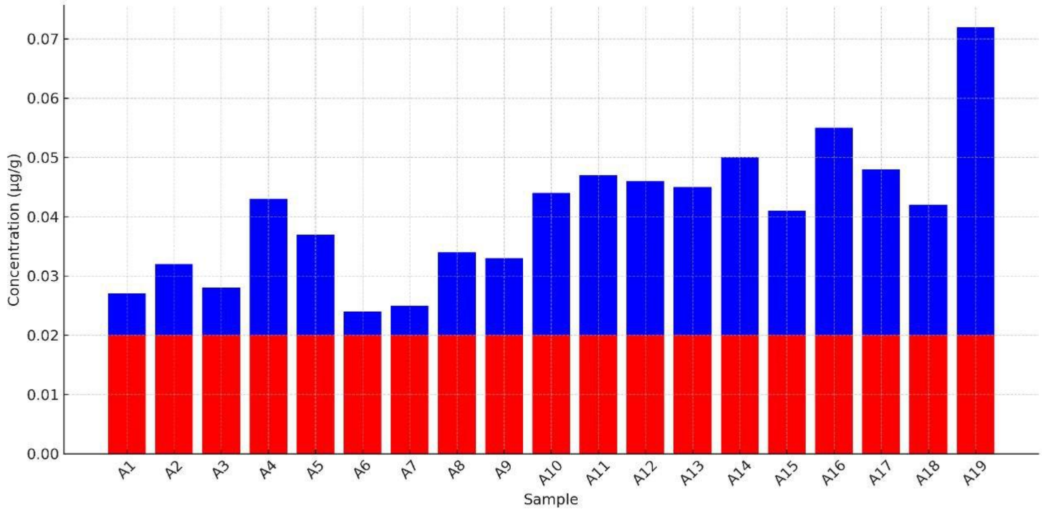

Fig. 2. Comparison of the concentrations(μg/g) of potassium bromate in bread samples with the maximum allowed limit recommended by FDA

Conclusion

This study reveals that potassium bromate was found in all bread samples collected from different bakeries in Ghemines City. This substance has been found at a concentration much above the allowable permissible level of potassium bromate set by the USFDA and Libyan Standard National Regulation in bread. Therefore, bread consumers and bakers are at risk of exposure to potassium bromate. In Libya, the authorities need to monitor the bakeries and producers through continuous surveillance to ascertain compliance with standards and the safety of humans, and enforce the ban on the use of potassium bromate in the baking industry. Even more, Libyan authorities should prevent the importation of bromated flour.

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