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Qualitative and Spectrophotometric Analysis of Potassium Bromate in Bread and Flour Consumed in Tarhuna, Libya

Suad Ali Uneis [1], Wafa Khalleefah Amhimmid [2 *], Rim Ahmed Salem[3], Tebra Mosbah Eldrhubi [4]
[1,2,3] Chemistry Department, Faculty of Science, Azzaytuna University, Tarhuna, Libya
[4] Chemistry Department, Faculty of Education, Azzaytuna University, Tarhuna, Libya

[*]*Corresponding author: khlwafaa321@gmail.com*

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Abstract:
Bread samples and flour were collected from seven bakeries covering the city of Tarhouna. The samples were analyzed for potassium bromate using standard methods. The studied samples were analyzed using a UV-Vis spectrophotometer (model 2550, Shimadzu Japan) and converted to concentration via a standard calibration curve of Potassium bromate absorbance against concentration. The concentration ranges between (1.0 – 26.45µg/g) in bread, and (1.7 – 5.3 µg/g) in flour. A significant difference in KBrO3 levels of bread and flour samples from different bakeries. The obtained results showed a high level of bromate in all samples exceeded the permissible limit of FDA and the low (258) prohibition of import and use of KBrO3 in Libya.

Keywords: Potassium Bromate, Bread, Flour, UV-Spectrophotometer.

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التحليل النوعي والطيفي لبرومات البوتاسيوم في عينات من الخبز والدقيق المستهلكة في ترهونة- ليبيا

سعاد علي ونيس[1]، وفاء خليفة إمحمد[2*]، ريم أحميد سالم[3]، تبرة مصباح الدرهوبي[4]
[1،2،3] قسم الكيمياء، كلية العلوم، جامعة الزيتونة، ترهونة، ليبيا
[4] قسم الكيمياء، كلية التربية، جامعة الزيتونة، ترهونة، ليبيا

الملخص
تم جمع عينات من الخبز والدقيق من سبع مخابز في مدينة ترهونة. تم تحليل العينات باستخدام الطرق القياسية للكشف عن وجود ونسب مادة برومات البوتاسيوم المحسنة. العينات المدروسة تم تحليلها طيفياً باستخدام جهاز UV-Vis spectrophotometer وذلك باستخدام منحنى قياسي لبرومات البوتاسيوم وقياس الامتصاصية مقابل التركيز. راوحت التركيز المتحصل عليها ما بين (1.0 – 26.45 µg/g) في الخبز، و (1.7 – 5.3 µg/g) في عينات الدقيق. حيث لوحظ تفاوت كبير في مستوى المحسن في العينات، كما أظهرت التحاليل أن جميع العينات قد تجاوزت الحد المسموح به من قبل إدارة الغذاء والدواء الأمريكية (FDA) وقانون منع استيراد واستخدام مادة برومات البوتاسيوم في ليبيا رقم 258 لسنة 2021.

الكلمات المفتاحية: برومات البوتاسيوم، الخبز، الدقيق، التحليل الطيفي.

Introduction

Bread is a major source of nutrition in Libya. It is widely consumed in homes, restaurants, and hotels. delivers up to 50-90% of total calorie and protein consumption.[1] Bread is made by blending low-protein wheat flour with additional ingredients including salt, sugars, yeast, flavorings, and flour improver (oxidizer). Wheat flour, which is used to make bread, has about 12% protein.[2] The first step in creating bread is to combine flour and water. Proteins found in flour hydrate to form gluten, an elastic matrix that holds the starch granules that make up the majority of the flour.[3] Gluten is a complex mixture of water-insoluble proteins classified as gliadins and glutenins.[4] Carbon dioxide (CO_2) bubbles occur during the fermentation of sugars produced from hydrated starch granules by a natural complement of amylase enzymes in flour. Mechanical function occurs when the gluten is stretched into sheets that trap CO_2. This promotes the growth of the gluten network and leaves an open cellular structure with the gas trapped in pockets. This gives the bread loaf's volume. The baking quality of flour, which is measured by the ability of the dough formed from it to retain gas, is the main problem for both the flour milling sector and bakeries. [5] As a result, several conditioning agents (flour/bread/improvers) such as Azodicarbonamide, potassium iodate, potassium bromate, ascorbic acid, and others are added to boost mixing strength, flexibility for moulding, and loaf volume. The production of disulphide bonds is aided by these oxidizing agents.

Potassium bromate is a popular oxidizing agent among flour milling companies and bakers worldwide since it is affordable and potentially very effective.[5] It acts as a ripening agent and dough conditioner by changing the sulfhydryl groups in gluten protein in flour into disulphide bridges, producing the dough less stretchable and more elastic; this makes the dough viscoelastic, allowing it to retain the carbon dioxide gas produced by the yeast. [6] Overall, the impact is to increase the volume and texture of the cooked bread. [7] In 1986, the International Agency for Cancer Research designated $KBrO_3$ as a type 2B carcinogen (possibly hazardous to people) based on substantial evidence that it caused cancer in experimental animals. [8] Many governments around the world banned bromate in flour and bakery items as a result of this discovery. Argentina, Brazil, Canada, South Korea, the United Kingdom, Australia, Peru, and Uganda are among the countries that have banned the use of potassium bromate.[9] The chemical was also prohibited in Sri Lanka in 2001, Nigeria in 2004[10], China in 2005, and India in 2016, and in Libya 2005. Countries such as the United States of America have not explicitly prohibited the use of $KBrO_3$, but have instead established maximum limits for its use as a food additive. The US Food and Drug Administration (FDA) allows 0.02µg/g (0.02 mg/kg) potassium bromate level in bread [11]. In light of the fact that baked products made from such treated flour contain insignificant $KBrO_3$ residues, a joint Food and Agricultural Organization (FAO)/World Health Organization Experts Committee on Food Additives (JECFA) suggested a maximum level of 75 ppm (75µg/g) for the treatment of flour in 1982. [12]

Several investigations have demonstrated that potassium bromate has numerous harmful consequences, including nephrotoxicity and ototoxicity in laboratory animals and people. The poisonous impact is caused by the hydrocyanic acid (HCN) produced during the hydrolysis of cyanogenic glucosides.[13] It is a carcinogen that has been demonstrated in rats to cause kidney cell tumors, mesotheliomas, and thyroid follicular cell tumors. [14] $KBrO_3$ has also been demonstrated in studies to be hazardous to several organs in people and laboratory animals. [15, 16, 17] $KBrO_3$ is highly irritating and harmful to tissues, particularly those of the central nervous system (CNS) and kidneys [18]. $KBrO_3$ has also been shown to be mutagenic in experimental animals. [19] According to nutritional studies, $KBrO_3$ affects the nutritional content of bread by degrading vitamins A2, B1, B2, E, and niacin, which are the most abundant vitamins in bread. [20]

The primary goal of this study was to establish the amounts of potassium bromate in frequently consumed bread loaves in Tarhuna, which are very important in terms of human health and food quality management.

Material and methods

Sample collection: Bread and flour samples were collected in ***October 2022*** from seven bakeries in the city of Tarhuna. The samples were selected based on their availability and popularity among consumers. For the flour samples bands of white flour Available in the bakeries as at the time of this study were used.

Sample Preparation: 10g of each of the Seven bread samples were taken from the center of the loaves and dried in an oven at 80ºC for about 2hrs. then cooled down at room temperature and ground to fine powder by ceramic mortar and pestle and stored in clean containers labelled from B1 to B7. 10g of seven flour samples were weighted and stored in clean containers labelled from F1 to F7.

Qualitative Determination for Presence of Potassium Bromate: (KI) Reagent was prepared by weighting 0.5g of potassium iodide in 100ml of (0.1N) HCl, 1g of each sample was weighted and transferred into a test tube adding 10ml of distilled water and shaking gently and allowed to stand for 30min. 5ml was decanted from the test tube. Then adding 5ml of the previously freshly prepared (KI) reagent to the test tube. Any colour change was noted. The change of colour indicating the presence of $KBrO_3$ from light yellow to purple is based on the reaction of bromate and iodide ions in an acid medium to produce tri-iodide.

Determination of Potassium Bromate Content: According to reported procedures, potassium bromate in bread and flour samples was quantitatively tested (Emeje et al 2010) [5]. As in the previous procedure, the absorption of the samples was taken by UV-Vis spectrophotometer (model DR3900 HACH) at Wavelength (352nm) and converted to concentration via a standard calibration curve of Potassium bromate absorbance against concentration. The absorbance was plotted against the concentration values as shown in Figure 1. The working graph thus obtained was used to estimate the concentration of $KBrO_3$ (mg/L) in the bread and flour samples using the following equation (1):

$$A = 0.20225 \text{ x } +0.04139, (R^2 = 0.99691) \quad (1)$$

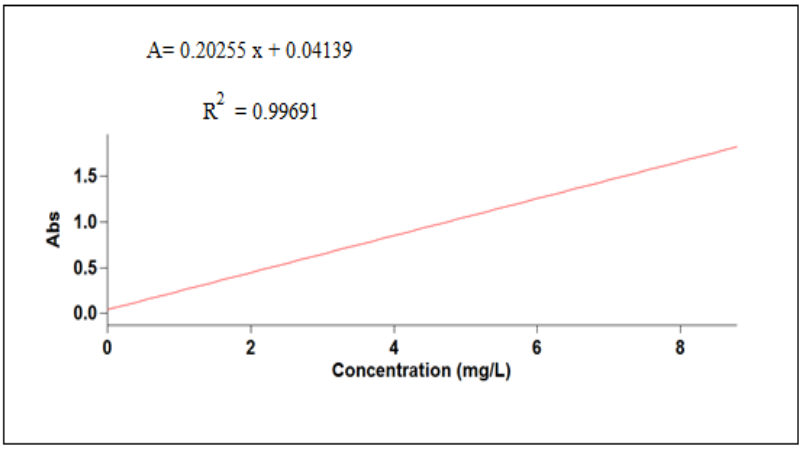

Figure 1: Calibration curve of potassium bromate.

Then the concentration of potassium bromate (µg/g) in each sample is calculated using equation 2.

$$\text{KBrO3 } Conc.\left(\frac{\mu g}{g}\right) = \frac{\text{KBrO3 } Conc.\ \left(\frac{\mu g}{mL}\right)}{sample\ weight\ (g)} x \text{ Dilution factor} \quad (2)$$

Results and discussion

The results of studied samples presented in Table 1 and 2 showed that all samples contained different amounts of potassium bromate residues in their products, The lowest concentration in bread was in sample (B6) at 1.0 µg/g, and the highest concentration was in sample (B3) at 26.25 µg/g.

Table 1 Qualitative and Quantitative Analysis of potassium bromate in bread samples:

Sample	Color reaction with KI	Readings	Concentration of $KBrO_3$ (µg /g)
B1	Purple	1.0530	2.55
B2	Dark Purple	3.6425	9.45
B3	Dark Purple	10.0000	26.25
B4	Dark Purple	1.7630	4.45
B5	Purple	0.9620	2.5
B6	Purple	0.4835	1.0
B7	Dark Purple	1.2153	3.0

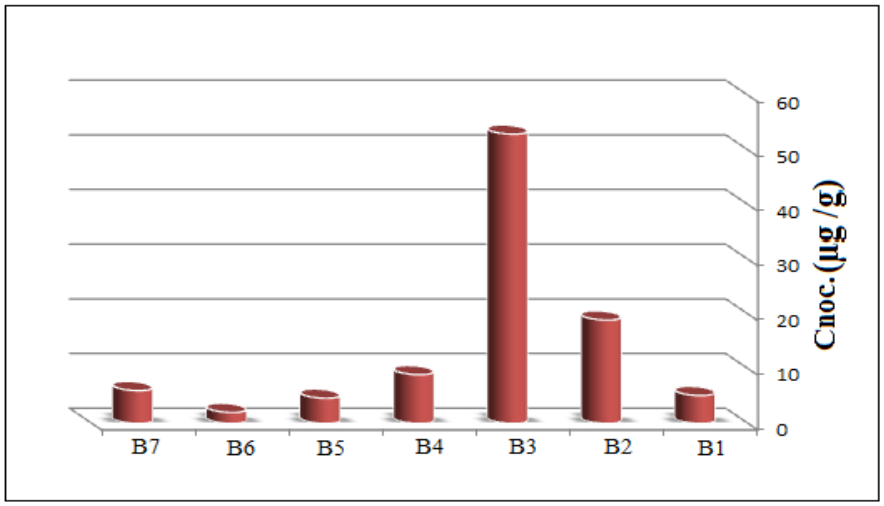

Figure 2: Concentration of KBrO3 in Bread Samples.

As for the flour, all samples contained potassium bromate residues ranging between 1.7 – 5.3 µg/g as illustrated in table 2. The presence of potassium bromate in the flour due to using it as a bleaching agent to give the white color to the flour.

Table 2. Qualitative and Quantitative Analysis of potassium bromate in Flour samples:

Sample	Color reaction with KI	Readings	Concentration of $KBrO_3$ (µg /g)
F1	Dark Yellow	1.5295	3.8
F2	Dark Yellow	1.1239	2.75
F3	Dark Yellow	1.6668	4.2
F4	Light Yellow	2.0866	5.3
F5	Yellow	0.9120	2.15
F6	Light Yellow	1.4193	3.5
F7	Yellow	0.7329	1.7

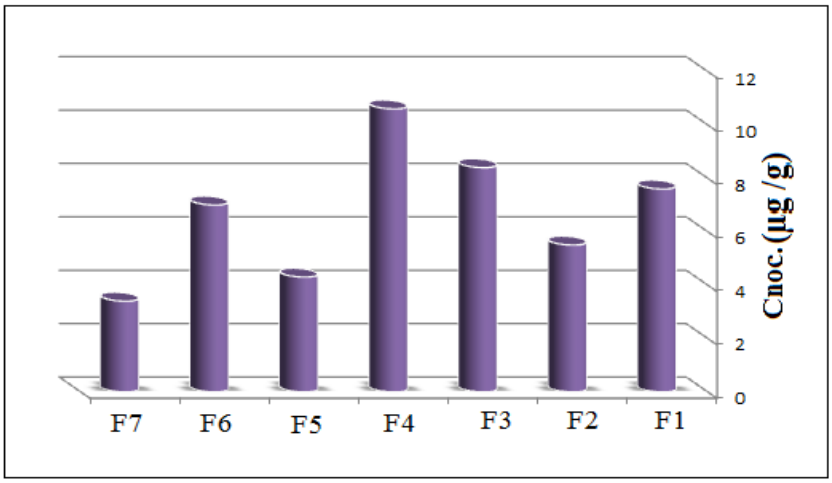

Figure 3 Concentration of $KBrO_3$ in Flour Samples.

All studied samples showed positive results in the presence of KBrO3, the spectrophotometric analysis confirms that where the concentrations far exceeded the permissible limit by (FDA) 0.02µg/g.

As a comparison of the obtained results in this study with result reports from other cities in Libya, the levels of KBrO3 in present study ranging from (1.0 – 26.45µg/g) is comparable to the study carried out in Tajora (6.0-26.67 µg/g) by (Alhanash et al., 2020) [21], and significantly higher than the values (0.6138-1.558µg/g) in Benghazi City reported by Mariam A. S. Busaadia et al., 2022).[22]

Conclusion

The results of the present study show that bread samples and flour from bakeries in the study area _Tarhuna_ contained high concentrations of potassium bromate at an unsafe level for human health. This means that bakers do not comply with the non-usage low in 2005 and (258-2021) of KBrO3 in bread making and other bakery products using bromate-enhanced flour in Libya.

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