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Research article

Potassium bromate in bread, health risks to bread consumers and toxicity symptoms amongst bakers in Bamenda, North West Region of Cameroon

Therese Ncheuveu Nkwatoh [a,d,*], Tayebatu Percline Fon [b], Lifoter Kenneth Navti [c]

[a] Department of Microbiology, Catholic University of Cameroon (CATUC), Bamenda P.O. 782, Big Mankon, Bamenda, North West Region, Cameroon
[b] Department of Biochemistry, Catholic University of Cameroon (CATUC), Bamenda P.O. 782, Big Mankon, Bamenda, North West Region, Cameroon
[c] Department of Biochemistry, The University of Bamenda (UBa), P.O. Box 39, Bambili, North West Region, Cameroon
[d] Faculty of Agronomy and Agricultural Science, University of Dschang (CRESA Forêt-Bois), Cameroon

A R T I C L E I N F O

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A B S T R A C T

This study evaluated the occurrence of potassium bromate in bread, its overall health risks to bread consumers, and its toxicity symptoms amongst bakers in Bamenda. Thirteen bakeries were included in a cross-sectional survey to gather information about the quantities of bread produced and the symptoms of potassium-bromated toxicity experienced by bakers during baking. The concentration of potassium bromate in the most consumed bread types was determined using a spectrophotometric method. The hazard quotient and hazard ratio were computed for each bread type to determine its chemical and carcinogenic risks. Results showed that all bakers had experienced symptoms of potassium bromate toxicity, and painful eyes, cough, diarrhea, and sore throat were the most recurrent symptoms of toxicity. The concentration of potassium bromate in all bread samples (100%) ranged from 48.50 mg/kg to 10148.50 mg/kg, exceeding the maximum acceptable limits by 9–203 times the dose (50 mg/kg) recommended by Food and Drug Administration. There was no significant difference ($p = 0.109$) in potassium bromate concentration between bread types, and simple bread, milk bread, and French bread had the highest concentration of potassium bromate. The chronic hazard quotient ranged from 277.93 to 2459.36, and the hazard ratio ranged from 251434.30 to 32862.86, indicative of possible chemical and carcinogenic risks after prolonged regular consumption. From the hazard ratios, the chances of having cancer from an average daily consumption of either simple bread or milk bread, or French bread are approximately 290,000 in 1,000,000 or 220,000 in 1,000,000 or 190,000 in 1,000,000. Thus regulatory authorities need to monitor, control or prohibit the use of potassium bromate as a flour additive.

* Corresponding author. Catholic University of Cameroon, Bamenda P.O. Box 782, Big Mankon Bamenda, Cameroon. ,
E-mail addresses: tnkwatoh@yahoo.com, t.nkwatoh@catuc.org (T. Ncheuveu Nkwatoh), Tayebatupercline@gmail.com (T.P. Fon), knavti@gmail.com (L.K. Navti).

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1. Introduction

For over nine decades, potassium bromate has been widely used as a flour additive because it is an excellent dough improver and a maturing agent [1]. In the late dough stage, potassium bromate oxidizes the sulphydryl groups of flour's gluten protein, making the dough less extensible and more elastic such that it can retain the carbon dioxide gas produced by the yeast used in leavening [2,3]. It also bleaches the dough, increases loaf volume, and improves the bread texture [4]. Moreover, potassium bromate is probably the cheapest and most effective oxidizer used in bread production, and bakeries exploit these beneficial properties for profit. During baking, heat catalyzes the conversion of potassium bromate into a less toxic substance (potassium bromide) [5]. However, excessive use of potassium bromate results in residual concentrations in bread having potentially harmful effects [6].

Potassium bromate is a possible human carcinogen [7], and several organizations, agencies, and countries have banned its use as a flour additive [3,8]. Some countries have established maximum acceptable doses for finished baked products. For example, the maximum permissible concentrations of potassium bromate in baked products in the U.S.A., Japan, and China are 0.02 mg/kg, 10 mg/kg, and 50 mg/kg, respectively [6,9]. The Food and Drug Administration (FDA) established acceptable concentrations below 75 mg/kg or 50 mg/kg [10]. Despite the prohibition or restrictions of potassium bromate as a flour additive, bakers still use large quantities to make bread [11].

Several studies have shown that potassium bromate has acute and chronic health effects. Acute symptoms of potassium bromate toxicity include; abdominal pain, diarrhea, irritation of the upper aerodigestive mucous membranes, and vomiting [12]. Free radicals of potassium bromate in the human blood result in nephrotoxicity and cancer [13–15]. It also induces renal cell tumors, mesotheliomas, and thyroid follicular cell tumors in rats [16]. In addition, it exerts mutagenic effects and causes injury to the tissues of the central nervous system (CNS) and kidneys [17].

Toxicity studies with experimental rats have shown that potassium bromate exerts; cardiac toxicity [18]; toxicity of the bone and blood [19]; liver/hepatic tissue and renal toxicity [20] etc. Several studies have also demonstrated its carcinogenicity [15,16]. Potassium bromate alters liver function [21]; causes changes in the cerebellum [19] and neuro behavior [22]. Recent studies have reported residual concentrations of potassium bromate in bread [2,4]. All these studies show the need to evaluate the human health risks of potassium bromate to bread consumers, given that bread is a staple food across the globe and is frequently consumed by the poor. Also, potassium bromate is a common flour additive used by bakers in many countries. In addition, some countries like Cameroon have not officially banned potassium bromate as a flour additive or established permissive doses in baked products. Therefore, this study aimed to evaluate the occurrence of potassium bromate in bread, health risks to bread consumers, and toxicity symptoms experienced by bakers during baking in Bamenda, North West Region, Cameroon.

2. Materials and methods

2.1. Study site and sample collection

Bamenda is a town in the North West Region of Cameroon, located at latitude 5°56" and 5°58" north of the equator and longitude 10°09" and 10°11" east of the Greenwich Meridian, at an elevation of 1258 m above sea level [23]. The town is amongst the most urbanized and fastest emerging cities in Cameroon. Bamenda has more than 600,000 inhabitants, with several local and modern bakeries supplying bread to the inhabitants and nearby villages.

2.2. Study population

The population of the study constituted bakers and managers of bakeries in Bamenda. One bakery was selected purposively from each of the thirteen localities on the basis of its popularity. Questionnaires were used to interview the managers and bakers of each bakery in a cross-sectional survey in 2021. The criteria for selecting bakers (mixers and oven bakers) was their active engagement in baking activities for two or more years. These categories of bakery workers were considered in the study because they are the most exposed to potassium bromate toxicity during bread making. Therefore a convenient sampling technique was used in selecting bakers based on their experience in baking.

2.3. Data collection

Data were collected from 126 study participants (bakers and managers of bakeries), purposively selected from thirteen bakeries in Bamenda using a self-administered structured questionnaire. The first section of the questionnaire included sociodemographic questions (age, gender, level of education, and duration of baking). The second part of the instrument assessed the symptoms of acute toxicity resulting from exposure to potassium bromate during baking. The most consumed bread type and the number/quantity of bread loaves sold per day were obtained from bakery managers.

For bread consumers, the overall health risks of potassium bromate through the dietary intake of bread were determined from the concentration of potassium bromate in analyzed bread samples, assuming that the average bread consumption in Cameroon during each meal is 0.6 kg [24]. Some parameters were calculated in the assessment of health risks of exposure to potassium bromate amongst bread consumers. These included estimated dietary intake (EDI), chronic hazard quotient (cHQ), acute hazard quotient (aHQ), hazard ratio (HR) and cancer benchmark concentration (CBC).

2.4. Collection of bread samples

Thirty-one samples of the most frequently consumed bread kinds were obtained from bakeries and bread vendors. The bread samples were packaged in labeled plastic bags and transported to the Health Science Laboratory of the Catholic University of Cameroon, Bamenda, for the analysis of residual concentrations of potassium bromate.

2.5. Preparation of reagent

Potassium bromate crystals (0.25 g) were weighed and dissolved in 250 ml of distilled water and 0.1 N of hydrochloric acid. The solution was prepared using the formula [1];

$$\frac{(Molarity \times Molar\ Mass \times 100)}{Specific\ gravity \times Percentage\ purity} \tag{1}$$

Where;

Mole is 0.1 M, *Molar Mass* is 36.465 g/mol, and *Specific gravity* is 36%.

2.6. Preparation of standard curve

A pure sample of potassium (0.25 g) was dissolved in 250 ml of distilled water to obtain a pure sample for the calibration curve. The required concentration (Cr) of pure potassium bromate for blanking was prepared from the original volume (in the range 0, 50,100, 150, 200, 250, 500, 600, 700, 800, 1000 μl) with each diluent corresponding to the varying required concentration (Cr). Ten replicates of these volumes were used in calibrating the spectrophotometric curve (Fig. 1). Fifty milliliters (50 ml) of freshly prepared 1 g of potassium iodide solution in 0.1 N HCL was added to each pure sample of potassium bromate. The absorbance of the pure potassium bromate sample in the UV Visible spectrometer was taken at a wavelength of 620 nm. The absorbance at each concentration of pure potassium bromate (50, 250, 500, 600, 700, and 800 μl) was used for plotting a calibration curve (absorbance against concentration) for potassium bromate (Fig. 1) [25] (David 1976). The original volume was calculated by using the formula [2];

$$CoVo = CrVr \tag{2}$$

Therefore [3],

$$Vo = \frac{CrVr}{Co} \tag{3}$$

Where Co = original concentration (1000 ml), Vo = original volume, Cr = required concentration and Vr = required volume (50 ml).

From the calibration curve, the unknown concentrations of potassium bromate in bread samples were calculated using the following relationship [4];

$$Y = mx + b \tag{4}$$

Where;

Y = absorbance, m = intercept, x = unknown concentration and b = slope.

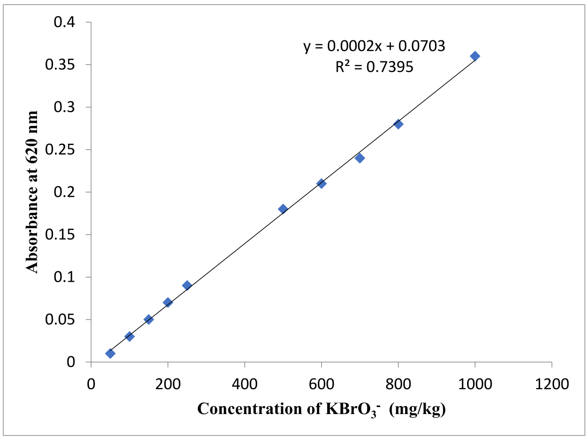

Fig. 1. Calibration curve for potassium bromate.

2.7. Quantitative and qualitative analysis of potassium bromate in bread samples

One gram (1.0 g) of bread crumbs from each bread sample was weighed with an electronic balance and transferred into different test tubes. Ten milliliters (10 ml) of distilled water was added to the bread crumbs in test tubes and shaken to mix well. After 20 min, 5.0 ml of the supernatant was decanted from the test tubes and centrifuged. Five milliliters (5.0 ml) of freshly prepared 1% potassium iodide solution in 0.1 N hydrochloric acid was added to the mixture and observed for color change from milky to deep purple. The absorbance of the samples in the spectrophotometer was taken at a wavelength of 620 nm, and the values were converted to concentration using the calibration curve plotted for the pure sample of potassium bromate [25].

2.8. Health risk assessment of potassium bromate

Human dietary exposure or estimated daily intake (EDI) was used to assess risk levels of potassium bromate via dietary intake of bread in Bamenda. The EDI values were used to determine the chronic hazard quotient (HQ) values. The hazard ratio (HR) values were used to predict carcinogenic risk.

2.8.1. Estimated daily intake of potassium bromate

The daily intake of potassium bromate depends on the potassium bromate concentration in bread, the daily bread consumption, and the average body weight of adults, which influences the tolerance of contaminants. Based on these assumptions, EDI was calculated as follows [5,26];

$$EDIingestion = \frac{C \times D}{BW} \tag{5}$$

Where; *EDI ingestion*– estimated daily intake via oral route (mg/kg bw per day), *C* – average potassium bromate concentration in bread samples (mg), *D* – daily intake of bread (kg), and *BW* – average body weight per person (kg).

From the survey, bread is a traditional breakfast food, frequently eaten as snacks. The average bread consumption during each meal was 0.6 kg [24]. The average body weight of Cameroonian adults was 70 kg, which is the default human body weight [27]. The average concentration of potassium bromate (in mg) in all bread samples was used in computing the estimated daily intake (EDI) over a long-time consumption. The short-term (acute) exposure to potassium bromate was assessed since bread consumers may likely experienced symptoms of acute toxicity via oral exposure. The estimated short-term intake (ESTI in mg/kg BW per day) was calculated as follows [6,28];

$$ESTI = \frac{Chighest \times D}{Bw} \tag{6}$$

Where *ESTI* – estimated short-term intake (ESTI in mg/kg BW per day), *Chighest*– highest Potassium bromate concentration in bread samples (mg). *D* – Daily intake of bread (kg), and *BW* – average body weight per person (kg). The average of the highest concentrations of potassium bromate in the different bread samples was used to calculate the estimated short-term (acute) intake. During baking, some of the potassium bromate escape from the bread in the form of vapor. The estimated daily intake via inhalation was not calculated because the concentration of potassium bromate in the air during baking was not measured. Also, the reference concentration value (RFC) of potassium bromate via inhalation is unknown [27].

2.8.2. Determination of non-carcinogenic dietary health risk

The non-carcinogenic risk resulting from potassium bromate consumption of each bread type was determined using the non-hazard quotient (HQ) value. The values of the chronic hazard quotient (cHQ) were determined using the following formula [7,27];

$$cHQ = \frac{EDIingestion}{ADI} \tag{7}$$

Where cHQ – chronic hazard quotient through ingestion (no unit), EDI ingestion is the estimated daily intake through oral route (mg/kg-day), and ADI – acceptable daily intake (in mg/kg per day). ADI is the estimated maximum daily intake of a toxicant over a lifetime that will cause no adverse effects at any stage in human life span. An acceptable daily intake (ADI) of 0.02 μg/g (0.02 mg/kg) potassium bromate in bead, recommended by the US Food and Drug Agency (FDA) [29] was used to estimate the chronic risk of potassium bromate in various bread types. The short-term (acute) health risk (acute hazard quotient, aHQ) was computed as follows [8];

$$aHQ = \frac{ESTI}{RfD} \tag{8}$$

Where aHQ is the acute hazard quotient, ESTI is the estimated short-term intake (ESTI in mg/kg BW per day), and RfD is the reference dose of potassium bromate (mg/kg-day). RfD is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime [27].

The reference dose (RfD) of bromate considered to be without deleterious non-cancer effect is 0.004 mg/kg/day [30]. Hazard quotient (HQ) < 1 indicates that the risk is acceptable, and HQ > 1 shows that the risk is unacceptable (has the potential to harm the human body) [27]. The hazard index (HI) is the sum of more than one hazard quotient for multiple chemical substances or multiple exposure pathways [28]. Only one chemical substance (potassium bromate) and one exposure pathway (oral pathway) were considered, so the hazard index was not computed.

2.8.3. Carcinogenic dietary risk

Carcinogenic risks estimate the probability that an individual will contract cancer over a lifetime of exposure to potassium bromate in bread. The hazard ratio (HR) for carcinogenic risk was determined as follows [9];

$$HR = \frac{EDIingestion}{CBC} \tag{9}$$

Where EDI ingestion is the estimated daily intake via ingestion and CBC is the cancer benchmark concentration. The CBC for the carcinogenic effect of potassium bromate was determined from the risk of 1 in 1,000,000 resulting from a lifetime exposure. This value was determined as follow [10];

$$CBC = \frac{RL \times BW}{CR \times OSF} \tag{10}$$

Where RL is the maximum acceptable risk level (1×10^{-6}), which is the probability of developing cancer over the lifetime due to potassium bromate exposure, BW is the average body weight (default bodyweight, 70 kg), CR is the food consumption rate (g/day) and OSF is the oral slope factor (mg/kg/d) [31]. This OSF value was obtained from the integrated risk information system (IRIS) [30]. The oral slope factor for potassium bromate is 7×10^{-1} per mg/kg-day. This value is the cancer potency estimate for kidney renal tubule tumors, mesotheliomas, and thyroid follicular cell tumors [30]. Hazard ratio (HR) greater than one is indicative of potential risk to human health.

2.9. Data analysis

Data were analyzed using the IBM Statistics SPSS version 21.0 (SPSS, Chicago, USA). Bar charts were used to present the bread production by locality, and the symptoms of potassium bromate toxicity. A scattered plot was used to present the residual concentration of potassium bromate in the different bread types. A one–way ANOVA was used to compare the means of potassium bromate concentration in the different bread types. The statistical significance was considered at the 0.05 level.

3. Results

3.1. Bread consumption in localities bamenda

Wheat bread, local bread, milk bread, simple bread, and French bread were the main types of bread produced in large quantities by bakeries in Bamenda (Fig. 2). Amongst these bread kinds, milk bread (40%), French bread (27%), and simple bread (15%) were the most daily consumed bread kinds while wheat bread (11%) and local bread (7%) were the least of all bread types consumed (Figs. 2 and 3). A total of 52,700 loaves of bread were produced daily by the bakeries that participated in the different localities. Therefore it is assumed that at least over 52,700 loaves of bread are consumed daily by the inhabitants of Bamenda. The localities with the highest production of bread were: Meta-quarters (19.57%), Mile 3-Nkwen (19.57%), and Foncha Junction (18.35%) (Fig. 3).

3.2. Occurrence and distribution of potassium bromate in bread types

Potassium bromate was present in all bread samples analyzed. Analysis showed that simple bread had the highest average concentration of potassium bromate, (5741.5 mg) followed by French bread (3792.4 mg) and milk bread (3452.6 mg) while, local bread (614.5 mg) and wheat bread (1351.5 mg) had the lowest concentrations (Fig. 4).

Fig. 2. Major bread Kinds produced by bakeries in Bamenda.

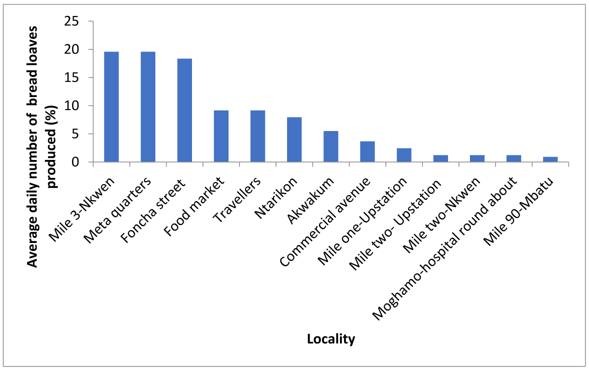

Fig. 3. Average number of bread loaves produced by bakeries per locality.

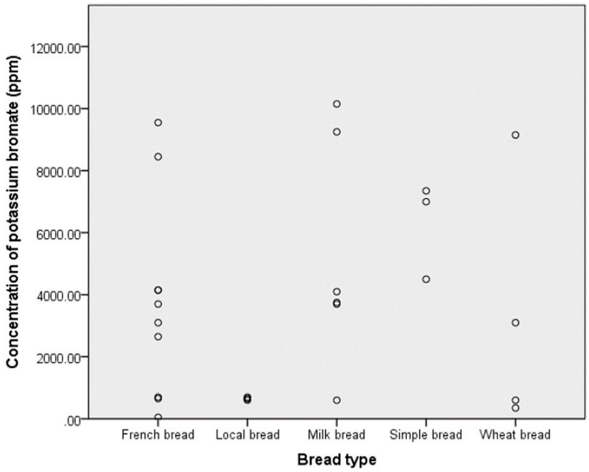

Fig. 4. Average residual concentration of potassium bromate in various bread types.

Out of the 13 localities, ten localities produced French bread, and French bread from Ntarikon had the highest concentration of potassium bromate (9551.5 mg) (Table 1). Eight localities produced milk bread, and milk bread from Mile 1-up-station had the highest concentration of potassium bromate (10151.5 mg) (Table 1). Four localities produced simple bread, and simple bread from Mile 2 up-station had the highest concentration of potassium bromate (4501.5 mg) (Table 1). Four localities manufacture wheat and local bread, and the highest level of potassium bromate in wheat and local bread was from Mile 1-Up-station (9151.5) and Akwakum (701.5 mg), respectively (Table 1). The color change due to the presence of potassium bromate in the bread samples ranged from yellow to deep purple (Table 1). The absorbance of light in the calorimeter was taken at 620 nm. Milk bread produced at Mile one-Up station absorbed the highest light (2.1 nm) at the wavelength of 620 nm, followed by French bread at Ntarikon (1.98 nm) and milk bread produced at Mile three-Nkwen (1.92 nm).

3.3. Symptoms of potassium bromate toxicity experienced by bakers

All bakers have experienced symptoms of potassium bromate toxicity during baking. The most recurrent symptoms of potassium bromate toxicity were painful eyes (18.28%), cough (15.05%), diarrhea (15.05%), and sore throat (13.98%). The least of all symptoms experienced by bakers was kidney disorder (6.46%) (Fig. 5). Out of all the bakers who experienced symptoms of toxicity, 68.82% of them baked once a day, while 31.18% baked twice a day.

3.4. Non-carcinogenic health risk assessment

3.4.1. Dietary acute and chronic risk assessment of potassium bromate

The highest concentration of potassium bromate in the various bread types was used to calculate the acute hazard quotient (HQ). The HQ value of each bread type was more than 1 (HQ > 1). Thus the risk was considered probable, indicating that high concentrations of potassium bromate in the different bread types can potentially pose acute toxicity threats to consumers. Simple bread with the highest concentration of potassium bromate had the highest HQ value, followed by milk and French bread (Table 2). Likewise, the

Table 1
Bread types and their respective residual concentrations of potassium bromate and the daily number of loaves consumed per locality.

SN	Locality	Bread type	Absorbance at 620 nm	Potassium bromate concentration (mg)	Color change	Number of bread loaves produced per day
1	Mile 2 Up-station	Simple bread	0.97	4498.5	Deep purple	400
2	Mile 2 Nkwen	French bread	0.08	48.5	Deep yellow	400
3	Foncha Street junction	French bread	1.76	8448.5	Deep purple	2000
		Milk bread	0.81	3698.5	Light purple	2000
		Wheat breed	0.14	348.5	Yellow	400
4	Ntarikon	French bread	1.98	9548.5	Deep purple	1000
		Milk bread	0.19	598.5	Light purple	1000
		Wheat bread	1.9	9148.5	Deep purple	600
5	Mile1-upstation	French bread	0.69	3098.5	Purple	400
		Milk bread	2.1	10148.5	Deep purple	400
6	Mile 3-Nkwen	Milk bread	1.92	9248.5	Deep purple	2400
		French bread	0.6	2648.5	Yellow	2000
		Simple bread	1.54	7348.5	Deep purple	2000
7	Food market	French bread	0.81	3698.5	Purple	1000
		Simple bread	1.47	6998.5	Deep purple	1000
		Milk bread	0.89	4098.5	Deep yellow	1000
8	Meta quarters	French bread	0.9	4148.5	Purple	2000
		Milk bread	0.82	3748.5	Purple	24,000
		Wheat bread	0.69	3098.5	Purple	2000
9	Travellers	French bread	0.9	4148.5	Purple	1000
		Milk bread	0.45	1898.5	Purple	2000
10	Commercial avenue	Milk bread	0.27	998.5	Purple	400
		Simple bread	0.21	698.5	Light purple	400
		Local bread	0.19	598.5	Light purple	400
11	Moghamo-Hospital round-about	Local bread	0.2	648.5	Light purple	200
		French bread	0.21	698.5	Light purple	200
12	Akwakum	Wheat bread	0.19	598.5	Light purple	600
		Local bread	0.21	698.5	Light purple	600
		French bread	0.2	648.5	Light purple	600
13	Mile 90-Mbatu	Local bread	0.2	648.5	Light purple	300

chronic hazard quotient (HQ) of each bread type was above 1 (HQ $>$ 1), indicating a possible chronic risk to consumers. Also, simple bread had the highest chronic hazard quotient, followed by milk bread, French bread, wheat bread, and local bread respectively (Table 2).

3.4.2. *Carcinogenic health risk assessment*

The hazard ratio (HR) values of the five bread types were more than 1 (HR $>$ 1) (Table 2), suggesting a definite or very high risk of cancer resulting from the consumption of bread from the 13 localities in Bamenda. The HR in the various bread types ranged from 251434.3 to 32862.86, with simple bread (251434.3), milk bread (201291.4), and French bread (181266.2) having the highest hazard

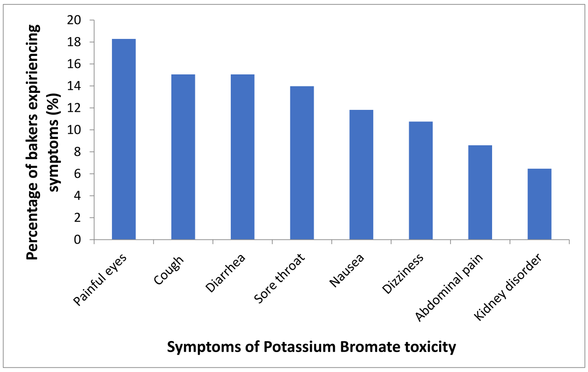

Fig. 5. Symptoms of potassium bromate toxicity experienced by baker.

ratios (Table 3).

4. Discussion

The concentration of potassium bromate in each bread type (Table 1) was higher than the maximum concentrations (0.02 mg/kg, 10 mg/kg, and 50 mg/kg) allowed in finished baked products in the U.S.A., Japan, and China respectively [6,9]. These concentrations were 9–203 times above the permissive safe limit (50 mg/kg) set by the FDA (Table 1). Earlier study by Ref. [32] also reported concentrations of potassium bromate in bread that were 81–499 times greater than the permissible limit set by the FDA. The high concentrations of potassium bromate in the current study indicate that almost all bakeries in Bamenda use potassium bromate as a flour additive to produce bread, and bread consumption is unsafe for the inhabitants.

The observed high concentrations of potassium bromate in this study may be associated with its excessive use, limited baking temperature, and baking period that would allow the complete breakdown of potassium bromate into a safe and less toxic potassium bromide residue [33]. Generally, bakers tend to use high concentrations of potassium bromate because higher concentrations make bread more appealing to consumers [34] since it imparts appealing qualities like size, color, and texture to bread which are also profitable. Also, bakers in the current study were probably unaware of the acceptable dose of potassium bromate in baked products since Cameroon has never officially prohibited potassium bromate or established maximum allowable limits in baked products. The observed concentrations of potassium bromate in the current study were higher than those obtained by [5, 34, 35, 36] in bread, though these authors also reported unsafe concentrations in bread.

The excessive use of potassium bromate during bread making in developing countries is a cause for concern since bread is consumed daily, especially by the poor population. Therefore, regulatory authorities must strictly monitor, regulate or prohibit its use as a flour additive. The European Union (1990), the United Kingdom (1990), Nigeria (1993), Canada (1994), Sri Lanka (2001), Brazil (2001), Columbia (2002), China (2005), and India (2016), Australia and New Zeeland have already banned the usage of potassium bromate as flour additive [35, 36]. Some countries like America, Japan, and China have set maximum allowable intake concentrations of potassium bromate in finished bakery products. In California, food products containing potassium bromate must have a warning label [6,9,33].

The main exposure routes of potassium bromate are oral and inhalation pathways [27]. In the current study, all the bakers have experienced symptoms of potassium bromate toxicity which are indicative of oral and nasal exposure routes (Fig. 5). During baking, some of the potassium bromate or its heat decomposition product in bread escape in vapor and is inhaled by bakers [37]. The symptoms experienced by bakers in the current study are similar to those reported by Refs. [12,25]. Health symptoms of potassium bromate include the following; abdominal pain, diarrhea, irritation to the mucous membrane of the upper aero-digestive tract, vomiting, sore throat, kidney disorder, oliguria, anuria, thrombocytopenia, vertigo, hypotension, depression, hearing impairment, hemolysis, bronchial and ocular problems [12,35]. Some bakers (6.46%) in the present study have experienced kidney disorders, probably resulting from oral or inhalation exposure during baking (Fig. 5). An earlier study by Ref. [1] showed that a diet formulated with bread containing potassium bromate causes liver and kidney malfunction in experimental rats. In Cameroon, chronic kidney disease affects about one in 10 adults in the general population [38]. However, kidney disorders are frequently associated only with clinical factors such as advanced age, hypertension, and diabetes mellitus [38]. Studies involving disease risk factors hardly consider the toxicological effects of chemical substances on humans.

In the current study, the acute and chronic hazard quotient (HQ) values of the various bread types were very high, indicating a possible health risk to bread consumers in Bamenda (Table 2). These high HQ values may be due to the high concentrations of potassium bromate in analyzed bread samples. For instance, simple bread, milk bread, and French bread with the highest concentrations of potassium bromate had the highest HQ values (Fig. 3, Table 2). The high HQ values of the various bread types in the current study may be the reason for the expression of symptoms such as diarrhea and abdominal pain experienced by some bakers after consuming bread (Fig. 5). Other symptoms like painful eyes, cough, sore throat, nausea, and dizziness were probably due to exposure to potassium bromate in the vapor during baking (Fig. 5).

Table 2

Estimated daily intake, estimated acute intake, acute and chronic hazard quotient of potassium bromate concentration in different bread types.

Bread Type	Highest KBrO3Concentration (mg/kg)	Average KBrO3concentration (mg/kg)	Average daily bread consumption (kg/ day)	Body weight (BW, kg)	Estimated Daily intake of KBrO3 (mg/kg/day)	Estimated short-term intake (mg/ kg/day)	Acceptable daily dose (mg/kg/day)	Reference dose (mg/kg/day)	Chronic hazard quotient (cHQ)	Acute hazard quotient (aHQ)
French bread	9548.5	3524.62	0.6	70	31.83	81.87	0.02	0.004	1591.50	2,387,125
Milk bread	10148.5	3914	0.6	70	36.89	87.01	0.02	0.004	1844.89	2,537,125
Simple bread	9148.5	4889	0.6	70	49.19	63.01	0.02	0.004	2459.36	2,287,125
Wheat breed	3098.5	3301.5	0.6	70	11.56	78.44	0.02	0.004	577.93	774,625
Local bread	698.5	639	0.6	70	5.56	6.01	0.02	0.004	277.93	174,625

Table 3
Estimated cancer hazard ratio (HR).

Bread type	Maximum acceptable risk level	Food consumption rate (CR, g/day)	Body weight (BW, kg)	Oral slope factor (mg/kg/d)	Cancer benchmark concentration (CBC)	Estimated Daily intake of KBrO3(mg/kg/day)	Hazard Ratio (HR)
French bread	0.000001	0.6	70	0.7	0.00017	31.83	190980.00
Milk bread	0.000001	0.6	70	0.7	0.00017	36.89	221387.10
Simple bread	0.000001	0.6	70	0.7	0.00017	49.19	295122.90
Wheat breed	0.000001	0.6	70	0.7	0.00017	11.56	69351.43
Local bread	0.000001	0.6	70	0.7	0.00017	5.56	33351.43

In the present study, the Hazard ratio (HR) of all the different bread types showed a possible carcinogenic risk to consumers. For instance, the hazard ratios for simple, milk, and French bread suggest that the chances of having cancer from an average daily consumption of either simple bread or milk bread, or French bread are approximately 290,000 in 1,000,000 or 220,000 in 1,000,000 or 190,000 in 1,000,000. In the bloodstream, potassium bromate occurs as highly reactive oxides and free radicals that may affect DNA and play a role in carcinogenesis [34]. For instance, potassium bromate induces and promotes the development of renal cell tumors in rats [9,20,39]. In Cameroon, kidney cancer is the third urogenital cancer, common among women, and renal cell carcinoma is the predominant histological type [40] and Although these authors linked the incidence of kidney cancer to clinical factors like smoking, hypertension, and diabetes, such studies should also consider the toxicological effects of chemical contaminants on humans.

The current study was limited only to the health risks of potassium bromate via the dietary intake of bread because the researchers never had the resources and equipment to measure the concentrations of potassium in vapor during baking. Also, the reference concentration value used for computing the estimated daily intake of potassium bromate via inhalation is unknown [27].

4.1. *Conclusion*

All bakers have experienced symptoms of potassium bromate toxicity, and painful eyes, cough, diarrhea, and sore throat were the most recurrent symptoms of toxicity. The concentration of potassium bromate in all bread types (simple, milk, French, wheat, and local bread) exceeded the maximum acceptable limits established by the Food and Drug Administration. Simple, milk and French bread had the highest concentration of potassium bromate. There was no significant difference between the concentration of potassium bromate in the different bread types ($p \leq 0.05$). The chronic and acute hazard quotient values indicated carcinogenic risk over prolonged regular consumption of all the bread types. Thus there is an urgent need for regulatory authorities in Cameroon to monitor, control or prohibit the use of potassium bromate as a flour additive. Further studies should be carried out to establish the reference concentration value used for computing the estimated daily intake of potassium bromate via inhalation.

Author contribution statement

Nkwatoh Therese Ncheuveu: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.
Tayebatu Percline Fon: Performed the experiments.
Lifoter Kenneth Navti: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

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