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Detection of Residual Potassium Bromate Concentrations in Cake Samples Sold at Kano State, Nigeria

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Abstract
Background: *The level of residual potassium bromate concentrations of cake samples sold within the three senatorial districts of Kano State was evaluated. The residual potassium bromate level was determined following standard Spectrophotometric protocols. Data for residual potassium bromate concentrations in cakes sold within the three senatorial districts of Kano State was expressed as Mean ±SD and analyzed using one-way analysis of variance ANOVA. Values were considered significant when $p<0.05$. Correlations were carried out for the mean levels of residual potassium bromate concentrations of the three senatorial district. A total of four hundred and fifty (450) cake samples from three selling points (markets, shops and bakeries) of the three senatorial districts of Kano State were analyzed. The mean residual potassium bromate levels in the samples analyzed ranged from 24.8 - 177.5mg/kg. Statistical analysis showed significant difference ($P=0.02$) between Kano Central Senatorial District and the two other Senatorial Districts of Kano State. Percentage (%) Compliance and Defaulters of Potassium Bromate in the Three Senatorial District of Kano State shows the highest potassium bromate defaulters to be found in Kano Central 51(34%) while the highest bromate compliance was found in Kano North 144 (96%). The results revealed that most of the cake samples obtained from Kano Central Senatorial District had exceeded the FAO/WHO/JECFA limit of 60mg/kg.*

Keywords: *Potassium bromate, Cake, Spectrophotometric, Kano State, Cancer*

Introduction

Cake is one of the modern day staple foods, which are modifications of bread. It is often leavened with varieties of rising agents like egg during its production to make it lighter, appealing to the eyes and more profitable to the producers. Cake is also a good source of calcium, vitamin C, carbohydrates; which provide the brain, body and muscles with energy (Castella, 2000). Potassium bromate ($KBrO_3$) a white crystalline powder is a colorless, odorless, strong oxidizing agent

commonly used as a dough conditioner to strengthen and allow higher rising of dough; it was permitted as a conditioner in bakery products since the bromate is converted to bromide with no residues when exposure to high heating temperature during baking (Uwah and Ikwebe, 2020). It is also a tasteless white crystal/powder initially used as a food additive and a commonly used flour enhancing agent in Nigeria (Emeje et al., 2010). It has a melting point of about 35^0 C; it decomposes at 37 ^{0}C releasing oxygen; It is soluble in water and almost insoluble in alcohol, It has a vapor density of 5.5 at 15 ^{0}C and boils at 59.48 ^{0}C with specific gravity of 3.27 at 17 ^{0}C.

Potassium bromate has been the oxidant of choice for a long time (Gandikota and Mac Ritchie, 2005). It is a flour improver that strengthens dough, allowing higher rising. It is an oxidizing agent and under right conditions will be completely used up in bread making (Akunyili, 2000). It has also been classified by the International Agency for Research on Cancer 1999 as category 2B carcinogen which is possibly carcinogenic to humans (IARC, 1999). It has been used in baking since 1914 when a patent was issued by the United States patent office (ABA/AIB, 2008; FAO/WHO, 1992). The use of potassium bromate as a food additive in production and consumption of bakery products has a deleterious effects on human health and nutritional value; it degrades the essential vitamins (A2, thiamine, riboflavin and niacin) and also reduces essential fatty acid content of the bakery products (Airaodion *et al*., 2019; Magomya et al., 2019). Exposure to potassium bromate has been linked to ototoxicity, abdominal pain, nephrotoxicity, nausea, cancer, kidney failure etc., in humans (Airaodion *et al*., 2019; Magomya et al., 2019). In 2003, the National Agency for Food, Drug Administration and Control (NAFDAC), the agency responsible for regulating drugs, foods and chemicals in Nigeria, banned the use of potassium bromate in bakery products on account of its deleterious effect and carcinogenicity in humans. According to the World Health Organization (2005), there is a potential risk of human exposure to bromate via drinking water also; although bromate is not typically found in drinking water; however, bromate ion can be formed as a byproduct from zonation disinfection process. Potassium bromate in foods has serious health implications. However, vitamin C (ascorbic acid) can be used instead of potassium bromate which is not as effective as potassium bromate but safer and healthier. Establishing the level of potassium bromate use will be highly important, as this will go a long way in highlighting the safety or otherwise of these products being sold around the study area.

Materials and Method

Sample site

This study was conducted at Kano State, Northern Nigeria. The State has 44 local governments, it is located in the Northwestern Nigeria with coordinates 11^0 30' N 8^0 30' E. It shares borders with Kaduna State to the West, Bauchi State to the South-East, Jigawa State to the East and Katsina State to the North. It has a total area of 20,131km^2 (7,777sqm) and population of 11,058,300 (NPC, 2006).

Bioassay for the Detection of Residual Potassium Bromate Concentrations

This was carried out according to the procedure of Dennis *et al*. (1994). A circular 2cm diameter from the center of a cake sample was taken and dried in an oven for 72 hours at 55 ^{0}C; the crust was ground to a fine powder with electrical grinder. 2500mg of each powdered sample was weighed into 250ml beaker, and 25ml of water was added, the mixture was centrifuged and the

supernatant (liquid fraction) was diluted to 50ml in a volumetric flask. Four millimeter (4ml) aliquot of each of the cake sample was measured into two separate 25ml calibrated flask. Five (5ml) of 5 x 10M solution of Congo red dye and 5ml of 5 x 10M solution of crystal violet dye was added separately followed by 10ml of 2M solution of HCl. Each flask was diluted to 25ml mark with water and shaken gently prior to colorimetric analysis. Spectrophotometric measurements were made on Cecil CE 7200 spectrophotometer model. The molar absorptivity of Congo red dye is 9.04×10^{4} $dm^3\ mol^{-1}\ cm^{-1}$ at λ 452 nm; its wavelength of maximum absorption; while the molar absorptivity of crystal violet dye is 9.70×10^{5} $dm^3\ mol^{-1}\ cm^{-1}$ at λ 485nm.

Data Analysis

Data for residual potassium bromate concentrations in cake samples sold within the three senatorial districts of Kano State was express as Mean ± SD and analyzed using One-way analysis of variance ANOVA by SPSS (version 6.1). Values were considered significant when $p < 0.05$.

Results

From the results, letter A, B, C, D and E represents the code for different types of cakes sample analyzed in Kano Central Senatorial district. Values represent Mean ± SD of triplicate determinations. Residual potassium bromate concentration in cakes sold at Ungogo, Fagge and Kumbotso were found to be significantly lower in concentration. Significant difference (P=0.002) in residual potassium bromate concentrations was found between Nassarawa and four other local governments of areas of Kano Central (Table 1).

Table 1: Mean Concentrations of Residual Potassium Bromate of Cakes Sold in Kano Central Senatorial District

S/N	Madobi	Conc. (mg/kg)	Fagge	Conc. (mg/kg)	Ungogo	Conc. (mg/kg)	Kumbotso	Conc. (mg/kg)	Nassarawa	Conc. (mg/kg)	FAO/WHO Standard
1	A1	33.6	B1	21.9	C1	36.7	D1	32.1	E1	23.2	60mg/kg (ppm)
2	A2	87.2	B2	25.6	C2	24.6	D2	26.8	E2	27.8	
3	A3	40.3	B3	5.5	C3	46.3	D3	65.4	E3	44.2	
4	A4	64.3	B4	7.2	C4	32.7	D4	40.8	E4	98.7	
5	A5	43.7	B5	48.4	C5	28.1	D5	50.6	E5	62.7	
6	A6	35.8	B6	70.6	C6	53.2	D6	44.7	E6	53.5	
7	A7	78.5	B7	75.6	C7	36.7	D7	66.3	E7	256.5	
8	A8	32.2	B8	91.6	C8	42.2	D8	78.1	E8	423.8	
9	A9	89.6	B9	35.6	C9	20.3	D9	82.2	E9	412.9	
10	A10	32.1	B10	33.6	C10	35.6	D10	54.3	E10	372.0	
Mean		53.7		41.6		35.6		54.1		177.5	
±SD		23.7		29.4		9.9		18.7		169.7	

P-value		0.002*									

From the results, letter F, G, H, J and K represents the code for different types of cake samples analyzed in Kano North Senatorial districts. Values represent Mean ±SD of triplicate determinations. Residual potassium bromate concentrations in cakes sold at Dawakin Tofa, Tofa and Rimin Gado was found to be significantly lower in terms of concentration. No significant difference (P=0.175) in residual potassium bromate concentrations was found between all the five local governments (Table 2).

Table 2: Mean Concentrations of Residual Potassium Bromate of Cakes sold in Kano North Senatorial District

SN	Dawakin Tofa	Conc.(mg/kg)	Tofa	Conc.(mg/kg)	Bichi	Conc.(mg/kg)	Danbatta	Conc.	Rimin Gado	Conc.	FAO/WHO Std
1	F1	18.9	G1	53.6	H1	58.5	J1	13.5	K1	53.8	60mg/kg (ppm)
2	F2	32.2	G2	27.8	H2	16.2	J2	32.4	K2	61.5	
3	F3	22.2	G3	16.1	H3	32.6	J3	17.8	K3	23.0	
4	F4	30.8	G4	50.2	H4	55.9	J4	42.7	K4	40.2	
5	F5	9.4	G5	19.4	H5	18.6	J5	26.1	K5	49.7	
6	F6	5.7	G6	26.2	H6	50.3	J6	57.8	K6	34.0	
7	F7	26.8	G7	34.2	H7	43.2	J7	39.0	K7	15.2	
8	F8	52.7	G8	40.7	H8	27.1	J8	48.0	K8	27.5	
9	F9	36.4	G9	32.2	H9	58.2	J9	52.2	K9	46.1	
10	F10	13.2	G10	53.6	H10	39.1	J10	60.1	K10	12.0	
Mean		24.8		35.4		39.9		38.9		36.3	
±SD		14.1		13.7		15.9		16.3		16.8	
P-value		0.175*									

From the results, letter M, N, P, Q and R represents the code for different types of cake samples analyzed in Kano South Senatorial Districts. Values represent Mean ±SD of triplicate determinations. Residual potassium bromate concentrations in cakes sold at Warawa, and Garko were found to be significantly lower in concentration. No significant difference ($p<0.992$) in residual potassium bromate concentrations was found between Gaya, Garko, Dawakin kudu, Warawa and Karaye (Table 3).

Table 3: Mean Concentrations of Residual Potassium Bromate of Cakes Sold in Kano South Senatorial District

SN	Gaya	Conc. (mg/kg)	Garko	Conc.(mg/kg)	Dawakin kudu	Conc.(mg/kg)	Warawa	Conc.	Karaye	Conc.	FAO/WHO Standard
1	M1	65.8	N1	17.9	P1	32.2	Q1	16.5	R1	13.3	60mg/kg(ppm)
2	M2	20.9	N2	37.2	P2	61.8	Q2	36.2	R2	32.7	
3	M3	70.6	N3	28.2	P3	52.9	Q3	50.1	R3	69.2	
4	M4	28.8	N4	52.5	P4	41.3	Q4	9.4	R4	59.5	
5	M5	57.8	N5	22.6	P5	52.0	Q5	78.5	R5	54.6	
6	M6	45.7	N6	58.2	P6	66.5	Q6	57.5	R6	51.1	
7	M7	32.7	N7	46.9	P7	50.3	Q7	25.2	R7	27.3	
8	M8	51.8	N8	35.7	P8	39.2	Q8	77.0	R8	9.3	
9	M9	17.3	N9	54.4	P9	63.5	Q9	4.6	R9	70.6	
10	M10	78.6	N10	77.3	P10	10.6	Q10	65.8	R10	60.5	
Mean		47.0		43.1		47.0		42.1		22.5	
±SD		21.5		18.3		16.9		27.6		22.5	
P-value		**0.992**									

The percentage (%) Compliance and Defaulters of Potassium Bromate in the Three Senatorial District of Kano State is presented in Table 4. From the results of Kano Central, The number of cake samples that were within the acceptable limit of FAO/WHO/JECFA Standard are 99(20%), while cake samples with residues of potassium bromate above FAO/WHO/JECFA Standards are 51(34%). In Kano North, the number samples with potassium bromate residues below FAO/WHO/JECFA Standards are 144(96%), while the number of cake samples that defaulted from FAO/WHO/JECFA are 6(4%). In Kano South, the cake samples that complied with FAO/WHO/JECFA Standard are 177(78%), while those that defaulted from the standards were 33

(22%). The highest potassium bromate defaulters were found in Kano Central 51(34%) while the highest bromate compliance was found in Kano North 144(96%).

Table 4: Percentage (%) Compliance and Defaulters of Potassium Bromate in the Three Senatorial District of Kano State

S/N	Senatorial zone	No. of compliance	% compliance	No. of defaulters	% defaulters
1	Kano central	99	66	51	34
2	Kano North	144	96	06	04
3	Kano South	117	78	33	22

Discussion

The Findings of this study indicated that some cake samples sold in Kano State contain residual potassium bromate beyond the acceptable limits of FAO/WHO/JECFA (1992). However, the level of concentrations varies between the cake types (local cakes, cup and icing cakes). This non-compliance of the bakers to the restriction of potassium bromate use could be due to the fact that our bakers are only interested in profit making not the health status of their consumers. Also ignorance could be another factor because most bakers are unaware or lack the knowledge of its side effect. Another factor could be due to its cheapness, because it also makes baking soft, fluffy and enhances its elasticity. And most importantly, the major factor behind the use of potassium bromate in bakery product could be due to lack of strict penalties or punishment for breaking the rule.

From the findings of this study, the mean concentrations of residual potassium bromate In Kano central, ranged from 35.65-177.52mg/kg (Ungogo- Nassarawa), in Kano North ranged from 24.80-39.95mg/kg (Dawakin Tofa- Bichi) and in Kano South ranged from 42.08-47.01mg/kg (Warawa- Dawakin Kudu). Significant difference ($P<0.002$) was found between Nassarawa Local Government Area of Kano State and all the other four local governments' areas of Kano Central senatorial district. The percentage compliance and defaulters of potassium bromate were presented in Table 4. The highest defaulters of potassium bromate in Kano State were found in Kano Central with percentage of 51 (34%), while the highest compliance to potassium bromate in Kano State was found in Kano North with percentage compliance of 144 (96%). Therefore, the implication of this result is that, all the cake samples with residues above sixty (60 mg/kg) are unsafe for consumption. The ones that was also safe for consumption could be due to the fact that the excess potassium bromate has been converted to bromide during baking. The findings of this study was inconformity to that of Dennis *et al.* (1994) who determined residual potassium bromate ranging from 238- 317ug/kg for both wrapped and unwrapped bread. Nehal *et al*. (2015) also found a detection limit of 0.123ppm; quantification limit of 0.41 and sensitivity at 0.040ppm. In India, the Centre for Science Environment (CSE, 2015) found residues of potassium bromate/iodate in the range of 1.15- 22.54 ppm.

In Iraq, Abdallaha and Hassan (2010) ascertained residual potassium bromate level in the range of 6.66mg/l to 67.45mg/l. In Palestine, Abou-Oboid *et al*. (2016) discovered that the use of two grams (2g) of potassium bromate per bag of flour (60 kg) was safe. In Nigeria, Ojeka *et al*. (2006) determined residual bromate level in the range from 3.70ug/g- 12.19ug/g. Similarly Ojo *et*

al. (2013) determined residual potassium bromate level between 0.5ug/g- 8.4ug/g and 0.83ug/g-1.42ug/g in wheat flour samples. Alli *et al*. (2012) reported residual potassium bromate concentration at Gwagwalada to be between 3.6ug/kg and 9.2ug/kg the quantity that exceeded the minimum allowed by the Food and Drug Administration (FDA). Contrary to the findings of this study is that Emeje *et al*. (2009) and Emeje *et al*. (2015) in which all samples contained residual potassium bromate beyond the quantity allowed by the FDA

Conclusion

Of the 450 cake samples analyzed for residual potassium bromate; only 90 (20%) were found to contain residual potassium bromate. The highest mean residual potassium bromate concentration of the study area was 177.52mg/kg from Nassarawa local government area of Kano Central while the lowest residual potassium bromate concentration was found to be 24.80mg/kg from Dawakin Tofa local government area of Kano North Senatorial district, revealing that most of the cake samples obtained from Kano Central Senatorial District had exceeded the FAO/WHO/JECFA limit. With the high prevalence of cancer and bromate toxicity like hypertension, anemia, renal dysfunction etc., it can be recommended that there should be regular monitoring of foods by the bodies concerned. It is also recommended that defaulters of potassium bromate use should be strictly punished by the law enforcement agencies.

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