



## Ascorbic Acid: A Safe Alternative to Potassium Bromate in Bread Production

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### ABSTRACT

Potassium bromate is widely used by bakers to enhance bread elasticity, functionality, and quality. However, due to its toxicity, the use of potassium bromate in bread production in Nigeria was banned by the National Agency for Food and Drug Administration and Control (NAFDAC); the regulatory agency for food and pharmaceutical products in 2003. Despite the ban, a review aimed at assessing the compliance levels of potassium bromate used in the production of low and high-cost bread consumed across Nigeria revealed that most of the bread sold and consumed in Nigeria still contained potassium bromate in quantities above the permissible limit. This implies that many bread sold in Nigeria are unsafe for human consumption. Bread makers are advised to opt for other safe alternative dough conditioners. Hence the need for formulating a safer and economically effective potassium bromate replacer (PBR). Seventy-two (72) Potassium bromate replacer (PBR) from a "safe" oxidant (ascorbic acid; 80-200ppm) and food acid (citric acid) were formulated and tested for their effectiveness in replacing potassium bromate in the bakery industries. Chemical composition (Fe, Zn and Cu) and organoleptic evaluation (volume, texture, color, taste and general acceptability) of the bread samples were used to compare the effectiveness of the different PBR. Result shows that volume, texture and general acceptability, to a greater extent, increase with increase in the concentration of the PBR, however, no clear trend was observed for color, taste and mineral composition of the bread.

**Key words:** potassium bromate replacer, potassium bromate, ascorbic acid, citric acid and Bread

### 1.0 INTRODUCTION

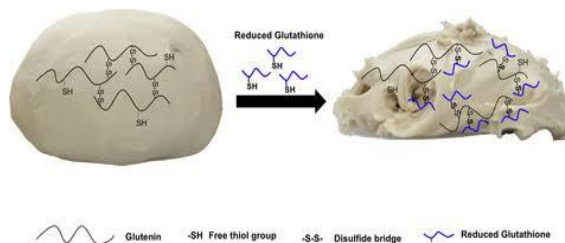
The elasticity of dough is at least partly due to disulfide crosslinks in the network of protein molecules (Debonne *et al.*, 2018). The viscoelastic properties of wheat flour doughs have profound effects on dough machinability and the textural characteristics and keepability of the finished product (Debonne *et al.*, 2018). Hence a range of functional ingredients are added to dough in order to improve its qualities.

The most common texture change observed by using bread improvers is an increase in the initial softness of the bread. Such changes are seen with the addition of the oxidants, fat, emulsifiers, and a range of active enzymes preparations. (Lachowicz *et al.*, 2021).

The main classes of additives used in breadmaking are: (i) oxidants/reductants; (ii) emulsifiers; (iii)

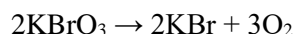
hydrocolloids; and (iv) preservatives. (Gioia, Ganancio and Steel 2017).

Oxidants and reductants are normally included to assist with gluten network development (Msagati, 2013). Oxidants improve stability and elasticity of the dough, which becomes stronger, increasing oven rise, and making crumb grain finer. They act on the gluten proteins of flour, i.e. oxidizable thiol (—SH) groups, creating additional disulfide bonds (S-S) (see figure 1) (Debonne *et al.*, 2018).



**Figure 1. Disulfide crosslinks in the network of protein molecules**

Most Bakeries use potassium bromate, a strong oxidizing agent, for bread improving effects such as to preserve flavor or improve the taste and appearance (Shanmugavel *et al.*, 2020), it also has significant effect on food biomolecules, such as starch and protein, thus improves the bread properties (Shanmugavel *et al.*, 2020). For many years the use Potassium bromate was permitted as a bread conditioner since bromate is converted to bromide, with no traces of it when exposed to heat during bread production (as shown in the equation below) (Kim *et al.*, 2015). However, this is dependent on the quantity of potassium bromate used and the duration of exposure to optimal temperature (Uwah and Ikwebe 2020).



The un-converted Potassium bromate as a result of high quantity of the additive or limited exposure to optimal temperature will now remain in the baked bread as Residual potassium bromate (RPB), This is why, to assess bread safety: based on potassium bromate content, the major possible means is to assess the RPB from baked bread. The International Agency for Research on Cancer (IARC) classified  $\text{KBrO}_3$  as a 2B (a possible human) carcinogen, experiments aimed at elucidating the mode of carcinogenic action have also revealed that  $\text{KBrO}_3$  is a complete carcinogen, possessing both initiating and promoting activities (Adejumo *et al.*, 2016). In addition, Potassium bromate possesses non-cancerous health problems like abdominal problem, kidney failure, hearing loss, bronchial and ocular problems (Adejumo *et al.*, 2016). It is also being demonstrated that  $\text{KBrO}_3$  induces renal cell tumors, mesotheliomas of the peritoneum, and follicular cell tumors of the thyroid. (Adejumo *et al.*, 2016).

On account of its deleterious effect and carcinogenicity in humans, the use of potassium bromate in bread processing was banned in many countries including Nigeria, However, despite the ban placed on the use of potassium bromate as bread-enhancer in Nigeria, many researches revealed the presence of potassium bromate residue in quite a number of breads consumed in Nigeria, which simply implies that baker are still using the additive so as to increase bread volume and texture.

Non-compliance to the ban directives placed on potassium bromate, according to many bakers, may not be unconnected to non-availability of its replacer which is as effective and economically viable as potassium bromate. Hence, the need for potassium bromate replacer, which is affordable and with less or no adverse effect arises.

In baking process, there are three main stages, this include mixing, proofing and the baking itself. The stage at which oxidation takes place determine the quality of an oxidant in baking industry, and the best is which act throughout the three processes above, however some oxidizing agent tent to act fast which makes them mainly functional during mixing and to a slight extent during proofing, the action of such oxidants, need to be delayed to ensure oxidation during baking process.

In contrast to many oxidizing agents such as potassium iodate and ascorbic acid, which are fast acting and mainly functional during mixing and to a slight extent during proofing,

Potassium bromate is a slow acting oxidant and mainly functional during the later Stages of proofing and the early Stages of baking. As a result, many bakers consider potassium bromate as the best and more economical oxidizing agent, as such they persistently resist all efforts made by relevant authorities to enforce the banning of its use as an additive in bread baking and makes it difficult to accept its alternative, even though it is associated with adverse effects on our health.

Ascorbic acid is considered as the safest of all the oxidizing agents used as additive in baking industry (Marijana *et al.*, 2021). As such, it has been used as a flour improver for a long time. Ascorbic acid is a very popular and widely used flour improver in bread products to incentives oxidizing process (Šimurina *et al.*, 2014). Hence, Potassium bromate replacer comprising ascorbic acid composition in an effective amount was considered an effective alternative that can replace carcinogenic potassium bromate as an oxidizing agent in bread baking.

In order to make other oxidizing agents to be functional throughout the baking process or at least during the early Stage of baking, some bakers combine fast and Slow acting oxidants to provide

adequate Strengthening of dough throughout the entire manufacturing process. However, these combined oxidants have disadvantages because they become chemical additives, thereby requiring full labelling by complete chemical name.

Investigation also shows that adding an effective amount of food acids slows down Oxidation of ascorbic acid to dehydroascorbic acid in a dough (Marijana *et al.*, 2021). Hence, ascorbic acid is changed to a slow acting oxidant that is functional throughout the entire manufacturing process.

Therefore, in order to find a safer substitute to a widely used carcinogenic potassium bromate, the present study explore the feasibility of formulating an effective potassium bromate replacer using ascorbic acid and some food acids.

## 2.0 MATERIALS AND METHODS

### 2.1 Materials

The materials used for the research include, potassium bromate, L-ascorbic acid (oxidant), acetic acid (food acid), Flour, yeast, sugar, salt,

groundnut oil, butter, sweetener, flavoring and water.

### 2.2 Methods

A total of seventy-two (72) potassium bromate replacers (PBR) were prepared and used in the present research. Ascorbic acid used is L-ascorbic acid and the Ascorbic acid mix formula ranges from about 80 ppm to 200 ppm by weight of flour. Food acid used is acetic acid, and its concentration ranged from about 0.010 to 0.20 parts per 100 parts flour.

#### 2.2.1 Preparation of Potassium Bromate Replacer

The potassium bromate replacers were prepared using ascorbic acid and acetic acid (food acid) of varying concentration as illustrated in table 2.1- 2.6 below.

Bakery concentration of potassium bromate was used as positive control while oxidant free solution was used as negative control. This is as illustrated in tables 2.1 – 2.6 below

**Table 1; Preparation A I -XII comprising of Ascorbic acid (200 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	200	200	200	200	200	200	200	200	200	200	200	200
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

**Table 2; Preparation B I -XII comprising of Ascorbic acid (180 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	180	180	180	180	180	180	180	180	180	180	180	180
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

**Table 3 Preparation of C I -XII PBR comprising of Ascorbic acid (160 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	160	160	160	160	160	160	160	160	160	160	160	160
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

**Table 4 Preparation of D I -XII PBR comprising of Ascorbic acid (140 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	140	140	140	140	140	140	140	140	140	140	140	140
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

**Table 5 Preparation of E I -XII PBR comprising of Ascorbic acid (120 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	120	120	120	120	120	120	120	120	120	120	120	120
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

**Table 6 Preparation of F I -XII PBR comprising of Ascorbic acid (80 ppm) and citric acid (0 - 0.2ppm)**

Ingredient			Potassium bromate replacer composition (ppm)											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Potassium bromate	BC	-	-	-	-	-	-	-	-	-	-	-	-	-
Ascorbic acid	-	-	80	80	80	80	80	80	80	80	80	80	80	80
Citric acid	-	-	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.00

### 2.2.2 Bread Preparation

Cauvain 2015 method was adopted with some modifications.

Before starting the bread-making process, all ingredients were measured accurately by weight as it is the preferred method for bread making. Before mixing the dough, the yeast was hydrated in water and very little amount of sugar was added, the water wakes the dry yeast up from its dormant state and the sugar gives the yeast something to feed on. Other ingredients such as groundnut oil, butter, sweetener, flavoring agents and the oxidants were then added to the to the above mixture. After mixing, the mixture was then allowed to settle for 5-10 minutes to check for foaming. Bubbles and foaming are signs that the yeast is alive and you can add it to your dough

In a separate container, a mixture of 500g of the sieved flour, 1g of salt and 10g of sugar was made.

By combining the two mixtures above, dough was made after which the dough is kneaded. The Dough was kneaded in a stand mixer using a dough hook.

The Kneading of the dough continue until it was smooth and elastic, it was then allowed to rest and ferment for about an hour.

The fermented dough was then shaped into loaves, transferred into a baking plate and close, and then allowed for another time to rise, this process is called proofing or proving.

After the bread has proofed sufficiently it was then baked in a clay molded oven.

### 2.2.3 Organoleptic Evaluation

Ten bakery staff were the test panelist. A five-point hedonic scale (1= dislike very much, 2= dislike slightly 3 = neither like nor dislike, 4 = like slightly and 5 = like very much) form was developed as an instrument for organoleptic evaluation. The organoleptic attributes evaluated were volume, texture, color, taste and general acceptability of the bread. The breads were presented to the judges in dishes labeled with appropriate codes. Water at room temperature was provided for each of the judges to rinse their mouth with before and after tasting to ensure unbiased evaluation. The five-point hedonic scale forms were filled by the judges

accordingly and collected at the end of the Organoleptic evaluation

## 2.2.4 Mineral Determination

### Quantitative determination of some useful metals

Exactly 1 g of each of the samples was digested with concentrated nitric acid and perchloric acid in a ratio of 3:1 on a hot plate. It was then filtered using whatman filter No. 1 in to a 50 ml volumetric flask and made up to mark with distilled water metals concentrations were determined using Atomic absorption spectrophotometer.

## 3.0 RESULTS AND DISCUSSION

**Table 3.1: Organoleptic (volume) evaluation of bread prepared using different Potassium bromate replacers**

S/No.		A	B	C	D	E	F
1.	+	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00
2.	I	3.67±0.21	3.15± 0.14	2.50± 0.07	1.93± 0.12	1.39 ± 0.21	1.19 ± 0.00
3.	II	3.65±0.51	3.13± 0.15	2.50± 0.21	1.83± 0.19	1.38 ± 0.23	1.17 ± 0.00
4.	III	3.55±0.41	3.12± 0.18	2.48± 0.42	1.82± 0.14	1.38 ±0. 18	1.18 ± 0.00
5.	IV	3.55±0.48	3.10± 0.45	2.51± 0.54	1.83± 0.24	1.37 ± 0.36	1.16 ± 0.00
6.	V	3.55±0.01	3.10± 0.81	2.45± 0.15	1.81± 0.20	1.36 ± 0.23	1.17 ± 0.00
7.	VI	3.35±0.02	3.10± 0.41	2.45± 0.82	1.76± 0.12	1.36 ± 0.08	1.16 ± 0.00
8.	VII	3.38±0.48	3.18± 0.48	2.42± 0.41	1.73± 0.23	1.34 ± 0.21	1.15 ± 0.00
9.	VIII	3.45±0.32	3.07± 0.12	2.40± 0.19	1.71± 0.19	1.33 ± 0.23	1.16 ± 0.00
10.	IX	3.44±0.47	3.07± 0.17	2.41± 0.71	1.70± 0.14	1.33 ± 0.23	1.15 ± 0.00
11.	X	3.44±0.08	3.05± 0.45	2.43± 0.42	1.65± 0.21	1.31 ± 0.18	1.14 ± 0.00
12.	XI	3.45±0.88	3.05± 0.75	2.35± 0.82	1.63± 0.19	1.30 ± 0.32	1.14 ± 0.00
13.	XII	3.45±0.45	3.05± 0.51	2.34± 0.51	1.61± 0.14	1.31 ± 0.23	1.13 ± 0.00
14.	-	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00

Key

**Table 3.2: Organoleptic (texture) evaluation of bread prepared using different Potassium bromate replacers**

S/No.		A	B	C	D	E	F
1.	+	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00
2.	I	3.92±0.32	3.42± 0.11	2.41± 0.12	1.71± 0.32	1.21 ± 0.23	1.25 ± 0.12
3.	II	3.92±0.42	3.35± 0.19	2.57± 0.42	1.72± 0.11	1.31 ± 0.09	1.22 ± 0.16
4.	III	3.86±0.45	3.32± 0.21	2.92± 0.17	1.65± 0.24	1.30 ±0. 18	1.23 ± 0.24
5.	IV	3.89±0.05	3.30± 0.35	2.59± 0.15	1.57± 0.16	1.31 ± 0.13	1.19 ± 0.09
6.	V	3.83±0.22	3.31± 0.21	2.83± 0.19	1.60± 0.09	1.26 ± 0.33	1.12 ± 0.18
7.	VI	3.82±0.09	3.27± 0.05	2.87± 0.41	1.65± 0.09	1.29 ± 0.28	1.19 ± 0.19
8.	VII	3.86±0.21	3.31± 0.18	2.21± 0.21	1.51± 0.17	1.38 ± 0.11	1.23 ± 0.27
9.	VIII	3.86±0.42	3.40± 0.09	2.46± 0.18	1.81± 0.11	1.36 ± 0.03	1.19 ± 0.30
10.	IX	3.87±0.20	3.50± 0.11	2.64± 0.41	1.70± 0.21	1.32 ± 0.10	1.21 ± 0.21
11.	X	3.75±0.11	3.53± 0.15	2.23± 0.43	1.45± 0.06	1.39 ± 0.12	1.23 ± 0.13
12.	XI	3.76±0.21	3.51± 0.24	2.39± 0.11	1.33± 0.12	1.32 ± 0.13	1.21 ± 0.10/
13.	XII	3.74±0.51	3.21± 0.02	2.50± 0.16	1.81± 0.21	1.23 ± 0.40	1.25 ± 0.07
14.	-	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00

**Table 3.3: Organoleptic (color) evaluation of bread prepared using different Potassium bromate replacers**

S/No.		A	B	C	D	E	F
1.	+	4.81±0.21	4.81±0.21	4.81±0.21	4.81±0.21	4.81±0.21	4.81±0.21
2.	I	4.22±0.15	4.10± 0.21	4.13± 0.24	3.81± 0.12	4.11 ± 0.23	4.15 ± 0.12
3.	II	4.21±0.12	3.95± 0.12	3.85± 0.15	3.78± 0.31	4.13 ± 0.09	3.98 ± 0.16
4.	III	4.13±0.11	3.98± 0.15	3.94± 0.27	3.96± 0.15	3.79 ±0. 18	3.72 ± 0.24
5.	IV	3.94±0.19	4.30± 0.31	4.11± 0.21	3.77± 0.18	3.88 ± 0.13	3.89 ± 0.09
6.	V	3.93±0.12	4.15± 0.23	3.88± 0.18	3.76± 0.12	3.69 ± 0.33	3.84 ± 0.18
7.	VI	3.92±0.15	4.02± 0.15	3.87± 0.14	3.86± 0.12	4.29 ± 0.28	3.92 ± 0.19
8.	VII	3.96±0.31	3.85± 0.19	4.11± 0.16	3.75± 0.18	3.82 ± 0.11	3.91 ± 0.27
9.	VIII	4.16±0.15	3.91± 0.29	4.14± 0.12	3.81± 0.12	3.79 ± 0.03	3.89 ± 0.30
10.	IX	4.13±0.21	3.76± 0.23	3.86± 0.23	3.72± 0.11	3.82 ± 0.10	3.90 ± 0.21
11.	X	3.92±0.14	4.12± 0.08	4.13± 0.14	4.14± 0.09	3.71 ± 0.12	3.87 ± 0.13
12.	XI	3.98±0.31	3.68± 0.41	3.97± 0.20	4.33± 0.08	3.83 ± 0.13	3.89± 0.10/

13.	XII	4.12±0.13	4.21± 0.08	4.10± 0.19	3.81± 0.15	3.73 ± 0.40	3.78 ± 0.07
14.	-	3.87 ±0.02	3.87 ±0.02	3.87 ±0.02	3.87 ±0.02	3.87 ±0.02	3.87 ±0.02

**Table 3.4: Organoleptic (taste) evaluation of bread prepared using different Potassium bromate replacers**

S/No.		A	B	C	D	E	F
1.	+	4.21±0.05	4.21±0.05	4.21±0.05	4.21±0.05	4.21±0.05	4.21±0.05
2.	I	4.02±0.32	3.98± 0.21	4.07± 0.02	4.07± 0.18	4.02±0.22	3.95±0.13
3.	II	3.95±0.21	3.98±0.11	4.11±0.15	3.68±0.45	4.02±0.04	3.95±0.04
4.	III	3.96±0.45	3.98±0.21	3.91± 0.11	3.85± 0.05	3.83 ±0.08	3.83 ± 0.15
5.	IV	3.94±0.05	3.83± 0.05	3.95± 0.10	3.79± 0.16	4.11 ± 0.02	4.05 ± 0.11
6.	V	3.82±0.22	4.11± 0.11	3.89± 0.12	3.85± 0.09	3.86 ± 0.03	4.02 ± 0.11
7.	VI	3.87±0.09	3.77± 0.05	3.87± 0.11	4.05± 0.12	4.02 ± 0.18	3.89 ± 0.09
8.	VII	3.98±0.21	3.81± 0.08	4.11± 0.03	3.91± 0.18	4.38 ± 0.11	4.01 ± 0.02
9.	VIII	3.86±0.42	4.20± 0.19	4.16± 0.20	3.88± 0.09	3.86 ± 0.13	4.12 ± 0.03
10.	IX	3.88±0.20	3.80± 0.14	4.15± 0.11	4.11± 0.03	3.92 ± 0.11	3.89 ± 0.11
11.	X	3.98±0.11	3.72± 0.11	3.83± 0.21	3.75± 0.11	4.13 ± 0.03	4.03 ± 0.12
12.	XI	4.08±0.21	3.92± 0.20	4.13± 0.10	4.13± 0.15	3.83 ± 0.11	4.08 ± 0.11
13.	XII	4.08±0.11	3.811± 0.02	4.12± 0.06	3.92± 0.11	4.03 ± 0.05	3.86 ± 0.18
14.	-	4.09 ±0.08	4.09. ±0.08	4.09 ±0.08	4.09 ±0.08	4.09 ±0.08	4.09 ±0.08

**Table 3.5: Organoleptic (General acceptability) evaluation of bread prepared using different Potassium bromate replacers**

S/No.		A	B	C	D	E	F
1.	+	5.000 ±0.000	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00	5.00 ±0.00
2.	I	3.91±0.31	3.72±0.43	3.29 ±0.56	2.91±0.568	2.54 ±0.56	1.81±0.62
3.	II	3.85±0.42	3.68±0.56	3.31 ±0.52	2.82±0.422	2.22 ±0.42	1.66±0.56
4.	III	3.89±0.42	3.66±0.57	3.32 ±0.56	2.88±0.632	2.31 ±0.65	1.58±0.57
5.	IV	3.69±0.56	3.69±0.56	3.25 ±0.43	2.79±0.483	2.22 ±0.42	1.49±0.56
6.	V	3.59±0.57	3.58±0.42	3.25 ±0.56	2.77±0.675	2.18 ±0.58	1.48±0.69
7.	VI	3.89±0.36	3.59±0.57	3.27 ±0.51	2.66±0.516	2.22 ±0.42	1.36±0.43
8.	VII	3.78±0.42	3.61±0.56	3.28 ±0.16	2.67±0.699	2.33 ±0.83	1.48±0.56
9.	VIII	3.98±0.36	3.49±0.43	3.22 ±0.42	2.59±0.527	2.51 ±0.58	1.39±0.43
10.	IX	3.85±0.57	3.46±0.56	3.22 ±0.22	2.48±0.516	1.95 ±0.36	1.47±0.69
11.	X	3.96±0.56	3.48±0.56	3.31 ±0.43	2.49±0.516	2.09 ±0.00	1.22±0.42
12.	XI	3.45±0.69	3.36±0.43	3.13 ±0.31	2.35±0.483	1.80 ±0.42	1.25±0.42
13.	XII	3.58±0.57	3.32±0.42	3.10 ±0.41	2.99±0.568	1.86 ±0.42	1.82±0.62
14.	-	1.000 ±0.000	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00	1.00 ±0.00

**Table 3.6: Metal content of the bread samples produced using different PBR (mg/kg)**

S/No.		Fe	Zn	Cu
1.	+	0.950±0.012	0.571±0.0001	0.012±0.0011
2.	AI	0.975±0.008	0.526±0.0012	0.009±0.0012
3.	AII	0.897±0.011	0.817±0.0003	0.008±0.0011
4.	A III	0.895±0.008	0.512±0.0005	0.009±0.0012
5.	AIV	0.957±0.007	0.496±0.0071	0.019±0.0028
6.	AV	0.954±0.004	0.521±0.0009	0.015±0.0017
7.	AVI	0.895±0.012	0.462±0.0007	0.009±0.0012
8.	AVII	0.899±0.009	0.510±0.0015	0.012±0.0001
9.	AVIII	0.879±0.011	0.523±0.0009	0.015±0.0007
10.	AIX	0.890±0.004	0.423±0.0005	0.015±0.0008
11.	AX	0.789±0.006	0.521±0.0006	0.014±0.0010
12.	AXI	0.990±0.009	0.610±0.0004	0.013±0.0011
13.	AXII	0.891±0.007	0.463±0.0011	0.012±0.0008
14.	BI	0.980±0.002	0.510±0.0005	0.013±0.0014
15.	BII	0.891±0.014	0.468±0.0016	0.012±0.0012
16.	BIII	0.890±0.008	0.521±0.0008	0.012±0.0008
17.	BIV	0.983±0.007	0.512±0.0011	0.013±0.0008
18.	BV	0.896±0.009	0.524±0.0016	0.014±0.0004
19.	BVI	0.898±0.013	0.551±0.0006	0.015±0.0007
20.	BVII	0.891±0.007	0.541±0.0008	0.015±0.0004
21.	BVIII	0.895±0.011	0.496±0.0014	0.014±0.0005
22.	BIX	0.879±0.018	0.511±0.0006	0.016±0.0001
23.	BX	0.897±0.005	0.521±0.0017	0.015±0.0008
24.	BXI	0.921±0.007	0.501±0.0012	0.017±0.0002
25.	BXII	0.836±0.011	0.462±0.0002	0.015±0.0011
26.	CI	0.892±0.007	0.510±0.0019	0.014±0.0005



27	CII	0.879±0.011	0.560±0.0013	0.018±0.0004
28	CIII	0.880±0.009	0.542±0.0008	0.012±0.0012
29	CIV	0.854±0.008	0.468±0.0014	0.014±0.0009
30	CV	0.955±0.007	0.433±0.0007	0.012±0.0004
31	CVI	0.846±0.009	0.491±0.0003	0.011±0.0009
32	CVII	0.871±0.003	0.502±0.0004	0.010±0.0021
33	CVIII	0.799±0.006	0.531±0.0001	0.014±0.0011
34	CIX	0.781±0.008	0.521±0.0001	0.012±0.0002
35	CX	0.880±0.005	0.436±0.0002	0.014±0.0012
36	CXI	0.781±0.011	0.455±0.0015	0.012±0.0009
37	CXII	0.752±0.005	0.511±0.0006	0.013±0.0013
38	DI	0.811±0.007	0.513±0.0004	0.014±0.0017
39	DII	0.895±0.011	0.486±0.0004	0.012±0.0008
40	DIII	0.798±0.006	0.701±0.0005	0.019±0.0007
41	DIV	0.951±0.015	0.541±0.0012	0.012±0.0014
42	DV	0.980±0.017	0.501±0.0006	0.016±0.0005
43	DVI	0.881±0.009	0.521±0.0005	0.012±0.0006
44	DVII	0.801±0.003	0.461±0.0018	0.015±0.0002
45	DVIII	0.912±0.007	0.502±0.0012	0.010±0.0011
46	DIX	0.875±0.005	0.517±0.0002	0.012±0.0001
47	DX	0.751±0.011	0.601±0.0005	0.013±0.0012
48	DXI	0.862±0.005	0.502±0.0014	0.012±0.0004
49	DXII	0.885±0.008	0.503±0.0002	0.011±0.0006
50	EI	0.751±0.001	0.515±0.0012	0.013±0.0005
51	EII	0.782±0.006	0.521±0.0002	0.012±0.0007
52	EIII	0.812±0.003	0.510±0.0012	0.012±0.0002
53	EIV	0.450±0.006	0.469±0.0004	0.012±0.0006
54	EV	0.882±0.007	0.501±0.0016	0.013±0.0008
55	EVI	0.712±0.012	0.523±0.0008	0.018±0.0011
56	EVII	0.814±0.009	0.506±0.0014	0.013±0.0001
57	EVIII	0.915±0.007	0.514±0.0006	0.015±0.0009
58	EIX	0.846±0.016	0.401±0.0008	0.012±0.0002
59	EX	0.902±0.008	0.522±0.0012	0.009±0.0004
60	EXI	0.811±0.011	0.513±0.0003	0.008±0.0011
61	EXII	0.846±0.009	0.486±0.0015	0.009±0.0005
-62	FI	0.799±0.007	0.510±0.0005	0.016±0.0006
63	FII	0.832±0.008	0.521±0.0005	0.012±0.0004
64	FIII	0.768±0.009	0.503±0.0018	0.012±0.0011
65	FIV	0.820±0.019	0.478±0.0002	0.013±0.0008
66	FV	0.880±0.015	0.521±0.0011	0.012±0.0012
67	FVI	0.912±0.008	0.495±0.0006	0.018±0.0002
68	FVII	0.751±0.002	0.503±0.0005	0.016±0.0005
69	FVIII	0.881±0.007	0.522±0.0014	0.012±0.0009
70	FIX	0.911±0.009	0.498±0.0006	0.008±0.0001
71	FX	0.798±0.007	0.541±0.0013	0.011±0.0006
72	FXI	0.833±0.008	0.504±0.0006	0.009±0.0007
73	FXII	0.891±0.007	0.455±0.0007	0.018±0.0005
74	-	0.885±0.009	0.499±0.0010	0.015±0.0001

### 3.2 DISCUSSION

The bread used as positive control in this research was obtained from the bulk of the bakery production, hence contain the bakery potassium bromate concentration which is far above the maximum acceptable concentration of 80 ppm. The potassium bromate residual concentration of the bread was determined to be 6.22 µg/g which is above the allowed limit by FDA of 0.02µg/g. on the other hand, the bread used as negative control contains no oxidant.

Table 3.1 shows the result for the Organoleptic (volume) evaluation of bread prepared using different Potassium bromate replacers. There is a greater correlation (Pearson) which ranged from 0.85-0.90 between the bread volume and the concentration of the ascorbic acid, while Pearson

correlation of the bread volume and food acid concentration is within the ranged of 0.69-0.72. this simply indicates that systematic increased in the concentration of ascorbic acid and citric acid may result to a better bread volume.

Similarly, the correlation of ascorbic acid and citric acid concentration to the bread texture are 0.89 and 0.92 respectively (see table 3.2).

However, the effect of the concentrations of the two acids on the color of the bread was very small 0.167 and 0.123 respectively, this simply implies that increasing the concentration of the two acids may not have a negative effect on the bread color, similar result was observed in the taste of the bread, the correlation of the bread taste and the concentration of the ascorbic was found to be

0.354, but negative correlation was observed the concentration of the food acid (citric acid -0.427)

The general acceptability result (table 3.5) shows high correlation between the concentration of the ascorbic acid in the formulated PBR and the acceptability of the final product by the consumers, the correlation ranged from 0.756- 0.996 and that of the citric acid 0.554-0.672.

Sample **AI** is having the highest Volume, texture and general acceptability among all the formulated PBR as well as retaining its color and taste.

Copper, Zinc and iron are nutritionally essential metals (Magomya *et al.*, 2013), copper (Cu) and zinc (Zn), serve as enzymes that are essential for intracellular processes and have DNA-binding domains (Magonya *et al* 2013). However, these metals are toxic when taken in excess (Magonya *et al* 2013) and is associated with a number of diseases. The concentration of Cu in the bread samples ranged from 0.04-0.18 mg/kg. These concentrations are within the permissible level of Cu in foods (Asif, Sharf and Anwar 2020).

PBR AII, EXI and FIX are having the least copper concentration of 0.008mg/kg while bread samples AIV and DIII are having the highest concentration of 0.019mg/kg. The samples can therefore be considered free from Cu contamination.

The average daily intake of zinc has been estimated to be maximally 20 mg/day for adults (Magonya *et al* 2013). In human, high levels of zinc have been associated with acute effects such as vomiting and gastrointestinal irritation. The highest Zn concentration in the bread samples analyzed was observed for sample AII (0.817mg/kg) while the lowest was in sample AIX (0.423mg/kg). These values are within the permissible level of Zn in foods (50mg/kg) (Asif, Sharf and Anwar 2020).

Iron is an essential element for almost all living organisms as it participates in a wide variety of metabolic processes, including oxygen transport, deoxyribonucleic acid (DNA) synthesis, and electron transport (Abbaspour, *et al* 2013). it is required for the synthesis of haemoglobin: a protein in red blood cells that carries oxygen from the lungs

to all parts of the body, and in many enzyme systems (Harvard T.H SPH). Iron is also part of myoglobin, a protein that carries and stores oxygen specifically in muscle tissues. Iron is important for healthy brain development and growth in children, and for the normal production and function of various cells and hormones (Harvard T.H SPH) Various groups differ in requirement for iron: the recommended dietary allowance (RDA) for adults (19-50 years) is 8 mg/day for men, 18 mg/day for women, 27 mg/day for pregnancy and 9 mg for lactation (IMFNB,2001). However, it can lead to tissue damage when in excess (Abbaspour, *et al* 2013).

The concentrations of Fe in the bread samples studied ranged from 0.712-0.990 mg kg<sup>-1</sup>. Sample EVI is having the lowest concentration while sample AXI is having the highest. The permissible limit for Fe in food is in the range of 2.5-5.0 mg/kg depending on the foodstuff. Therefore, the Fe concentrations are all within the permissible limit Metal containers used for kneading of dough during bread making may be responsible for high levels of such metals. Environmental contamination such as Atmospheric deposition from urban and industrial areas may result in contamination of agricultural produce with heavy metals which are in turn transferred to the finished products.

### 3.0 CONCLUSION

In conclusion, it can be observed, from the above result that sample AI (200 ppm/0.2 ppm) is having the highest Volume, texture and general acceptability of  $3.67 \pm 0.21$ ,  $3.92 \pm 0.32$ , and  $3.91 \pm 0.31$  respectively) without having much negative effect on its color and taste ( $4.22 \pm 0.15$  and  $4.02 \pm 0.32$  respectively). It is also evidently proven that the concentration does not affect the nutritionally essential metals.

### 4.0 RECOMMENDATION

We recommend further, in-depth research on the formulation of potassium bromate replacers formulation from other oxidants and food acids

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