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Original Research Article

Assessment of Potential Carcinogens in Some Fast Foods Sold in A Nigerian University Campus

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ABSTRACT

The subject of cancer is one that has become widely recognised in the world, with several factors contributing to its onset in a person. One of the most prominent factors associated with the development of cancer is the presence of carcinogenic contaminants in consumed foods. This study assayed for two contaminants (potassium bromate and acrylamide) recognised as potential carcinogens by the International Agency for Research on Cancer (IARC) in selected fast foods consumed within a Nigerian University campus. Samples of fifteen different bread and flour products were analysed for potassium bromate using a standard spectroscopic method, and acrylamide analysis by HPLC was carried out on four different fried potato samples. Potassium bromate was present in 67% of the samples analysed in amounts ranging from 2.677±0.25 mg/kg to 7.839±0.36 mg/kg. Acrylamide was present in amounts ranging from 1.92 µg/kg to 23.67 µg/kg in 50% of the potato samples analysed. The tolerable daily acrylamide intake is estimated at 2.6 µg/kg body weight per day. Based on the result obtained, some of the bread and fried potatoes sold within a Nigerian University campus contained potassium bromate and acrylamide, compounds known as potential carcinogens.

Keywords: Acrylamide, Potassium bromate, HPLC, Carcinogen, Campus.

Introduction

The disease known as cancer has gained much attention over the years. This condition occurs when the cells of an organism undergo mutations that involve the acquisition of abilities to replicate and evolve independently of the innate control mechanisms programmed in cells and even propagate to other sites in the body.[1] These mutations can be caused by radiation, viruses, obesity, hormones, chronic inflammation, or exposure to certain carcinogenic chemicals. The accumulated effect of exposure to these agents leads to the onset of cancer through carcinogenesis.[2]

Over the years, nutrition has been flagged as a defining factor in cancer development and plays a vital role in its prevention, management, and possible treatment. The regulation and monitoring of food quality have increased information leading to the discovery of cancer-causing contaminants (carcinogens) present in foods.[3] The incidence of cancer among Nigerians has increased over the years, and many cases have resulted in mortality.[4] The Cancer Country Profile 2020 reported 115,950 new cases and 70,327 deaths from cancer in Nigeria in 2018,[5] demonstrating the seriousness of the disease. Individuals are constantly exposed to hazardous chemicals in foods. Some of these foodborne carcinogens depend on the temperature, cooking time, and product type.[6] When consumed, these chemicals can accumulate in the human body, resulting in serious health complications such as cancer, in the long run, reducing the quality of health of the individual. Carcinogens can be mutagenic, nephrotoxic, and immunotoxic.

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The presence of such chemicals in foods is a matter of great public health concern. Such compounds can induce chronic effects in man and animals that range from central nervous system disorders, cardiovascular, pulmonary, and intestinal tracts to death.[4] The biological components of factors affecting carcinogenesis can be divided into genotoxic and non-genotoxic agents. Genotoxic agents are micro components of food that cause DNA damage. In contrast, non-genotoxic agents cause cancer without directly altering the DNA. They act through mechanisms such as induction of immunosuppressants, inflammatory responses and endocrine modulation.[7] Acrylamide is a potentially carcinogenic compound formed when starchy foods are processed at high temperatures above 120^{o}C.[8] Fried potato is a typical sample used to assess acrylamide in foods. [9,10] It exists as a white crystalline solid with a boiling point of 136°C and a melting point of 84-85°C. Its vinyl group is deficient in electrons and is pilloried quickly by nucleophiles. This is the exact mechanism it uses in interacting with nucleophiles in biological molecules.[11] It is classified as a probable carcinogen in humans by the International Agency for Research on Cancer (IARC)[12] and reasonably anticipated to be a human carcinogen by the United States National Toxicology Program (NTP).[13] Acrylamide can react with cellular or subcellular components due to its structure and metabolic transformation potential. Potassium bromate ($KBrO_3$) exists in powder or white crystals. It has a molar mass of 167 g/mol and is an oxidising agent used as a food additive, mainly in bread-making. It is classified in Group 2B by the IARC;[14] its use in baking has been banned by the National Agency for Food and Drug Administration and Control (NAFDAC), the regulatory agency in Nigeria [15]. This study aims to assess potassium bromate and acrylamide, respectively, present in baked products and fried potatoes sold within a University campus.

Materials and Methods

A total of 15 flour-based products (Table 1) and four samples of fried potato products (Table 3) were purchased for potassium bromate and acrylamide analysis, respectively.

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Table 1: A list of flour-based product samples that were assayed for potassium bromate

S/No	Sample ID	Location
1	A_1	Site 1
2	A_2	Site 2
3	A_3	Site 3
4	B_1	Site 1
5	B_2	Site 2
6	B_3	Site 3
7	C_1	Site 1
8	C_2	Site 2
9	C_3	Site 3
10	D_1	Site 1
11	D_2	Site 2
12	D_3	Site 3
13	E	Site 1
14	F	Site 1
15	G	Site 1

Table 2: Determination of potassium bromate in flour-based products sold in a Nigerian University campus.

S/No	Sample ID	Colour change	Quantity (mg/kg)
1	A_1	Light Purple	2.677 ± 0.25
2	A_2	Light Purple	3.652 ± 0.41
3	A_3	Light Purple	3.335 ± 0.31
4	B_1	Light Purple	4.226 ± 0.22
5	B_2	Light Purple	4.594 ± 0.38
6	B_3	Light Purple	4.806 ± 0.47
7	C_1	Dark Purple	7.839 ± 0.36
8	C_2	Dark Purple	5.871 ± 0.25
9	C_3	Dark Purple	5.452 ± 0.34
10	D_1	Light Cream	-
11	D_2	Clear	-
12	D_3	Light Brown	-
13	E	Clear	-
14	F	Light Cream	-
15	G	Dark Purple	6.148 ± 0.45

Values are mean ± SD of triplicates. Colour change This is a qualitative test for the presence of potassium bromate. The quantity of potassium bromate in each sample correlates with the degree of purple colour.

Hydrochloric acid, potassium bromate, potassium iodide, acrylamide (> 99%), and acetonitrile (HPLC grade) were obtained from commercial distributors.

Sample collection

The flour-based products and fried potatoes samples were purchased from major outlets patronised by students within a Nigerian campus in Southwestern Nigeria between February and March 2018. The samples were placed in plastic bags, sealed and tagged with sample ID and location. Samples were stored at 4^{o}C until the analysis time, and each food sample was analysed in triplicates.

Potassium bromate analysis

The protocol described by Emeje *et al.*[16] was employed. To 1 g of flour-based product, 10 ml distilled water was added in a tube. The tube was shaken and left to stand at 30 ± 10^{o}C for 20 minutes. To 5 ml of the solution obtained, 5 ml 0.5% potassium iodide solution was added, and colour change was observed, and absorbance was taken at 620nm using a spectrophotometer. The concentration of potassium bromate in the samples was quantitatively determined by extrapolating the absorbance read from the calibration curve prepared using standard values of 1 to 5 mg/L.

Acrylamide analysis

A quantity of 1.0 mg/mL of acrylamide standard stock solution was prepared by dissolving 1.0 g of acrylamide in 1.0 L of distilled water followed by the preparation of serial dilutions- 50 - 2000 µg/L. These were kept in amber HPLC bottles at a temperature of 4°C till they were to be used. The samples were homogenised separately, and 1.0g each were placed in test tubes. To these tubes, 10ml distilled water was added. The tubes were placed on a shaker for 20 minutes at 25°C and 50 µL each of Carrez I and II (15 g Potassium hexacyanoferrate in 100 ml water and 30 g zinc sulfate in 100 ml respectively) were added to precipitate the proteins then centrifuged at 3500 rpm for 20 minutes. Quantitative transfer of 5ml of each of the supernatants was done into glass tubes and then micro-filtered into amber HPLC vials for HPLC analysis at 210 nm, 214 nm, and 230 nm. The solvents for HPLC were acetonitrile and distilled water. HPLC analysis was carried out on an Agilent 1029 series HPLC machine.

Statistical analysis

The average of triplicates was obtained using Microsoft Excel, and values are presented as mean ± SD.

Results and Discussion

Potassium bromate was not detected in the freshly baked loaves of bread and doughnuts, while the highest quantity was recorded in the unsliced loaf (Table 2). This could be a result of the batch effect.

Acrylamide was present in fried potatoes and French fries from two sites (Table 3). Chromatograms of acrylamide obtained from HPLC are as shown in Figure 1-5.

The results obtained from this study showed that potassium bromate was present in some flour-based foods sampled. 67% of the total samples analysed contained potassium bromate in varying degrees above the permissible limit of 0.02 mg/kg (µg/g) set by the FDA. This observation is similar to reports by Emeje *et al.*[17-19] were higher than approved amounts of potassium bromate were detected in loaves of bread sold in the Eastern areas of Nigeria and the federal capital territory (FCT), respectively.

Table 3: Estimation of Acrylamide in Potato Samples

S/No	Sample ID	Location	Potato sample	Presence	Quantity (µg/kg)
1	A	Site 1	Fried Potato	Positive	23.67
2	B	Site 2	French fries	Positive	1.92
3	C	Site 1	Potato chips	Negative	Nil
4	D	Site 3	Potato chips	Negative	Nil

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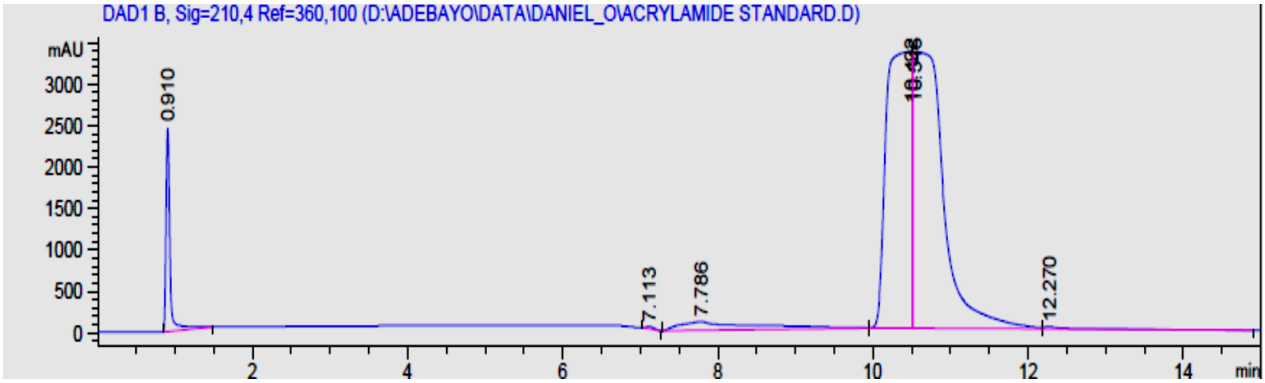

Figure 1: Chromatogram of acrylamide standard recorded at 210 nm and a flow rate of 0.25 mL/min. The chromatogram is offset for clarity.

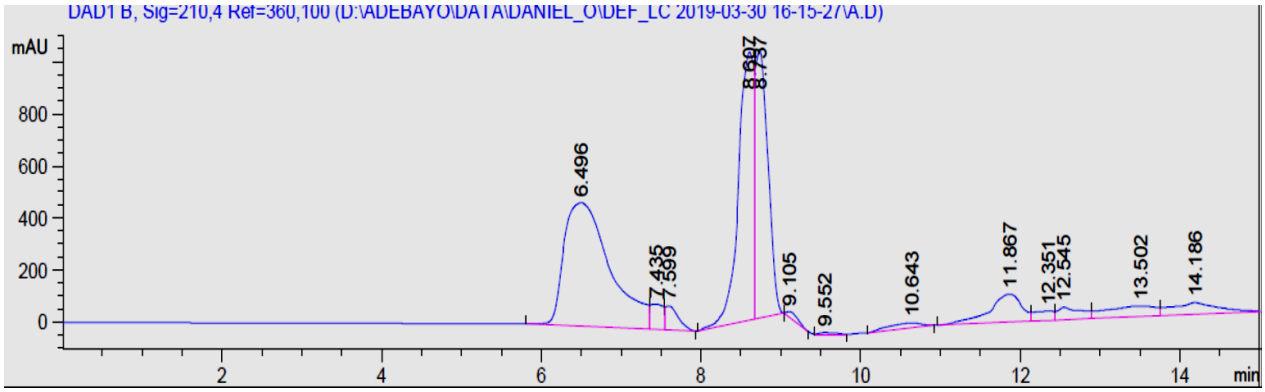

Figure 2: Chromatogram of Sample A recorded at 210nm and a flow rate of 0.25 mL/min. The chromatogram is offset for clarity.

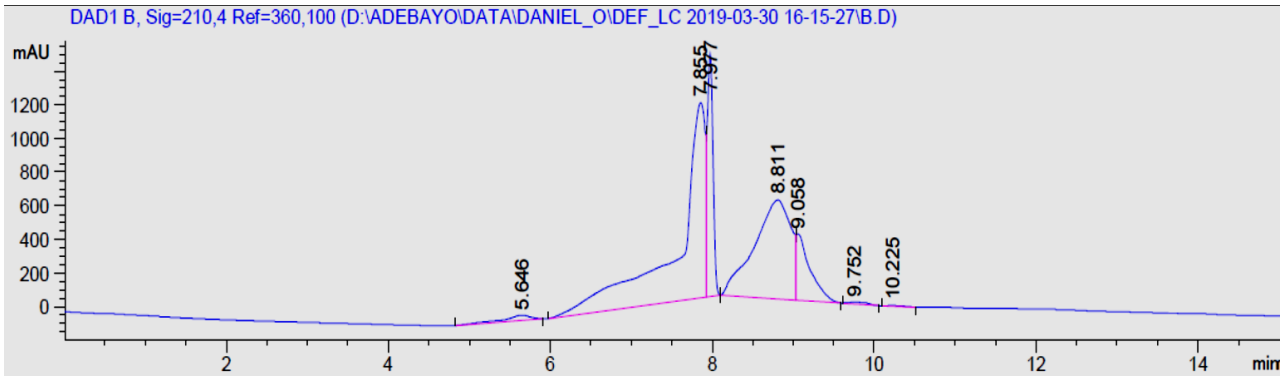

Figure 3: Chromatogram of Sample B recorded at 210 nm and a flow rate of 0.25 mL/min. The chromatogram is offset for clarity.

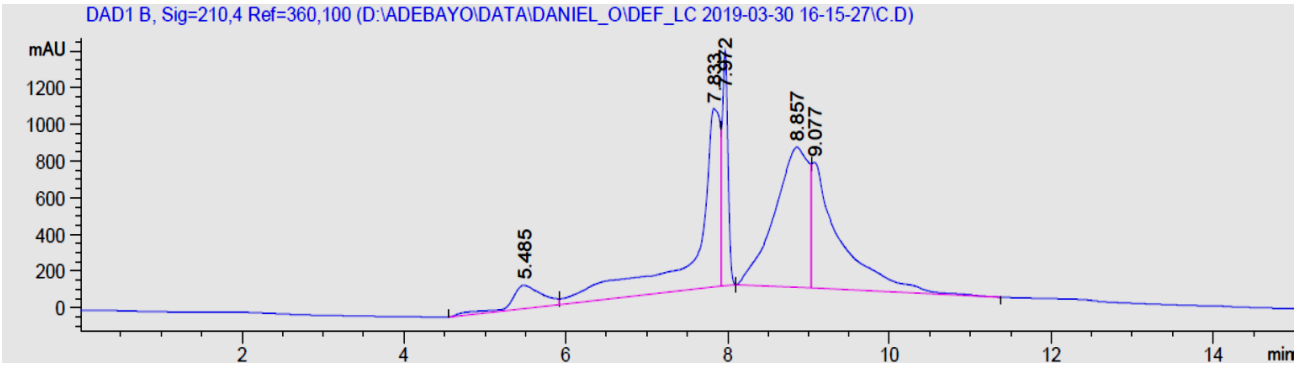

Figure 4: The chromatogram of Sample C was recorded at 210 nm and a flow rate of 0.25 mL/min. The chromatogram is offset for clarity. No peak for acrylamide was recorded.

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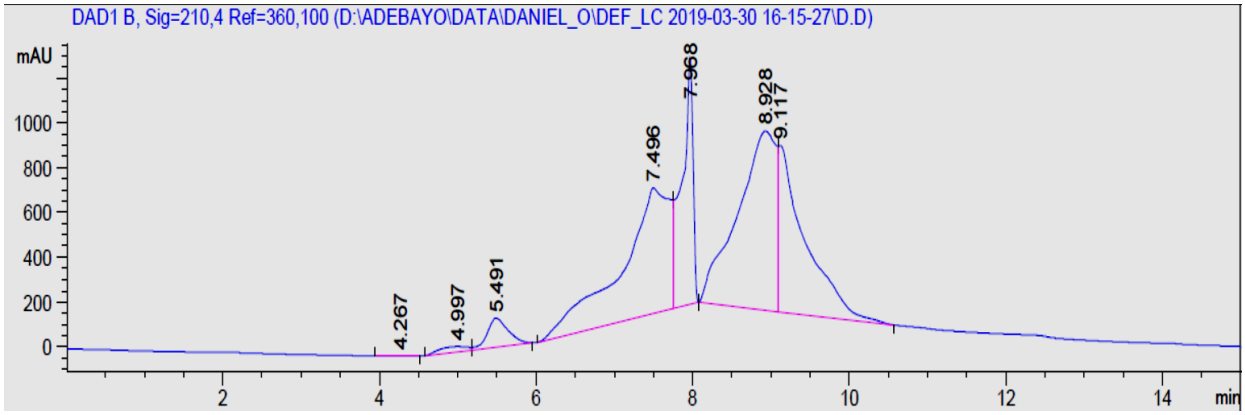

Figure 5: The chromatogram of Sample D was recorded at 210 nm and a flow rate of 0.25 mL/min. The chromatogram is offset for clarity. No peak for acrylamide was recorded.

Another study by Ergetie and Hymete[18] also reported high amounts of bromate in bread in different bakeries in Addis Ababa, Ethiopia. Potassium bromate has been described as a potential carcinogen. It is also nephrotoxic, causing non-cancer-related conditions such as kidney failure, hearing loss, bronchial and ocular problems, and even abdominal problems. Other toxicity reports indicated incidences of nausea, vomiting, diarrhoea, hematemesis, irritation of the mucous membranes of the upper respiratory tracts, central nervous systems (CNS) effects such as lethargy, sedation and even CNS depression.[18] Acrylamide was detected in two of the four fried potato samples analysed in this study. This result is similar to that reported by Wang *et al.*[20] although their value was higher than that obtained in this study. This could be due to the processing methods. Acrylamide is formed at high temperatures by a reaction between amino acids and sugars.[21] Acrylamide has been used to induce cancer in experimental animals when administered at high doses exceeding the amounts ordinarily present in foods. There was previously no consensus on its ability to induce cancer in humans.[22-24] An association was reported between acrylamide intake and cancers such as endometrial cancer, multiple myeloma and oesophageal tumours.[25,26] The quantity of acrylamide in Sample A was higher than the estimated tolerable daily intake of 2.6 µg/kg body weight per day.[27] Humans exposed to acrylamide had recorded cases of memory loss, disorientation, muscle weakness, ataxia, neuropathies, and asthma.[28] The presence, therefore, of this compound in food consumed by humans is of health concern.

Conclusion

Potassium bromate and acrylamide were present in some of the samples analysed. This means that the ban on potassium bromate in baking is not strictly adhered to by all bakeries in the country, resulting in the continued presence of this compound in some flour-based products. There is a need to improve monitoring strategies by the national regulatory agency, NAFDAC, to ensure compliance. Also, less heat should be employed in the processing of potatoes chips to prevent acrylamide formation since both compounds can be detrimental to health when consumed.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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