

## Research Article

## Acrylamide in West african Foods; an Awareness and Consumption survey

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Received : 23 Oct 2020

Accepted : 29 Oct 2020

Published : 02 Nov 2020

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## Abstract

Acrylamide is a probable carcinogen, thus a food safety hazard. Following its discovery in foods in 2002 by the Swedish National Food Administration (SNFA), research on dietary acrylamide has increased exponentially but with little focus on heat-processed carbohydrate-rich West African (WA) foods. Thus this research aimed to investigate the extent of awareness of the acrylamide and the degree of consumption of these foods by West Africans through, an online survey. There were 1103 responses, 89.5% and 10.5% from seven West African countries and the United Kingdom (UK), respectively. 98.0% of the respondents were unaware of the occurrence of acrylamide and 99.6% were unaware of its toxicity. 81.0% of all the participants consume baked and fried carbohydrate-rich WA foods weekly. Chi square test showed no significant difference between the awareness of acrylamide and its toxicity, with p-value (0.108)>0.05.

**Keywords:** Acrylamide, Heat-processed West African (WA) foods, Food safety, Process contaminants, Consumption trend, Online survey

## Introduction

The nutritional composition of a diet is an essential factor, which determines the health status of an individual. In addition to the nutrients, other chemical components of the food may also be important in the onset of neurodegenerative diseases and cancers [1, 2, 3, 4]. Such non-nutrient compounds include the so-called process contaminants; acrylamide in heat-processed foods, nitrosamines in cured fish and meats, furans in baked, fried and caramelized foods, and polycyclic aromatic hydrocarbons (PAH) in smoked and roasted meats [5, 6]. Recent studies have indicated that the correct application of food processing methods may also determine a healthy diet and aid in disease prevention [7, 8].

The presence of acrylamide in heat-processed carbohydrate rich foods has been a subject of interest since 2002, when it was incidentally found in potato fries by Swedish National Food Administration (SNFA) [9]. Studies conducted before and after 2002 confirmed the adverse health effects of the compound which include carcinogenicity, neurotoxicity, mutagenicity and genotoxicity [10-14]. Several surveys on the presence and level of the compound in different groups of heat-treated foods were conducted between the year 2002 and 2017. Indigenous carbohydrate-rich foods of regions of the world including Austria, Caribbean, China, Colombia, India, Iran, Italy, Saudi-Arabia, Turkey, United States, Poland and several other European countries have been tested through survey exercises [2, 15-21, 4, 22-26,]. These studies found varying amounts of acrylamide in the different foods examined.

In 2011, the European Commission (EC) adopted a recommendation which pertains to the official survey of foodstuffs with the potential to contribute appreciably to the dietary acrylamide intake [27]. The United

States Food and Drug Administration (USFDA) also published a guidance document in 2016, which contains non-binding recommendations for food industries [28]. In addition, the European Commission (EC) and the USFDA manage a large database on the occurrence of acrylamide in foods [29-31].

The dissimilar food consumption patterns prevalent in different countries and continents are important determinants of the contribution of a particular food product to the total amount of acrylamide consumed [32]. For instance, the exposure assessment for the US indicates 35% contribution from fried potato products and only 7% contribution from coffee [32]. On the other hand, the acrylamide exposure assessments for the Swedish and Dutch population show that coffee consumption contributes 39% and 13% respectively [33, 34].

Although, the level of acrylamide in traditional foods of several countries have been determined, there is still paucity of information on the acrylamide content of popular West Africans (WA) heat-processed foods. In addition, there is a gap to be filled with regards to the knowledge of the level of awareness of West Africans on the presence and the health implications of process contaminants including acrylamide.

For West Africans, an awareness of the existence of these process contaminants and the mitigating strategies required to reduce them would lead to improvements in the making of the United Kingdom (UK) and Europe, the Food Standards Agency (FSA) and Food Drink Europe (FDE) are two important organizations that have undertaken the role of creating awareness and advising individuals and food business operators on best ways to reduce the amount of acrylamide in heat-processed foods. Such

advice include avoidance of excessive browning during home or industrial cooking of foods and selection of ingredients and materials with low asparagine content for cooking [35,36]. However, in the case of West African countries, no organization is yet responsible for creating awareness on the occurrence and ill effects of process contaminants such as acrylamide.

Several studies on baked products such as gingerbreads, crackers and biscuits indicated that the ingredients; flours, baking agents, honey, inverted sugar and sucrose could affect the acrylamide concentration. These ingredients are often used in the production of the West African foods mentioned above. This study focuses on the assessment of the current awareness level of different groups of West Africans on the presence and health implications of food processing contaminants including acrylamide and the consumption pattern of heat-processed foods of West African origin.

The West African foods selected are bread, chin-chin, kokoro, puff-puff (doughnut), pancake, and fish roll and meat pie. These food are heat processed, carbohydrate-rich and may contain asparagine, thus there is the propensity for development of acrylamide. Asparagine and reducing sugars such as fructose and glucose are important precursors for acrylamide formation [37-40].

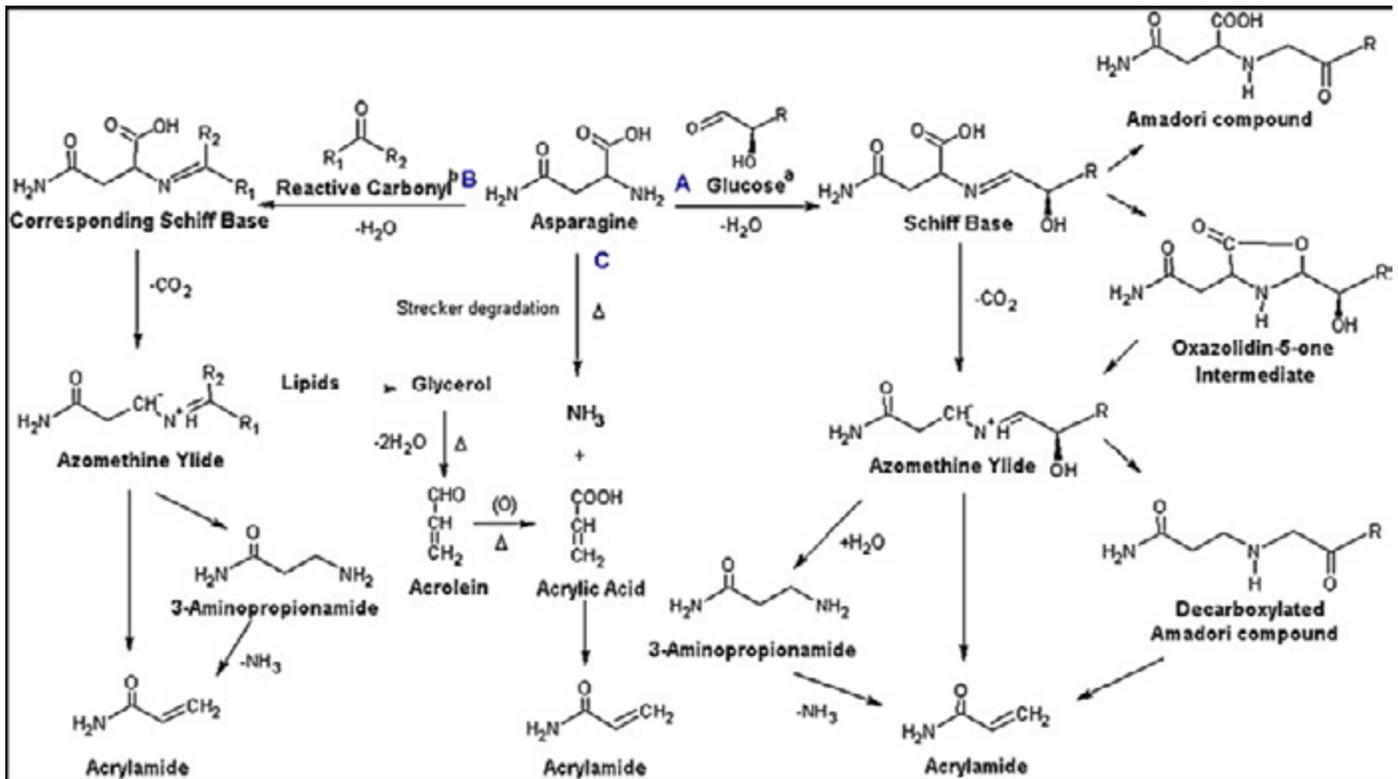


Figure 1: Pathways for the development of acrylamide in foods (Cheng et al., 2013)

## Methodology

### Background

The investigation was conducted using Bristol Online Survey website. The focus was on the awareness of the presence and health implications of dietary acrylamide. The survey covered aspects such as the participant's country of residence, knowledge of the occurrence and health implications of dietary acrylamide [41].

The West African countries covered are shown in figure 2. The United Kingdom (UK) was also included in the survey as there are many British nationals of West Africans origin



Figure 2: Map of West Africa (Encyclopædia Britannica, Inc.)

## Design of the Survey

The survey was designed with an easy-to-complete multiple-choice questions (MCQs) and polar (yes-no) questions. The number of answer alternatives for each multiple-choice question (MCQ) also varied depending on the purpose of the question. For instance, the MCQ for the country of residence allowed up to 21 answer options. Polar questions were used for aspects such as the respondent's knowledge of the existence and health effects of process contaminants. In addition, the MCQ on the pattern of consumption of baked WA foods contained scaled answer options such as 'weekly' and 'once in a while'. A web link for the survey was created and sent to participants via email, Facebook and WhatsApp. The account was protected by password to ensure the confidentiality and protection of the collected responses. Further protection of the data subjects (respondents) was provided by complying with the institution's ethics and data protection policies. The results were analysed and validated using appropriate statistical methods.

## Results

### Country of Residence

West African respondents from eight major national groups completed the survey (figure 3). Out of the 1103 total survey responses, 116 (10.5%) responses came from participants residing in UK. The 346 responses from participants dwelling in Nigeria represent the highest percentage of the total responses (31.4%), while the 235 responses from Ghanaian respondents represent the second highest percentage of the total responses (21.3%). The responses collected from respondents dwelling in Ivory Coast represent the third highest percentage of the total responses (15.7% of total responses). Benin, Gambia, Liberia and Sierra Leone contributed 7.9, 0.6, 11.1, and 1.5% respectively to the total responses collected

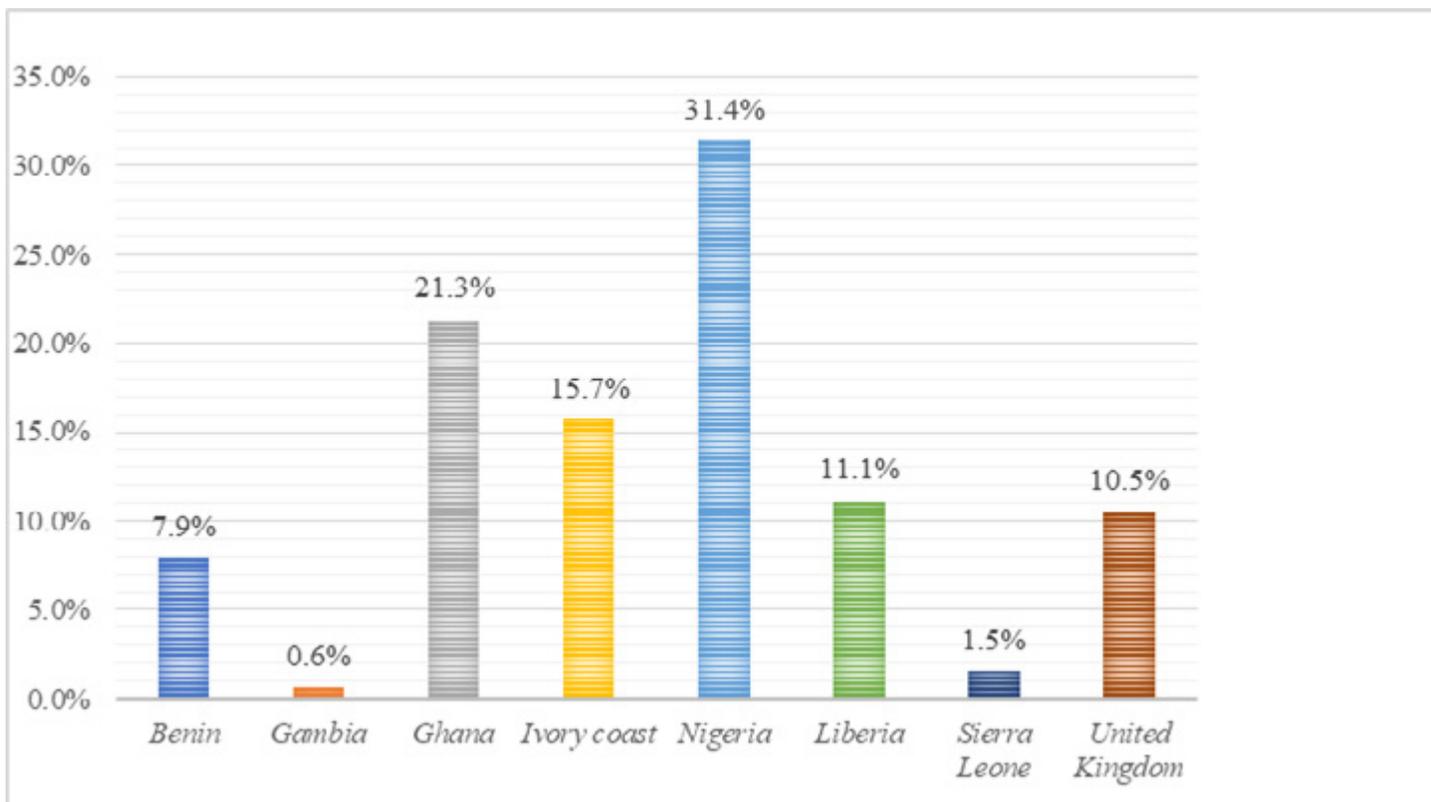


Figure 3: Country of residence, and response percentage

### The participants knowledge of the chemical hazards associated with heat-processed foods

As depicted in figure 4, only 5.1% of the 1103 participants were aware of the association between heat-processing of foods and development of toxic chemicals.

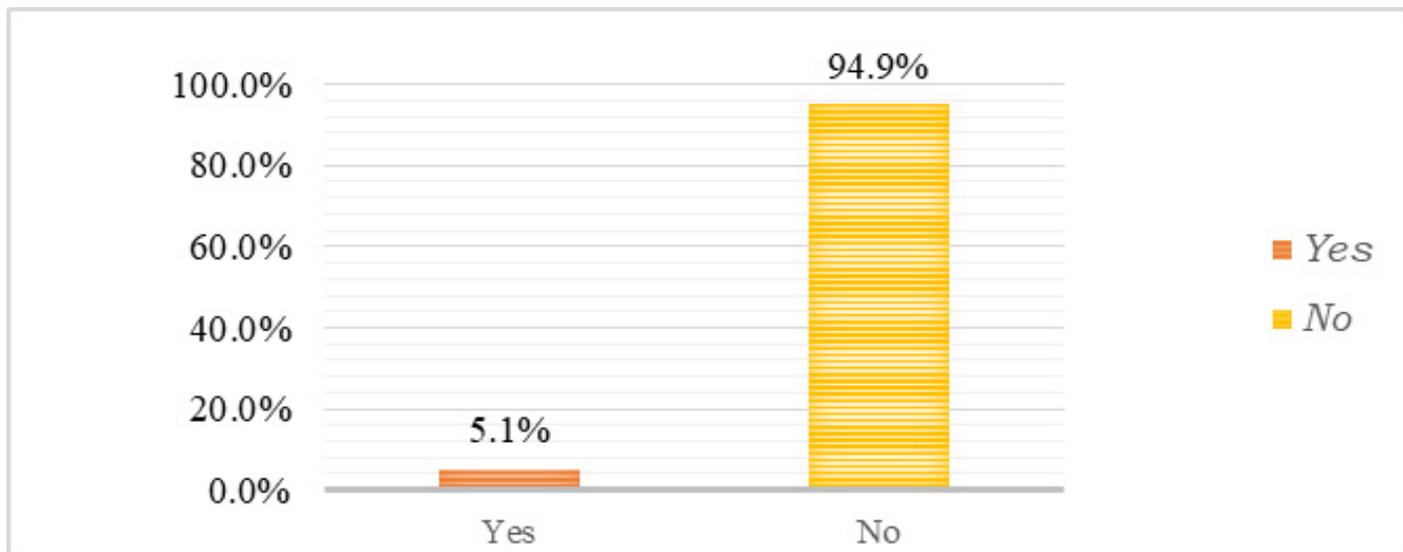
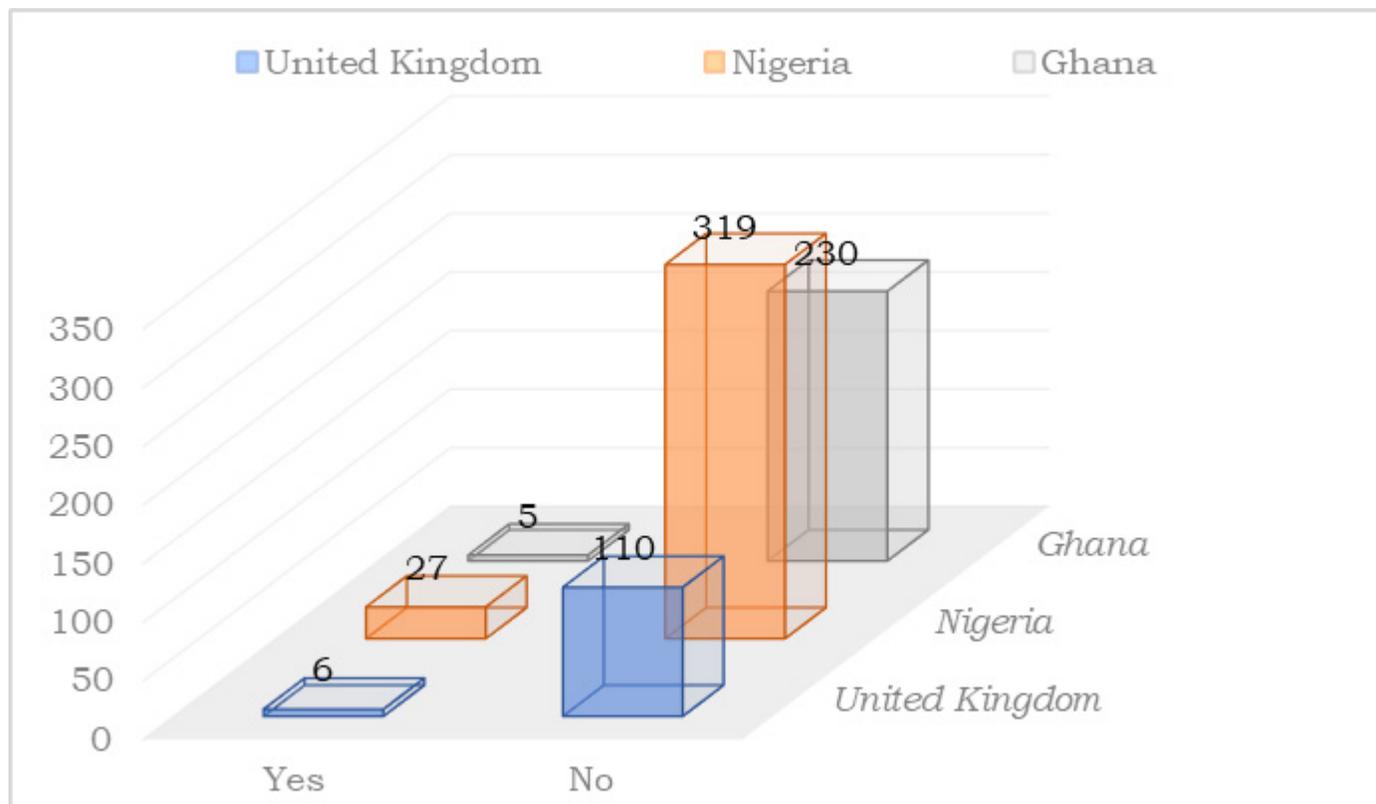


Figure 4: Knowledge of chemical hazards associated with heat-processed foods

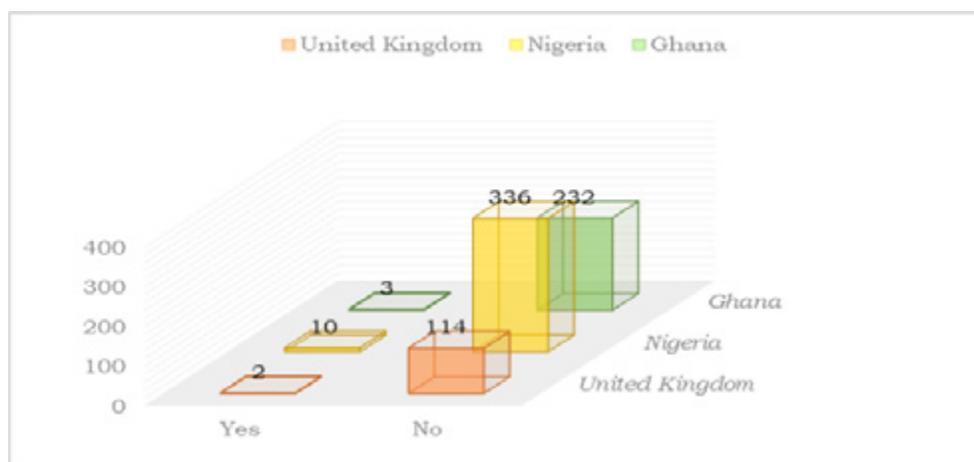


**Figure 5:** Comparison of the knowledge of respondents from Ghana, Nigeria and the UK on the chemical hazards associated with heat-processed foods

Responses received from Ghana, Nigeria and the UK participants for the question on the knowledge of the link between chemical hazards and heat processing of food showed 2.1, 7.8, and 5.2 % respectively were informed. Altogether, 2% of all the participants had knowledge of the presence and adverse effects of these process contaminants (table 1).

**Table 1: Knowledge of Furans, Nitrosamines, and PAHs**

Knowledge of Process Contaminants e.g. Nitrosamines, Furans, PAHs	Response Percent	Response Count
Yes	2.0%	22
No	98.0%	1081
Sample size (N)		1103

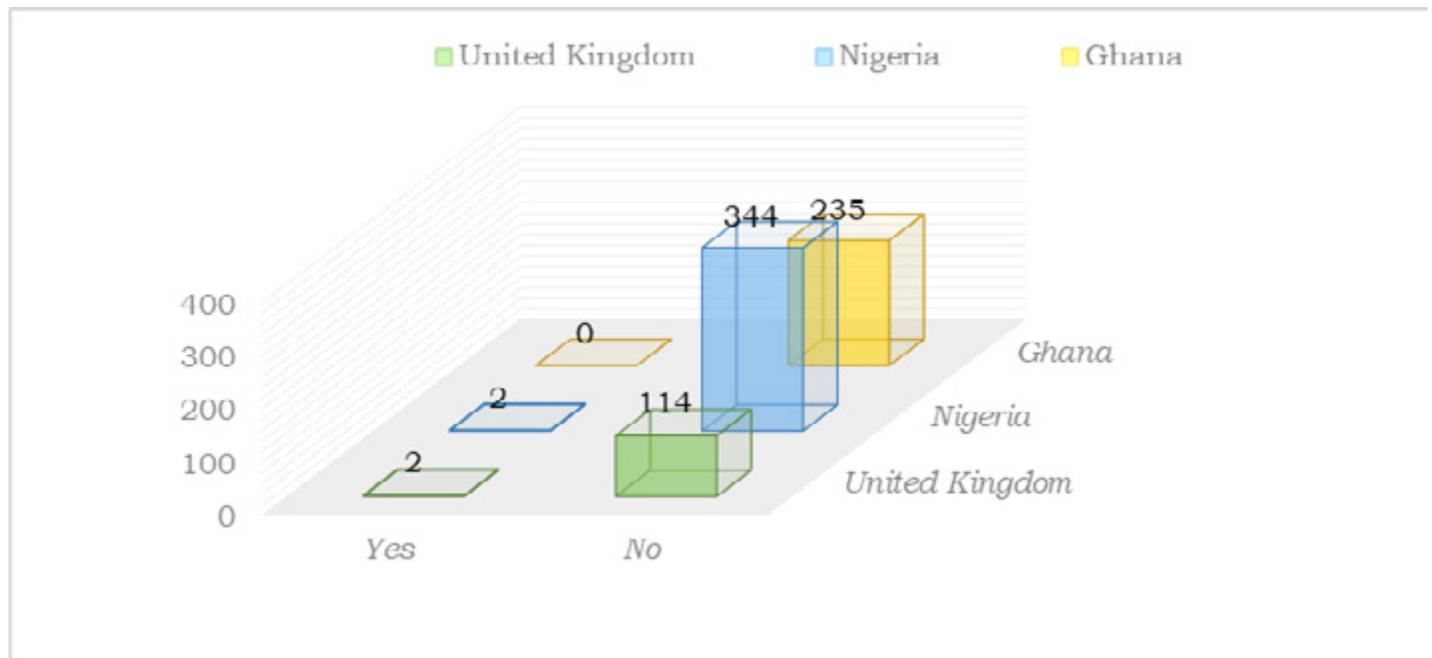


**Figure 6:** Comparison of the knowledge of Ghana, Nigeria and the UK respondents on the presence and health implications of food-borne furans, N-nitrosamines, and PAHs.

The percentage of participants informed on the presence and deleterious effects of N-nitrosamines, furans and PAH for Ghana, Nigeria and the UK were 1.3, 2.9 and 1.7% respectively. Only 0.4% of the 1103 respondents (table 2) were informed on the deleterious effect of acrylamide and the association of the process contaminant with heat-treated foods.

**Table 2: Awareness of the formation and health implications of AA in heat-processed foods**

Awareness of the formation and health implications of AA in heat-processed foods	Response Percent	Response Count
Yes	0.4%	4
No	99.6%	1099
Sample size (N)		1103



**Figure 7:** Comparison of the knowledge of Ghana, Nigeria and the UK respondents on the presence and health implications of food-borne acrylamide

For Ghana, Nigeria and the UK the percentages of participants informed on the presence and adverse health effects of acrylamide were 0.0, 0.6 and 1.7% respectively. Statistical analysis of all responses using Chi square test showed no significant difference in the proportion of the WA groups that are aware of the existence and effect of the process contaminant, with p-value (0.108) >0.05.

### Consumption of Baked WA Foods

The highest number of responses for frequently consumed baked WA foods was obtained for sweet bread, indicating that it may be the most frequently consumed WA baked food. Approximately forty eight percent (48.2%) of the total responses suggested that WA breads are the most frequently consumed baked WA foods (figure 8). Other frequently consumed WA baked foods shown by the survey include meat-pie, doughnuts and chin-chin with 17.4, 13.6, and 9.8% responses respectively (figure 8). The responses from the participants indicated that baked kokoro and pancake are the least frequently consumed WA baked food. The responses received from GHN, NGR and UK residents are compared in figure 9.

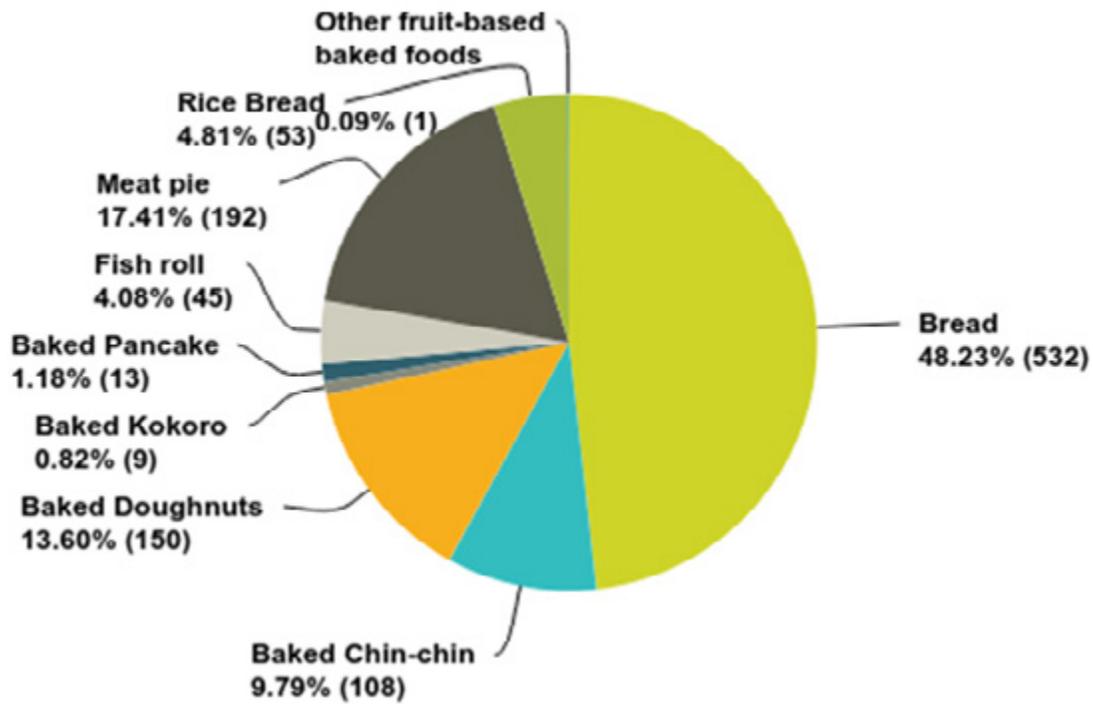


Figure 8: Frequently consumed WA baked foods Change "bread" to "sweet bread" on pie

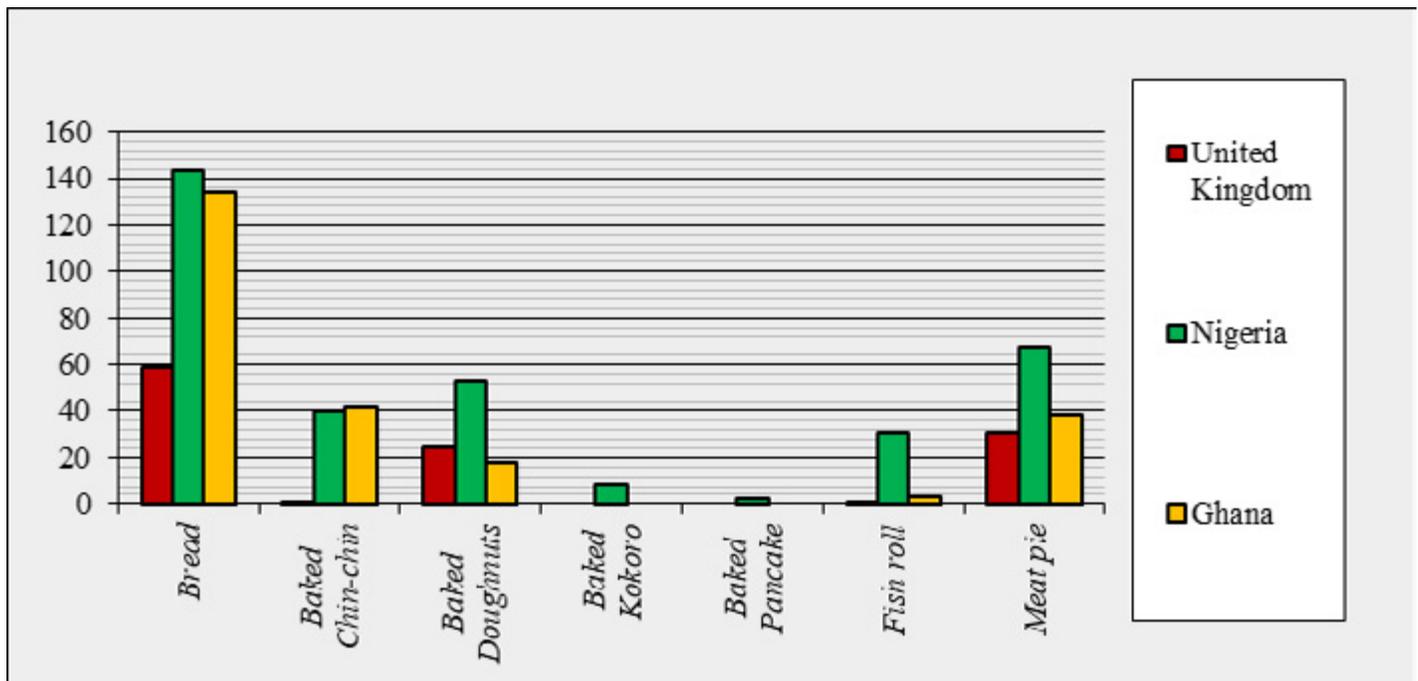


Figure 9: Comparison of frequently consumed WA baked foods for Ghana, Nigeria and the UK residents.

The study indicated that 369 participants representing 33.5% of all the respondents consume WA baked foods as often as once a week. The survey also indicated that the percentages of participants that consume these baked foods twice and thrice a week are 30.9 and 16.6 % respectively (figure 10).

thrice a week and occasionally (monthly) are 7.2 and 11.9% respectively. The responses received from Ghana, Nigeria and the UK residents are compared in figure 11.

In addition, respondents that consume this category of foods more than

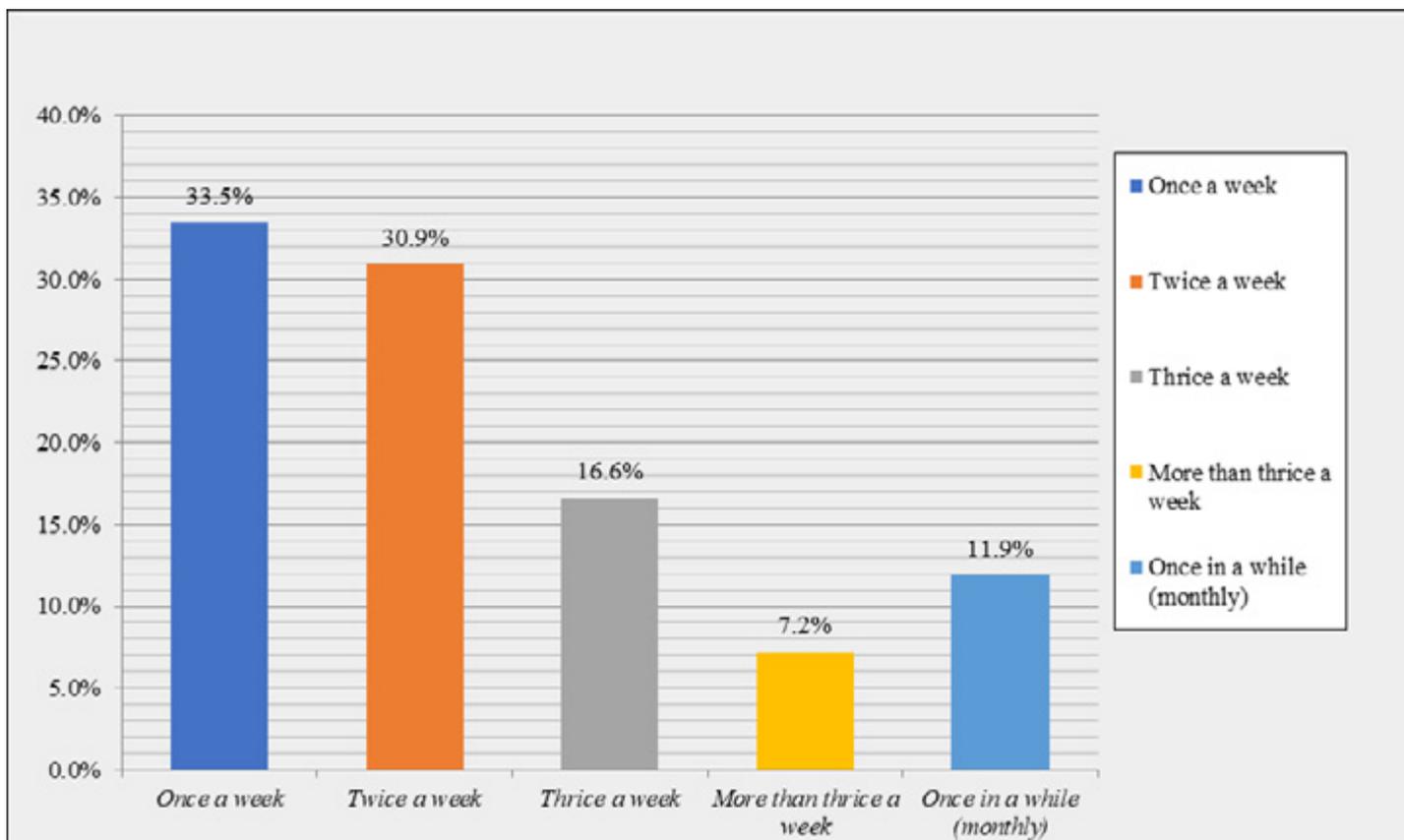


Figure 10: Consumption frequency of WA baked foods

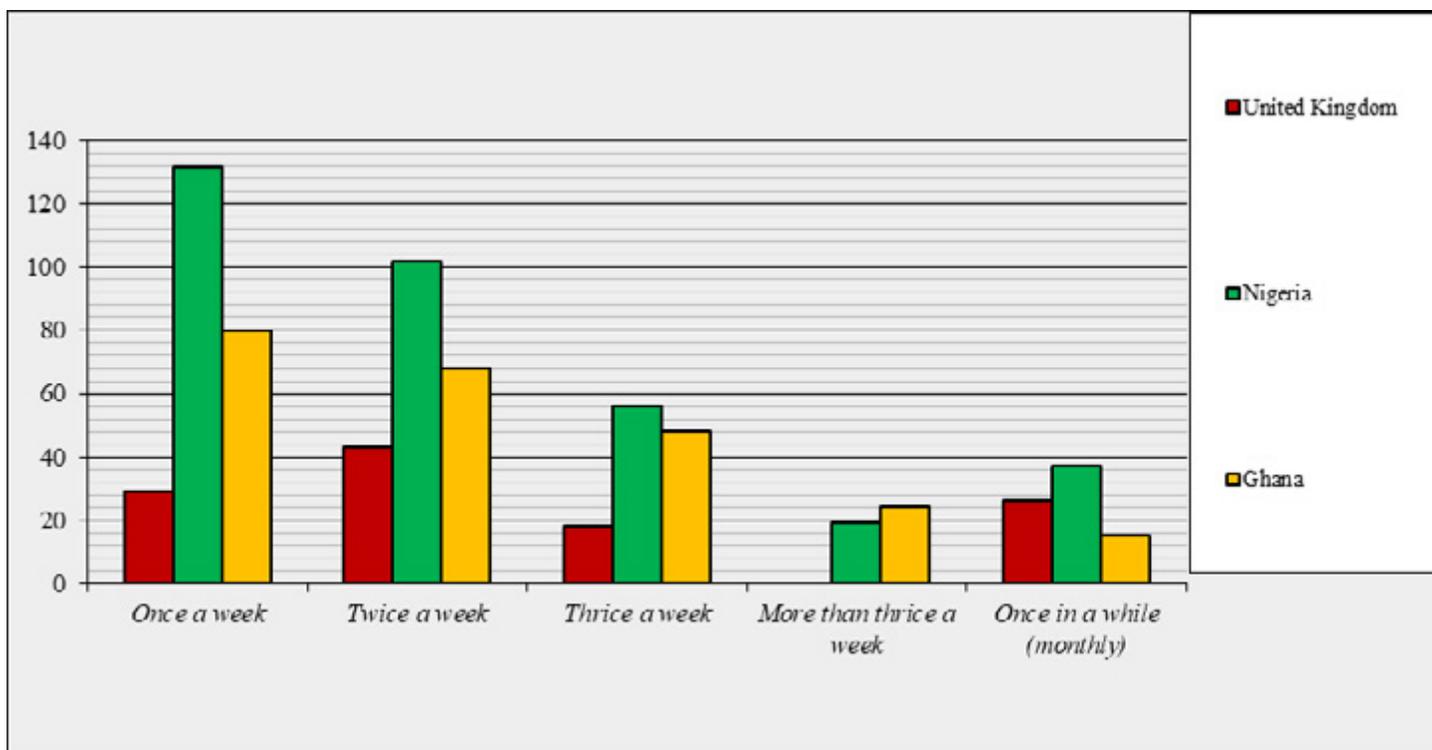


Figure 11: Comparison of the consumption pattern of WA baked foods for Ghana, Nigeria and the UK

## Consumption of Fried WA foods

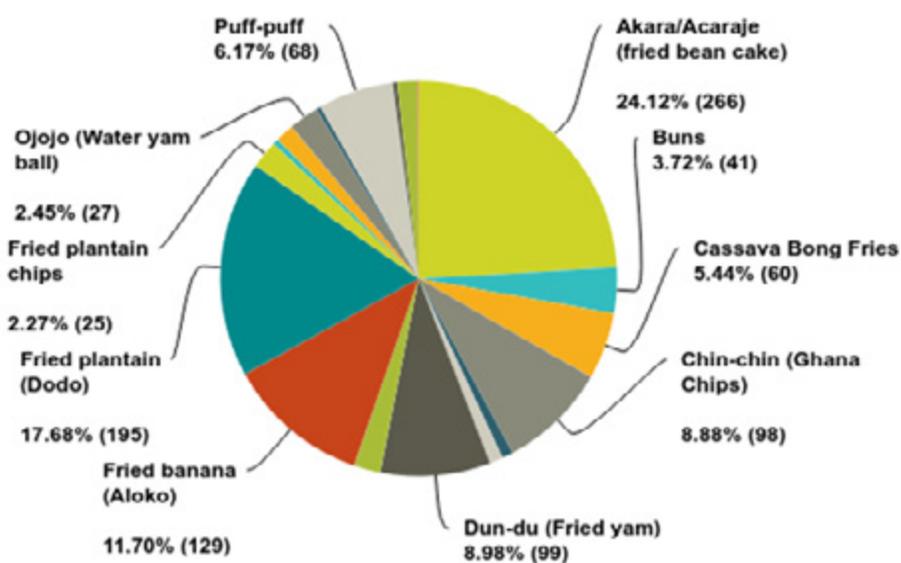
The primary ingredients in the popular West African heat-processed foods and the consumption frequency are summarised in table 3. It is apparent that the foods are carbohydrate rich and contain significant amount of protein hence the propensity for acrylamide development during cooking.

**Table 3: Summary of the popular West African carbohydrate rich heat-processed foods.**

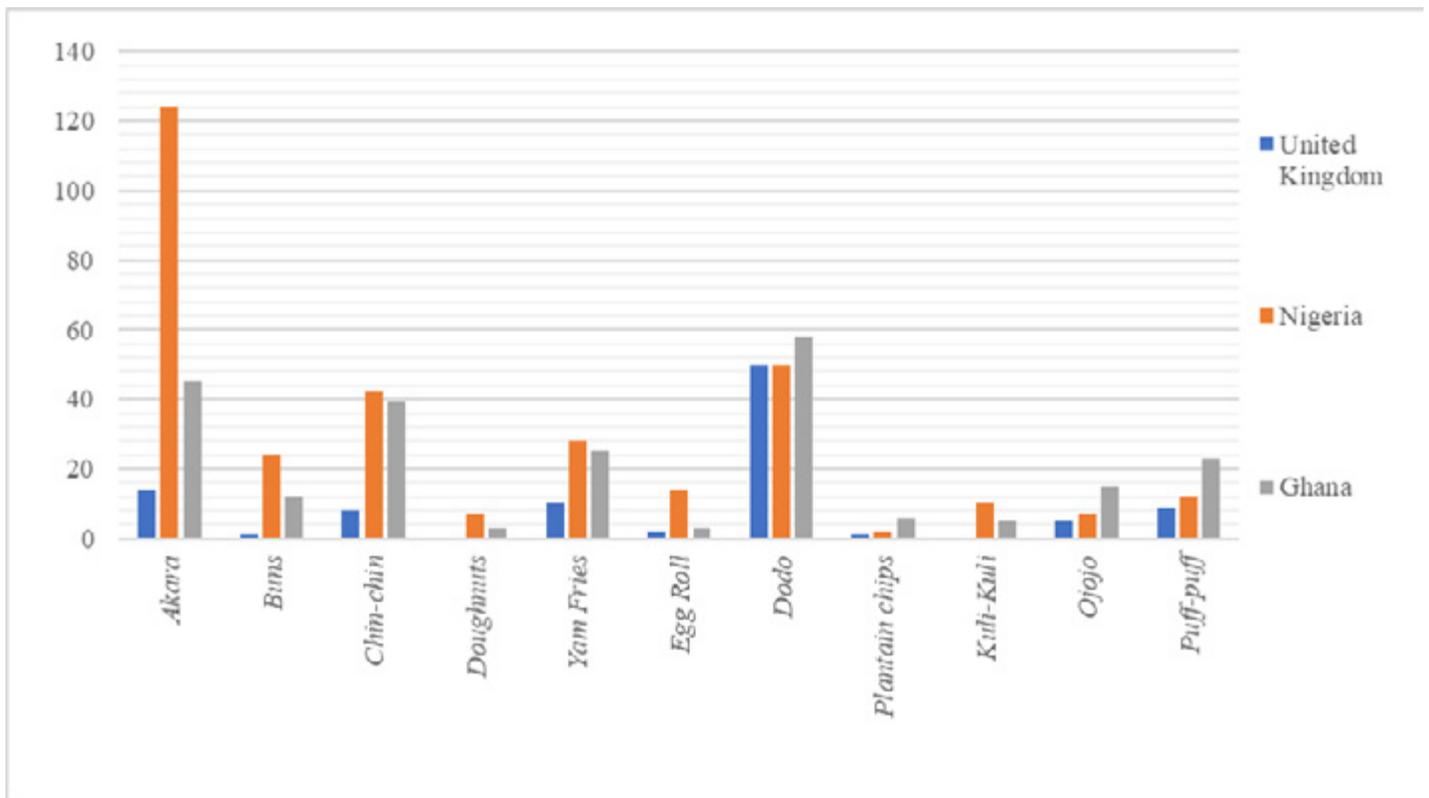
Food	Primary Ingredients							Cooking methods		Consumption frequency (%)
		Flour	Sugar	Egg	Milk	Butter	Oil	Frying	Baking	
Akara	Beans	-	-	-	-	-	√	√	-	24.12
Buns	-	√	√	√	√	√	√	√	-	3.72
Chin-Chin	-	√	√	√	√	√	√	√	√	8.88
Dodo	Plantain	-	-	-	-	-	√	√	-	17.68
Doughnut	-	√	√	√	-	-	√	√	-	-
Egg Roll	Egg	√	√	√	-	-	√	√	√	-
Kuli-Kuli	Peanuts	-	√	-	-	-	√	√	√	-
Ojojo	Water Yam	√	-	-	-	-	√	√	-	2.46
Plantain Chips	Plantain	√	-	-	-	-	√	√	-	2.27
Puff-Puff	-	√	√	√	-	-	√	√	-	6.17
Yam Fries	-	√	-	-	-	-	√	√	-	8.98

The highest number of responses for frequently consumed fried WA foods was obtained for akara, indicating that it may be the most frequently consumed WA fried food (figure 12). Other highly consumed WA fried foods include chin-chin, plantain and yam fries. The collected responses indicated that foods such as kuli-kuli and ojojo are WA fried foods, which are not consumed so frequently.

The responses received from participants from Ghana, Nigeria and the UK are compared in figure 13.

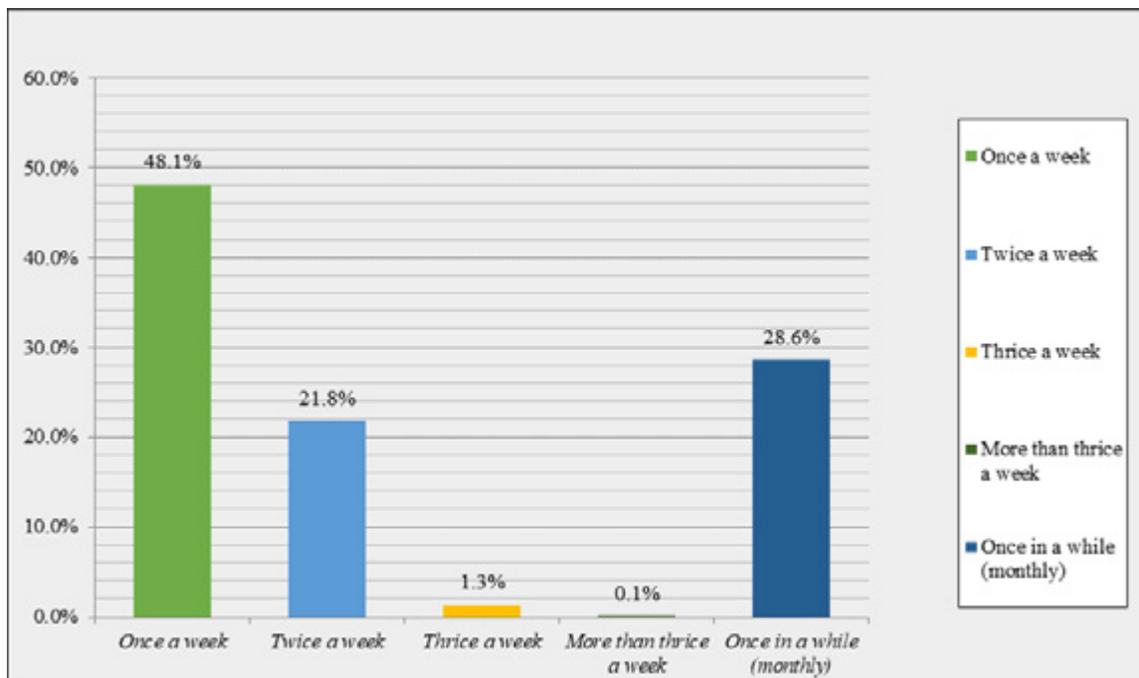


**Figure 12: Frequently consumed WA fried foods**

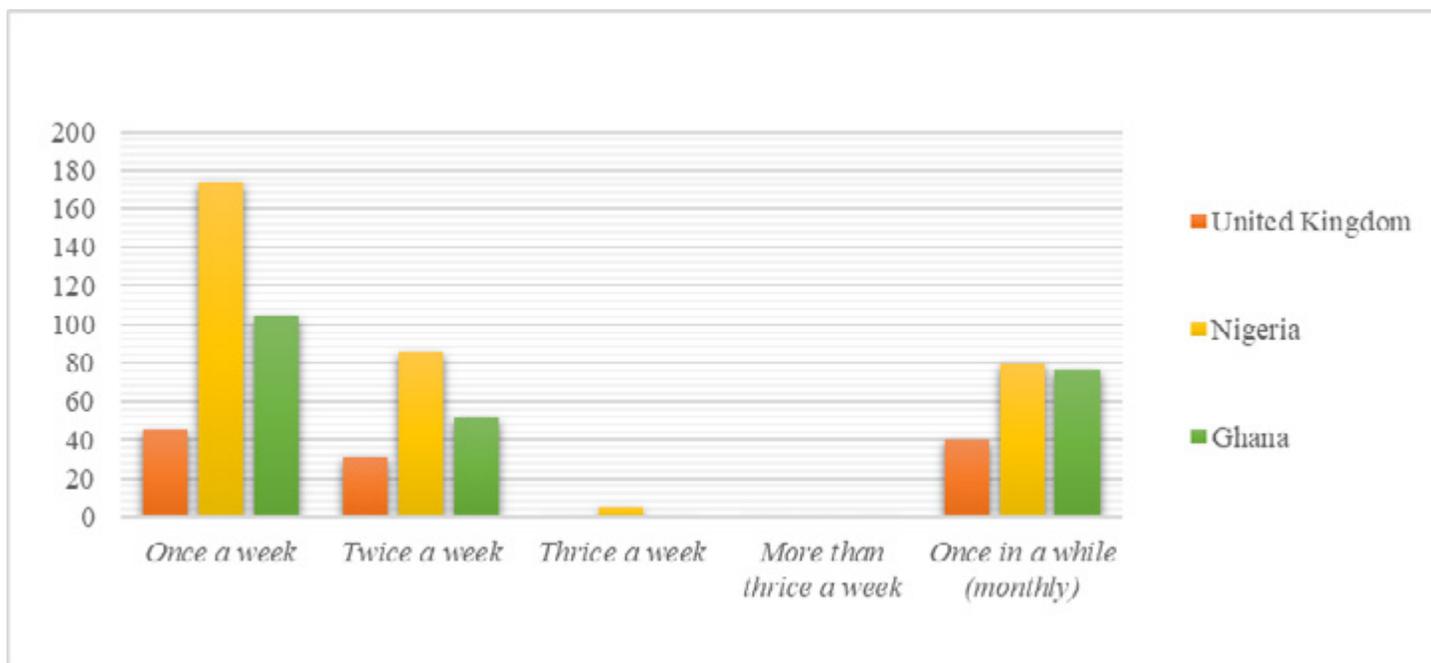


**Figure 13:** Comparison of frequently consumed WA fried foods for Ghana, Nigeria and the UK residents

According to the results from the survey exercise, 531 respondents representing 48.1% of all the participants consume WA fried foods as often as once a week (figure 14). The collected responses also indicated that the percentages of participants that consume these fried foods weekly and once in a while (monthly) are 21.8 and 28.6 % respectively. The responses received from Ghanaian, Nigerian and UK residents are compared in figure 15.



**Figure 14:** Consumption frequency of WA fried foods



**Figure 15:** Comparison of the consumption pattern of WA fried foods for Ghana, Nigeria and the UK residents

## Discussion

Various explanations can be given for the unequal proportions of the responses obtained from the West African groups. The results from the survey could be partly attributed to demographical factors, which affect changes in immigration and emigration for these groups of individuals, irregular electric power supply and internet unavailability. According to the report by the Office for National Statistics on the population, Ghana and Nigeria has the highest proportion of African-born UK residents, both representing 89% of the total [42]. In addition, there are reports that Nigeria and Ghana contribute majorly to the population of foreign-born UK residents [43].

The feedback received from the participants indicated that majority of the West African participants were not cognisant of the link between heat-treatment of foods and production of hazardous chemicals. This is seen in figure 4 with only 5.1% of the 1103 participants cognisant of the association between heat-processing of foods and release of toxic chemicals. For the evaluation of the knowledge on the link between chemical hazards and heat processing of foods, the percentage of informed participants for Benin (BN), Ghana, Ivory Coast (IC), Nigeria and UK were 2.4, 2.1, 6.1, 7.8, and 5.2 respectively.

According to the awareness survey, most West Africans have not heard of the existence and possible adverse health consequences of process contaminants including furans, N-nitrosamines and PAHs. Only 2% of the participants were informed on the presence and ill effects of these process contaminants (table 1). The percentage of participants informed on the presence and deleterious effects of N-nitrosamines, furans and PAH for Ghana, Nigeria and the UK were 1.3, 2.9 and 1.8% respectively.

Furthermore, very few percentage of the West African respondents were informed on the deleterious effect of acrylamide and the association of the toxic compound with heat-treated foods. Only 0.4% of the 1103 respondents had knowledge of the occurrence and ill effects of the process contaminant (table 2). Only 0.6 and 1.7% of participants from Nigeria and the UK affirmatively responded to having knowledge of the existence and ill effects of acrylamide. This findings may be an indication that most West

Africans are only concerned about the sensory and nutritional aspects of food consumption and not conscious of the risk of frequent consumption of certain foods.

The low level of awareness of the WA respondents with respect to dietary acrylamide and other process contaminants may be due to the lack of an effective public health education, communication and campaign on process contaminants by food control agencies. It could also be a reflection of the insignificant value placed on matters related to food safety and consumption. Although the general level of awareness on the existence and adverse health effects of dietary acrylamide is low, the study indicated that West Africans residing in UK were slightly more informed.

The assessment of the knowledge of the WA participants on the existence and toxic effects of dietary acrylamide suggests that West African sources of information dissemination such as television stations and newspapers pay little attention to matters of food safety and control. This is unlike UK, where awareness on the occurrence and effects of dietary acrylamide was created by sources such as BBC and the Telegraph newspaper (The Telegraph, 2017). In addition, Food Drink Europe (FDE) created toolboxes for food businesses to be able to mitigate the amount of acrylamide in their food products.

The feedback (figure 8) from the consumption studies, indicated that the WA breads are the most consumed, thus in agreement with other similar studies, bread being the main staple food. West African breads are quintessential ready-to-eat baked foods, which are often eaten with sauce containing vegetables, meat or fish. They are also combined with foods such as roasted groundnuts, akara (fried bean cake), and fried eggs. Doughnuts came a close second. Kokoro was only popular in West Africa, and the consumption rate in the diaspora was low.

According to the survey, the highest responses for frequently consumed baked WA foods including bread, doughnuts and meat-pie came from Nigerian residents (figure 11) and then followed by the Ghanaians. These observations could be explained partly by the relatively higher number of WA participants from these two national groups. The result may also

suggest the higher preference and affordability of the food items in these parts of the world. Figure 10 shows that most of the participants consumed baked WA at least once a week. The total percentage of responses for weekly consumption of baked WA food (i.e. 81.0%) is an indication that baked WA foods might be the most important dietary source of acrylamide for West Africans. Comparatively, the participants in the UK, consumed baked WA foods 'twice in a week' than 'once in a week' (figure 11). This may be partly attributed to the busy lifestyle of people in this part of the world, which requires frequent consumption of ready-to-eat baked snacks. This is in agreement with previous studies on the consumption of these pastries in some African and western countries [44, 45]. Several factors have been described as the underlying reasons for food consumption patterns and choice behavior among different groups of individuals [46, 47]. One important factor which has been attributed to the preference of these ready-to-eat foods is the time constraints and pressures associated with working life.

Based on the findings of this study, there is a steady consumption of heat-processed WA foods among Africans living in the UK and other WA countries. Hence, these individuals need to be informed on the existence, ill effects of dietary acrylamide, and the strategies that may help to reduce its levels in WA foods [48-51].

## Conclusions

Statistical analysis of all responses using Chi square test showed no significant difference in the proportion of the WA groups that are aware of the existence and effect of the process contaminant, with p-value (0.108) >0.05. Generally, the level of awareness of the West African participants regarding the presence and health implications of process contaminants such as furans, n-nitrosamines, PAHs and acrylamide is very low.

Based on the results, there is a need for the creation of awareness for the presence and possible ill effects of dietary acrylamide and other process contaminants. It can also be concluded that there is a steady consumption of heat-treated carbohydrate-rich West African foods. Hence, baked WA foods such as breads, doughnuts and meat pies may be important dietary source of acrylamide for West African consumers.

Finally, the results justify the necessity for investigations on the determination of acrylamide, the propensity of acrylamide development and the factors that influence the synthesis of acrylamide in relevant West African food and food products. It is anticipated that the results may provide a strong rationale for the analysis of acrylamide in West African carbohydrate rich heat-processed foods and the reduction of acrylamide in such foods.

## Conflicts of Interest

There is none as the research is not funded by any external body.

## Acknowledgements

The research was carried out at London South Bank University as part of a PhD project. The authors would like to acknowledge the technical support of Mr Ken Unadkat and Mr William Cheung.

## Highlights

- The level of awareness of acrylamide in thermally processed West African foods is extremely low, about 2%
- The consumption of thermally processed West African foods is quite high, about 81%.
- The consumption trend in the West African countries were similar to the trend in the diaspora (UK).
- Only about 0.4% of the respondents were aware of the toxicity of

acrylamide.

- There is no significant difference between the awareness of the occurrence of acrylamide in West African foods and its toxicity.

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