

# Proximate Composition, Minerals and Heavy Metals Content of Cassava, Plantain and Yam Flour Sold in Some Markets in Port Harcourt, Nigeria

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## ABSTRACT

Edible flour in Nigerian markets are either exposed or packaged. This could influence nutrients and minerals as well as heavy metals in the products which become toxic to humans if safe limits are exceeded. In this study, five (5) samples each of packaged cassava, yam and plantain flour sourced from three supermarkets; similar exposed flour samples purchased from three open markets were evaluated for proximate composition, minerals and heavy metals using standard methods. The control samples were prepared in the laboratory. Our results showed that there was significant differences ( $p=0.05$ ) between the flours. Carbohydrate, moisture, ash, crude lipid, protein and fibre content of exposed flour samples were within the range 84.2-87.4 %, 5.36-10.3 %, 1.3-2.7%, 0.18-0.46 %, 0.47-2.3 % and 1.87-5.46 %; that of packaged flour 84.9-92.52 %, 2.5-8.1 %, 1.9-2.8 %, 0.3-0.93%, 0.42-0.51 %, 1.84-4.94 % whereas the control samples was 77.92-86.4 %, 9.1-13.22 %, 0.33-7.07 %, 0.12-1.85 %, 0.15-3.22 % and 1.52-3.12 %, respectively. Minerals such as K, Ca, Na and Fe in exposed flour samples were within the range 5.22-10.14, 0.76-1.38, 1.53-2.04 and 5.34-9.86 mg/kg whereas that of packaged flour samples were 8.51-15.98, 1.08-1.81, 1.37-2.16 and 9.57-11.47 mg/kg, respectively. Ca and Na were not detected in the control samples. Heavy metals content of all samples were below Codex Alimentarius Commission permissible limits of 1.5, 1.0 and 1.0 mg/Kg for Pb, Cd and As, respectively. Therefore, fortification of these flours to improve on their nutritional qualities is necessary. Also, exposed flour should be bagged and sealed to minimize moisture absorption and environmental contamination.

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**Keywords:** Minerals, heavy metals, proximate composition, flour, markets.

## 1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* spp.) and plantain (*Musa parasidiacal*) are staple foods for millions of people living in Africa [1, 2, 3]. They are ranked among the top three reliable foods consumed in Nigeria. These crops are rich in carbohydrate and also contain essential minerals [4, 5, 6]. Apart from being a staple food for millions of people, diabetic patients in Nigeria rely on unripe plantain meal to reduce post pyramidal glucose level [7].

In order to drastically reduce post harvest losses, increase product shelf life and meet high demand of these staples which have high moisture content, they are usually processed into edible flour [8, 9, 10]. Processing methods and varieties of cassava, plantain and yam could influence proximate composition of flour derived from these crops [11, 12, 13]. In recent times, patronage of edible flours in Nigerian markets is on the increase [14]. Therefore, ascertaining nutritional composition of commercially available edible flours is important.

Essential macroelements and microelements perform important role in biological systems [15, 16]. Due to some health benefits of essential metals (EMs) and adverse health effects of toxic metals (TMs) in food, periodic monitoring of its level in food is important [17]. Heavy metals usually contaminate human body through ingestion of food or exposure to environments that is heavily contaminated. Relevant regulatory bodies have set safe limits of each heavy metal in foods [18]. However, consumption of foods that exceeded the safe limits could cause hematological, cardiovascular, neurological, developmental, respiratory, and gastrointestinal disorders as well as many disease conditions [15, 19, 20, 21].

Edible flours such as cassava, plantain and yam flour in Nigerian markets are either exposed or packaged. Contamination of these products usually occurs during processing and retailing [6]. This could affect its nutritional composition, minerals and heavy metals content [22, 23]. Since there are limited studies in that regard, this study is aimed at determining the nutritional composition and quantity of heavy metals present in packaged and exposed

45 cassava, plantain and yam flour retailed in some supermarkets and open markets in Port Harcourt, Rivers State,  
46 Nigeria.

## 47 2. MATERIALS AND METHODS

48 A total of fifteen (15) edible flour samples which comprise five samples each of 1 Kg packaged cassava, yam and  
49 plantain flour were obtained from ED, SL and SR supermarkets in Port Harcourt, Nigeria. Similarly, fifteen sterile  
50 plastic containers were used to separately put 1 Kg of five samples each of exposed cassava, plantain and yam flour  
51 purchased from fifteen retailers at RO, M3 and OM markets in Port Harcourt metropolis. The flour samples were  
52 transported to Food and Industrial Microbiology Laboratory, University of Port Harcourt for analysis. The control  
53 sample comprise 1 Kg each of cassava, yam and plantain flour prepared in the laboratory under hygienic condition  
54 using the methods described by Onyenwoke and Simonyan [2], Omohimi [6] and Ajayi [3], respectively with slight  
55 modification.

### 56 2.1 Determination of proximate composition

57  
58 The furnace incineration gravimetric method of AOAC [24] as described by Harbers and Nielsen [25] was adopted  
59 to determine ash content of the flour samples. Determination of moisture content of the flour samples involved  
60 gravimetric method as described by Bradely [26]. Crude fibre content was determined using AOAC [24] method.  
61 The Kjeldahl procedure described by AOAC [27] was used to estimate crude protein content of the samples. Fat  
62 content was determined using Soxhlet extraction method described by AOAC [24]. Carbohydrate content of the  
63 flour samples estimated as amino free substance was determined by mathematical estimation using the proximate  
64 variables [24].

### 66 2.2 Determination of minerals and heavy metals

67  
68 Mineral analysis of the samples was determined using AOAC [27] method. At 550 °C, the samples were ashed.  
69 Using a beaker, 5 g of the ashed sample was boiled with 10 ml of 20 % hydrochloric acid which was filtered into a  
70 100 ml flask. The liquid in the flask was made up to the mark using deionized water. Minerals and heavy metals  
71 present in the resultant filtrate were determined. To determine sodium and potassium content, standard flame  
72 emission photometer was used whereby NaCl and KCl were the standards. Atomic absorption spectrophotometer  
73 (AAS Model SP9) was used to determine Ca and Fe content. The values obtained were expressed in mg/100 g.

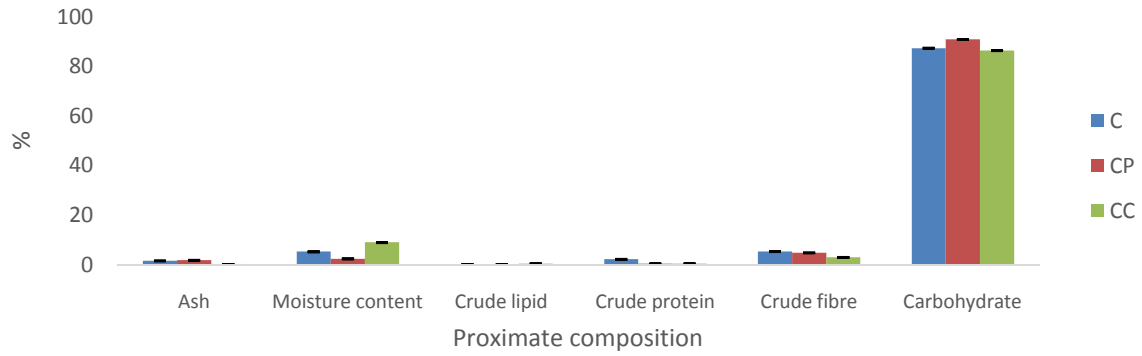
### 76 2.3 Data analyses

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78 All analyses were done in duplicates and expressed as mean± standard deviation. Statistical analyses to compare  
79 minerals and heavy metal content of cassava, yam and plantain flour samples that were either exposed or packaged  
80 was carried out using analysis of variance (ANOVA) and test of significance at 95 % (P=.05). Statistical Package  
81 for the Social Sciences (SPSS) IBM Statistics v.20 software was used to perform statistical analyses.

## 83 3. RESULTS

84  
85 The proximate composition of packaged and exposed cassava flour including the control sample is presented in  
86 Figure 1. Depicted in Figure 2 is also the proximate composition of packaged and exposed plantain flour including  
87 the control sample while that of packaged and exposed yam flour is shown in Figure 3. Shown in Table 1 are the  
88 minerals and trace metals content of exposed and packaged cassava, plantain and yam flour including similar flours  
89 prepared as control samples.

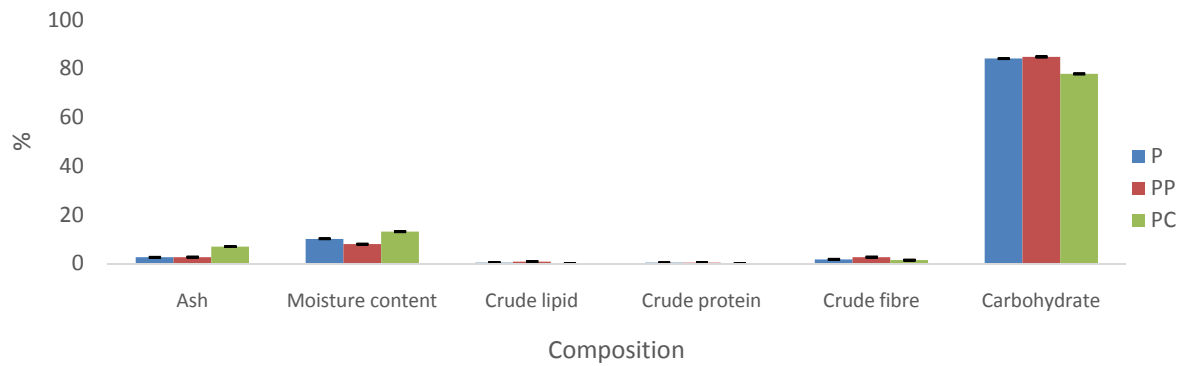
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**Figure 1.** Proximate composition of cassava flour

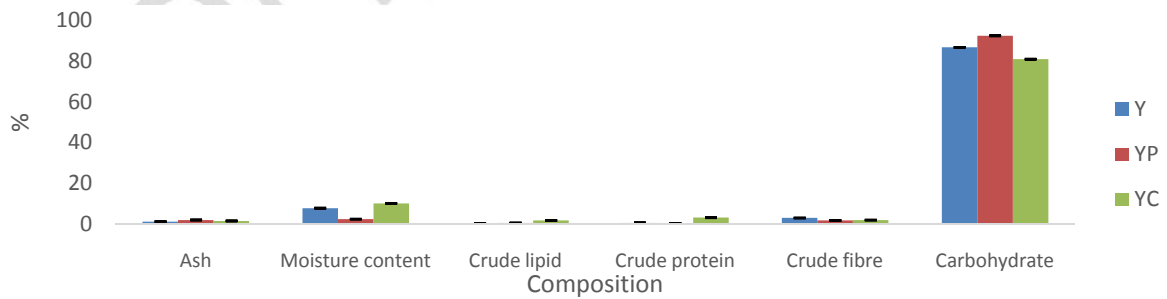
Key: C - Exposed cassava flour; CP - Packaged cassava flour; CC- Cassava flour as control sample



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**Figure 2.** Proximate composition of plantain flour

Key: P - Exposed plantain flour; PP - Packaged plantain flour; PC- Plantain flour as control sample



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**Figure 3** Proximate composition of yam flour

Key: Y- Exposed yam flour; YP - Packaged yam flour; YC - Yam flour as control sample

**Table 1.** Minerals and heavy metals content of cassava flour, plantain flour and yam flour (exposed and packaged)

Sample	K (mg/kg)	Ca (mg/kg)	Na (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	As (mg/kg)
Y	7.25 ± 0.00 <sup>c</sup>	1.38 ± 0.006 <sup>c</sup>	2.04 ± 0.005 <sup>d</sup>	5.34 ± 0.004 <sup>a</sup>	0.004 ± 0.002 <sup>b</sup>	0.002 ± 0.003 <sup>b</sup>	0.04 ± 0.0002 <sup>d</sup>	0.00011 ± 0.0 <sup>a</sup>
P	10.14 ± 0.01 <sup>f</sup>	1.06 ± 0.011 <sup>b</sup>	1.53 ± 0.007 <sup>b</sup>	9.86 ± 0.04 <sup>f</sup>	0.003 ± 0.0003 <sup>a</sup>	0.0001 ± 0.00 <sup>a</sup>	0.015 ± 0.0003 <sup>b</sup>	0.0018 ± 0.0001 <sup>b</sup>
PP	8.51 ± 0.003 <sup>d</sup>	1.08 ± 0.33 <sup>b</sup>	2.16 ± 0.001 <sup>d</sup>	11.47 ± 0.09 <sup>i</sup>	0.003 ± 0.0015 <sup>a</sup>	0.003 ± 0.0003 <sup>b</sup>	0.54 ± 0.005 <sup>f</sup>	0.006 ± 0.001 <sup>f</sup>
C	5.22 ± 0.01 <sup>b</sup>	0.76 ± 0.003 <sup>a</sup>	1.65 ± 0.043 <sup>b</sup>	6.67 ± 0.05 <sup>b</sup>	0.0052 ± 0.003 <sup>b</sup>	0.003 ± 0.000 <sup>b</sup>	0.52 ± 0.001 <sup>c</sup>	0.0023 ± 0.001 <sup>c</sup>
YP	15.98 ± 0.01 <sup>b</sup>	1.81 ± 0.01 <sup>d</sup>	1.37 ± 0.01 <sup>a</sup>	10.68 ± 0.1 <sup>h</sup>	0.0092 ± 0.001 <sup>c</sup>	0.000 ± 0.000 <sup>a</sup>	0.027 ± 0.01 <sup>e</sup>	0.0043 ± 0.001 <sup>d</sup>
CP	13.54 ± 0.003 <sup>g</sup>	1.42 ± 0.11 <sup>c</sup>	1.84 ± 0.05 <sup>c</sup>	9.57 ± 0.05 <sup>e</sup>	0.005 ± 0.0004 <sup>b</sup>	0.028 ± 0.024 <sup>c</sup>	0.058 ± 0.004 <sup>b</sup>	0.0053 ± 0.001 <sup>e</sup>
Cassava control	3.2 ± 0.02 <sup>a</sup>	ND	ND	7.2 ± 0.02 <sup>c</sup>	<0.0061	<0.0001	0.003 ± 0.002 <sup>a</sup>	<0.0001
Plantain control	5.11 ± 0.02 <sup>b</sup>	ND	ND	10.2 ± 0.02 <sup>g</sup>	<0.0001	<0.0001	<0.0001	<0.0001
Yam control	9.31 ± 0.12 <sup>c</sup>	ND	ND	8.2 ± 0.12 <sup>d</sup>	0.0115 ± 0.0002 <sup>d</sup>	<0.0001	0.0025 ± 0.0001 <sup>a</sup>	<0.0001

Values presented in the table are MSE (Mean ± standard Error), Mean values (n = 2) having different superscript alphabets in the same column are significantly different (p < 0.05).

Y - Exposed cassava flour; CP - Packaged cassava flour; P - Exposed plantain flour; PP - Packaged plantain flour; Y - Exposed yam flour; YP - Packaged yam flour; ND - Not detected

## 114 4. DISCUSSION

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### 116 4.1 Proximate composition

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118 This study showed that moisture content of exposed and packaged plantain flour was 10.3 % and 8.1 %, respectively. Yarkwan and Uvir [12] reported similar results from a related study. According to Omohimi *et al.* [6], moisture content of processed yam flour from different markets range between 9.2-14.61 %. The moisture content of yam flour subjected to different drying methods reported by Hsu *et al.* [28] is in agreement with our result. Low moisture content of flour is an indication of better product shelf life [29]. According to Odentunde *et al.* [4], cassava flours from different markets had moisture content within the range of 9.66-10.54 %. If edible flour is directly exposed to the atmosphere with high relative humidity for a long period, it is most likely to experience increase in moisture content [30]. This study showed that moisture content of each of the flour samples used as control was higher than similar flour sample packaged or exposed. Inadequate drying of the control samples could be a major factor behind its high moisture content. However, lower moisture content of all the packaged flour samples compared with the exposed ones could be as a result of its packaging. Researchers have established that moisture content of any food product is an index of its keeping quality as well as a shelf life indicator [31]. It is quite interesting that moisture content of packaged and exposed yam, cassava and plantain flour obtained from selected markets in Port Harcourt, Rivers State are within 12 - 14 % recommended by Standard Organization of Nigeria (SON) for edible flour or food powder during storage [32].

133 Results from this study shows that ash content of packaged plantain, yam and cassava flour was 2.8, 2.1 and 1.9 %, respectively. These values were slightly higher than ash content of exposed plantain, yam and cassava flour which was 2.7, 1.3 and 1.7 %, respectively. Abiodun *et al.* [33], reported that ash content of pounded yam flour from *Dioscorea alata* was approximately 1.9 %. According to Arinola *et al.* [13] and Ajibola and Olapade [34], ash content of unripe plantain flour and cassava flour subjected to different drying methods range between 3.11-3.91 % and 0.99-1.39 %, respectively. In a related study, Emurotu *et al.* [22] reported that ash content of cassava flour samples range between 1.03-1.64 %. This result is in agreement with ash content of cassava flour samples (both the exposed and packaged) with the exception of the control sample. Ash content of cassava, plantain and yam flour as control sample was 0.33 %, 7.07 % and 1.63 %, respectively. Different varieties of cassava, plantain and yam processed into flours could have accounted for differences in ash content of the flour samples especially plantain flour. Generally, ash content of food materials is an indication of the level of minerals in a food sample [9]. Prevention of biochemical activities of microorganisms present in the packaged flour samples might be the reason ash content of the products were higher than that of exposed flour samples [32].

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147 The lipid content of packaged and exposed cassava flour was 0.3 %. This result is an indication that exposure or packaging of cassava flour did not influence its lipid content. From a related study, Ajibola and Olapade [34] reported that lipid content of cassava flour range between 0.32-0.56 %. This result is in agreement with lipid content of cassava flour both packaged and exposed as well as control sample. Similarly, crude lipid content of yam flour reported by Hsu *et al.* [28] is in harmony with our result. This study revealed that lipid content of each control sample did not vary widely from that of similar flour sample packaged or exposed with the exception of yam flour. Result from this study shows that lipid content of packaged yam and plantain flour was 0.62 % and 0.93 %, respectively. Also, that of exposed yam and plantain flour was 0.18 % and 0.46 %, respectively. Therefore, lipid content of both packaged flours was higher than similar flours that were exposed. This could be as a result of reduced proteolytic and lipolytic enzymatic activity of microorganisms present in packaged yam and plantain flour did not result in huge loss of nutrients such as lipids compared with the flour samples that were exposed.

158

159 Exposed and packaged cassava flour had a protein content of 2.3 % and 0.51 %, respectively. Relatively high protein content of exposed cassava flour compared with that of packaged flour could be as a result of edible flours from different sources mistakenly mixed with it during retailing of the product in open markets. Ajibola and Olapade [34] reported that protein content of cassava flours subjected to three drying methods range between 1.51-1.89 %. Odetunde *et al.* [35] reported that protein content of cassava flour range between 2.10 - 3.44 %. This result corroborates the protein content of exposed cassava flour. Meanwhile, protein content of plantain flour which range between 4.75 - 9.84 % reported by Ogundare-Akanmu *et al.* [36] is not in agreement with our results. However, protein content of yam flour reported by Obadina *et al.* [37] corroborates the result obtained from this study. It is

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167 critical that protein content of all the flour samples were less than 1 % except yam flour (control sample) which had  
168 3.22 % protein content. Studies have shown that high intake of plant protein could prevent onset of risk factors  
169 associated with cardiovascular diseases, reduce risk for stroke, lower body weight, cholesterol and blood pressure  
170 levels. It also helps maintain bone and muscle health [38, 39].

171  
172 According to Yarkwan and Uvir [12], crude fibre content of fresh, sundried and oven dried plantain flours was 1.40,  
173 10.11 and 10.43 %, respectively. In another related study, Pacheco-Delahaye *et al.* [40] reported that dietary fiber  
174 content of unripe plantain flour dehydrated using different methods range between 9.01 - 9.67 %. This result is not  
175 in agreement with crude fibre content of packaged and exposed plantain flour which was 2.76 % and 1.87 %,  
176 respectively. A study carried out by Obadina *et al.* [37] revealed that fiber content of yam flour was within the range  
177 1.17 - 2.26 %. This result corroborates with the crude fibre content of packaged yam flour which was 1.84 %. The  
178 result obtained from a related study by Hsu *et al.* [28] is in agreement with crude fibre content of both exposed and  
179 packaged yam flour. According to Eleazu and Eleazu [11], crude fibre content of cassava flour from six cassava  
180 varieties range between 1.65 - 2.32 %. Their result is not in agreement with crude fibre content of packaged and  
181 exposed cassava flour which was 4.94 % and 5.46 %, respectively. Meanwhile, this study revealed that crude fibre  
182 content of each control sample was lower compared with that of similar flour sample either exposed or packaged  
183 with the exception of yam flour. Dietary fibre is beneficial to human health because it reduces appetite, alleviates  
184 constipation, lowers variance in blood sugar levels and reduces risk of developing heart disease. It could also reduce  
185 onset risk or symptoms of metabolic syndrome and diabetes as well as reduce risk of developing colorectal cancers  
186 [41, 42].

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188 Findings from this study revealed that carbohydrate content of each packaged flours was slightly higher than that of  
189 similar flour sample exposed to the environment. Carbohydrate content of packaged cassava, yam and plantain flour  
190 was 90.94 %, 92.52 % and 84.9 % while that of exposed cassava flour was 87.40 %, 86.85 % and 84.2 %,  
191 respectively. Lower moisture content for each packaged flours compared with that of similar flour sample exposed  
192 to the environment could be responsible for its carbohydrate content being higher than that of exposed flour. This  
193 study also showed that carbohydrate content of each control sample was slightly lower when compared with that of  
194 similar flour sample that was either exposed or packaged. High carbohydrate content of all the flour samples both  
195 the packaged, the exposed and the control samples is in agreement with earlier studies that reported these staples to  
196 be a rich source of carbohydrate [4, 5, 6, 7, 43].

## 197 **4.2 Heavy metals content**

198 Arsenic (As), cadmium (Cd), lead (Pb) and chromium (Cr) are heavy metals. They are known to be toxic. Arsenic  
199 and Cd are teratogenic whereas Cd and Cr are carcinogenic. Although iron (Fe) is a heavy metal, it is an essential  
200 micro-element for living things. However, at high concentration Fe becomes toxic to living things [44]. Exposure of  
201 humans to Pb could increase blood pressure. Lead is harmful to the cardiovascular system [17]. Damage to bones,  
202 kidneys and DNA could be caused by cadmium. mRNA transcriptional changes in the gills of *Mytilus*  
203 *galloprovincialis* has been associated with cadmium. Long period of human exposure to cadmium could result in  
204 nephrotoxicity. The limit stipulated by World Health Organization (WHO) in terms of Cd and Pb content in cassava  
205 flour is 0.5 ppm, respectively [45]. Similarly, Codex Alimentarius Commission (CAC) tolerable limit for Pb and Cd  
206 content in flour samples is 0.1-1.5 mg/Kg and 0.05-1.0 mg/kg, respectively. Adebayo-Oyetoro *et al.* [46] reported  
207 that quantity of As permissible in cassava flour was between 0.5-1.0 mg/kg. Although, safe limit for quantity of Cr  
208 in foods is not specified by the CAC, daily allowance of 1.50 µg/day is recommended [44]. European Union Food  
209 Standard recommends that Cd and Pb should not exceed 0.1 mg/kg [36].

210 This study has shown that the control samples had lower minerals and heavy metals than the ones that were either  
211 exposed or packaged. This result is in agreement with a similar study carried out by Yarkwan and Uvir [12].  
212 Processing methods, exposure of retailed flour samples to environment, storage conditions and level of soil  
213 contamination with heavy metals where plantain, cassava and yam was grown could have influenced quantity of  
214 minerals and heavy metals in their respective flour samples. The exhaust fumes from heavy duty trucks that  
215 conveyed bulky goods to the market could also have deposited heavy metals on the exposed flour samples [12].

216 Therefore, exposure of flour in open markets should be discouraged due to potential health consequences of  
217 consuming such products.

218 Our results revealed that cadmium and lead content in both exposed and packaged flour samples are within  
219 International Standard. Adebayo-Oyetoro *et al.* [46] reported that quantity of As and Pb in cassava flour samples  
220 obtained from the market were lower than the recommended limit (1.0 mg/kg) except one sample which exceeded  
221 approved limits. Based on International Food Standards, Shin *et al.* [18] reported that quantity of Cd, Cr and As in  
222 commercial yam powder products in South Korea were within safe level but Pb content exceeded safe limits. The  
223 Cd and Cr content of commercial yam powder reported by Shin *et al.* [18] is in agreement with the results obtained  
224 from this study but As and Pb content was higher than the results obtained from this study. A related study by Iyabo  
225 *et al.* [17] revealed that Cd and Pb content of amala (cassava flour) were 0.03 and 0.14 mg/kg, respectively. They  
226 also reported that Cd and Pb content of amala (yam flour) were 0.02 and 0.30 mg/kg, respectively. Analysis results  
227 by Emurotu *et al.* [22] revealed that Pb and Cd content of cassava flour were below detection limit. This is not in  
228 agreement with the results obtained from this study. Research findings by Lanlokun *et al.* [21] revealed that Cd  
229 content between 0.51- 4.51 mg/kg was present in most plantain flour samples obtained from different locations.  
230 However, the researchers did not detect Pb in the plantain flour samples. This contradicts the result obtained from  
231 this study. Lanlokun *et al.* [21] also reported that As was not detected in plantain flour samples analyzed with the  
232 exception of one flour sample which contained 120.23 mg/kg arsenic acid. Obi *et al.* [47] reported that As, Cr, Pb  
233 and Cd content of unripe plantain flour are 0.027, 0.053, 0.063 and 0.033 ppm, respectively.

### 234 **4.3 Minerals content**

235 Iron (Fe) is important in formation of hemoglobin, transferrin, ferritin and bone iron-containing enzymes,  
236 transport, DNA synthesis, and electron transport chain [45]. Potassium and sodium are beneficial for human health.  
237 These ions are important in the body because they are associated with many physiologic and pathophysiologic  
238 processes [48]. Calcium is important in human body because of its role in muscle contraction, blood clotting, nerve  
239 impulse, transmission, building strong teeth and bones [49].

240 Gomes *et al.* [16] reported that Fe content of cassava flour range between 2.95-15.45 mg/kg is in agreement with the  
241 results obtained from this study. According to Emurotu *et al.* [22], safe level of potassium, calcium and iron content  
242 of cassava flour should be 4.84-6.71 µg/g, 1.18-1.53 µg/g and 0.66-1.27 µg/g, respectively. The limit for Fe content  
243 in cassava flour recommended by World Health Organization (WHO) is 300 ppm [45]. According to Gomes *et al.*  
244 [16], the concentration of calcium in four cassava flour samples from Nigeria ranged between 1.18-1.53 mg/kg. This  
245 result is in agreement with calcium content of packaged cassava flour which was 1.42 mg/kg. Potassium and  
246 calcium content of exposed and packaged yam flour was lower than the values reported by Nina *et al.* [9] from a  
247 similar study. In another related study, Emurotu *et al.* [22] reported that cassava flour contains calcium, potassium  
248 and iron which range between 1.36 - 1.53, 4.84 - 6.71 and 0.66 - 1.27 µg/g, respectively. The quantity of minerals in  
249 both exposed and packaged plantain flour is higher than that of fresh unripe plantain, sundried and oven dried unripe  
250 plantain flours reported by Yarkwan and Uvir [12] from a related study. The variety of plantain processed into  
251 plantain flour and processing methods adopted could be responsible for the differences in its mineral content.

## 252 **CONCLUSION**

253 Based on proximate composition and minerals content of packaged and exposed cassava, yam and plantain flour  
254 samples from selected open markets and supermarkets in Port Harcourt, Nigeria, fortification of the products is  
255 suggested. An interesting result from this study shows that heavy metals content of the flour samples did not exceed  
256 safe limits recommended by relevant international regulatory bodies. To further minimize heavy metal  
257 contamination of cassava, plantain and yam flour placed in open markets, the products should be bagged and sealed.

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260 **COMPETING INTERESTS**

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Authors have declared that no competing interests exist.

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