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Levels of Heavy Metals in Street Vended Fried-Cocoyam (Xanthosoma Sagittifolium) Chips Sold along Sango - Oshodi Expressway Nigeria

Idowu-Adebayo, Folake[1] Adegunwa Mojisola O.[2] Adebowale Abdulrasaq. A.[3] Otitoju, Olawale[4] Sanni Lateef O.[3]

1.Department of Food science and Technology, Faculty of Agriculture, Federal University Oye, P.M.B 373 Oye-Ekiti, Ekiti state, Nigeria

2.Department of Hospitality and Tourism, Federal University of Agriculture, P.M.B 2240 Abeokuta, Nigeria

3.Department of Food science and Technology, Federal University of Agriculture, P.M.B 2240 Abeokuta, Nigeria

4.Department of Biochemistry, Natural Science Research Unit Federal University Wukari TarabaState, P.M.B 1020,Nigeria

Abstract

Heavy metals have been reported to have positive and negative roles in human life. Eighty samples were purchased from vendors, twelve samples of raw materials and thirty six samples were collected along processing line. The samples were digested carefully and metal elements were analyzed using Atomic Absorption Spectrophotometer. Analyzed iron, lead, cadmium and arsenic in raw materials used by the three processors ranged from 0.000 to 16.010, 0.000 to 0.013, 0.000 to 0.155 and 0.250 to 0.809mg/Kg respectively. Heavy metal contents of samples taken along the processing line ranged from 0.00, 0.222 to 0.226, 0.758 to 0.959 and 0.00 to 0.801 mg/Kg for lead, arsenic, iron and cadmium respectively. The content of iron, cadmium and arsenic of street vended samples ranged from 0.653 to 0.8, 0.00 to 0.10 and 0.221 to 0.225 mg/kg respectively The results of the present study showed that metal elements except arsenic were within the NIS maximum permitted level (0.1mg/kg for lead, cadmium and arsenic; 1.5mg/kg for iron) by Nigerian Industrial Standard and Codex Alimentarius for street vended food.

Keywords: Heavy metals, Street vended food, health, contaminants, Cocoyam, *Xanthosoma sagittifolium.*

1. Introduction

There is increasing recognition that street food vending plays an important socio-economic role in terms of employment potential, providing special income particularly for women and provision of food at affordable costs to mainly the lower income groups in the cities. Because of socioeconomic changes in many countries, this sector has experienced significant growth during the past few decades (WHO, 1996; Comfort 2010). Increased industrialization and civilization in the general populace has made these vended food sources a popular menu even among the elites.here are varieties of street vended foods/snacks consumed in Nigeria among which include ‘Koko’ (cocoyam chips), ‘Kokoro’, Plantain chips, Roasted Yam, ‘Robo’, ‘Kulikuli’, ‘Fura’, Roasted corn. The technologies employed in the processing, distribution and storage of indigenous foods are based on the long established knowledge of traditional processing of such foods (Olajide et al., 2006).The bulk of such local foods/snacks vended along the streets in Nigeria as in most developing countries are characterized by low quality processing, which generally starts from the farm where the raw materials were obtained through other processing stages to the final consumers (Aroyeun et al., 2000). Traders and cottage processors tend to adopt measures which attract the least cost in relation to expected earnings from the local varieties of foods being processed. It is conceivable that even if it were possible to carry out necessary analysis at every stage of processing, the facilities to do so are presently too expensive for the local processors. This situation, however, poses a dilemma to the society.

The Food and Agriculture Association (FAO) defines street food as ‘ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers especially in the streets and other public places’ (FAO, 2007). World Health Organisation (WHO, 1996) defines"street-vended foods" or its equivalent "street foods" as foods and beverages prepared and/or sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation.

Heavy metals have been reported to have positive and negative roles in human life (Adriano, 1984; Slaveska et al., 1998; Divrikli et al., 2003; Dundar et. al., 2004; Colak et al., 2005; Oktan et al., 2005); Otitoju et al., 2012. Some like iron, zinc and copper are essential for biochemical reactions in the body while others like cadmium, lead and arsenic are major contaminants of food and may be considered the most important problem to our environment (Zaidi et al., 2005; Otitoju et al 2012).

Nigeria is the world’s largest producer of Cassava, Yam and Cocoyam (FAO, 2007). Whereas the potentials of cassava and yam have been intensively explored, cocoyam on the contrary has been long abandoned at the backstage and shadowed by several unsavoury socio-cultural perceptions and unfavourable comparative economic considerations (Ekwe, 2008). The average production figure for Nigeria is 5,068,000metric tonnes which accounts for about 37% of total world output of cocoyam (FAO, 2007). There are two main edible types of cocoyam in Nigeria; *Colocasia esculenta* (L) scholt known as taro and *Xanthosoma sagittifolium* known as tannia. Apart from consumption of various cocoyam foods, rural households also vend them as a way of coping with food scarcity (Opata et al., 2009). Based on the facts that street vended foods though contribute substantially to the diet of the people, it may at the same time, pose potential health risks. It is therefore crucial that fried cocoyam chips are upgraded for quality and safety in order to safeguard the consumers from the consumption of poorly prepared and low quality street food.

Hence the objective of this research is to determine the level of heavy metals in street vended fried cocoyam chips along Sango-Oshodi expressway Nigeria.

2. Materials and methods

2.1 Materials

Cocoyam corms, salt, water, vegetable oil and fried cocoyam chips. Other materials are analytical balance for weighing, fume cupboard for digestion process, concentrated trioxonitrate(v) acid (HNO_3), distilled water, deionized water, digestion flasks, Atomic Absorption Spectrometer (AAS)(Thermoscientific S series, S4AA system).

2.2.1 Methods

Fried cocoyam chips were purchased from vendors at Sango, Ojaoba (Abule Egba), Iyana ipaja motor park, Oshodi and Mile two motor parks. Three traditional processors in Ago Inija (processor I), Ago Ilaro (processor II) and Oke-Odo (processor III), at Ajilete, Ipokia local government of Ogun State, Nigeria were selected. Heavy metals analysis were conducted on the different samples of fried cocoyam chips processing stages and on the sample purchased from the street vendors.

2.2.2 Determination of Heavy metals

Reagents

High purity of certified reagents was used for all analysis. Concentrated Trioxonitrate (v) (HNO_3) was used for digestion while distilled water was used to rinse the apparatus before and after every point of use and deionized water to analyze the digested samples.

Sample Digestion for Atomic Absorption Determination

Two grams (2g) of each food sample was weighed into a 100ml digestion flask. 15ml of concentrated trioxonitrate (v) acid (HNO_3) was added. The digestion flask containing the samples were then placed on a water bath (Gerhardt) in a fume cupboard, and sufficiently heated until a clear solution was obtained.

Atomic Absorption Analysis of Digested Samples

After digestion, each of digested samples was carefully poured into a100ml volumetric flask and made up to the mark. The metal elements (Iron, Lead, Cadmium and Arsenic) were analysed by using Atomic Absorption Spectrophotometer (Thermoscientific S series, S4AA system) at wavelength of 248.3nm, 217.0nm, 228.8nm and 193.7nm respectively using acetylene gas, air and N_2 gas.

2.3 *Statistical Analysis*

All data were reported as means of three replicates. The data obtained were subjected to analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS version 16.0) software to determine whether there is a significant difference at 0.05 levels. Duncan Multiple Range Test (DMRT) was used to separate the means.

3. Results and Discussion

3.1 Results

Table 1-5 show the level of mineral contaminant in raw materials, fried cocoyam chips processing stages from the three processors in the study area, fried cocoyam chips produced in the laboratory (control) and street vended cocoyam chips from eight vendors. The level of arsenic in vegetable oil processed cocoyam ranges between 0.223mg/kg to 0.226mg/kg for the three processors were higher than Nigerian Industrial Standard (2000) 0.1mg/kg maximum level of tolerance and were significantly different at $p<0.05$ to arsenic level of control vegetable oil 0.084mg/kg. Lead was not detected in the vegetable oil used in the three processing centers and in the laboratory. The level of cadmium and iron ranges between 0.05 to 0.08 mg/kg and 1.4 to 5.06mg/kg respectively for processor I, II, III and control. Lead and iron were not detected in water samples taken from the three processing centers and the laboratory. Level of arsenic (0.800 to 0.809mg/kg) in the water samples of the three processors were higher than 0.01mg/kg specified by NIS (2003) and were significantly different ($p<0.05$) from level of control water 0.003mg/kg. Lead was not detected in any stages used by the individual processors and in the laboratory control samples while cadmium were detected at a very low level (0.009) at frying, cooling and packaging stages for the three processors only. The arsenic level 0.22 to 0.2256mg/kg in processing stages for processor I, II and III were higher than 0.1mg/L specified by NIS (2008) whereas the arsenic level ranges from 0.0098 to 0.011mg/L in the processing stages of control sample. Iron ranges from 0.6520 to 0.9592mg/kg were significantly different at $p<0.05$in peeling, slicing, washing and salting stages only for the three processing centers and laboratory.

Lead levels detected in street vended fried cocoyam chips for vendor 4 (0.0019mg/kg) and vendor 8 (0.0031mg/kg) only were significantly less than acceptable limits (NIS, 2008). Arsenic values 0.2214 to 0.2254mg/kg for all the eight vended samples were higher than 0.1mg/L specified by NIS (2008). Low level of cadmium contaminant (0.001mg/kg) was detected in vendor 1, 2 and 4 samples only. Iron levels ranges from 0.6552 to 0.8mg/kg detected in all the eight samples were significantly different at $p<0.05$ when compared with the control group. The values were within the WHO, NIS and Codex Alimentarius acceptable standard of 1.5mg/kg.

3.2 Discussion

Food insecurity is a major problem in most developing nations. This phenomenon exists in different forms ranging from food contamination to food adulteration. However, exposure to food contaminants such as heavy metals, pesticides, fertilizer or other agricultural inputs is on the increase (Otitoju and Otitoju, 2013; Wilson and Maud, 2008). Lead contaminant that was not detected in the processing stages in the samples from the study areas and in the laboratory could be attributed to less contamination from industrial activities since the place is mostly residential areas. However slightly high content of lead in some street vended samples is in agreement with lead content of street foods and volume of vehicular traffic as reported by Ologunde *et al*., (2000). The presence of cadmium during and after frying may be from the vegetable oil used in frying the samples and not from the environment. These vegetable oils may have been contaminated from the farm, production stage or at the point of frying. Although, the level of cadmium in the frying, cooling and packaging stages of the three processing techniques and in some street vended samples were significantly less than the acceptable limit of 0.1mg/kg by Codex (2001) its presence may be of public health concern over long exposure period or when consumed at very high concentrations.

The present of iron in all the raw materials used in the processing stages could be as a result of uptake from the soil, its presence in natural water or its presence in atmosphere is in agreement with the earlier work reported by Akaninwor *et al* (2006). Similarly, the absence of lead and or low level of cadmium in the food samples may be as a result of high level of iron (Fe). This is in agreement with earlier report that higher affinity for essential trace metals Fe^{2+}, Zn^{2+} and Ca^{2+} results in decreased uptake of lead and cadmium in plants (Khan *et al* 1983; Sandstead, 1995). However the values of iron were within Nigerian Industrial Standard acceptable limit as the presence of such essential nutrient metals in excess of the required threshold concentration in the body can trigger some toxic activities.

Arsenic contaminants were reportedly high in all the processing stages of processor I,II and III this could be as a result of high level in the raw materials (cocoyam, water and vegetable oil) used in producing the fried cocoyam. Arsenic is widely distributed throughout the earth's crust, in the environment, arsenic combined with oxygen, chloride and sulphur to form inorganic compound which is the toxic form of arsenic for humans. Arsenic toxicity has been reported to be detrimental to human health because of their perceived carcinogenic property (Sabine and Wendy, 2009; Miller et al. 2002; Hu et al. 2005). The presence of arsenic in all the samples may be an indication that cocoyam is a possible bioaccumulator of this heavy metal and may require further processing and studies to establish the safety of this food samples for human consumption.

Heavy metals contaminate food source and accumulate in both agricultural products and sea food through water, air and soil pollution (Chen and Chen, 2001; Otitoju and Otitoju, 2013). The major health challenge is that most heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. Most of them are extremely toxic because of their solubility in water. Even low concentrations of heavy metals have been reported to possess damaging effects on man and animals because there is no good mechanism for their elimination from the body (Chen, Wang and Wang, 2005; Singh, et al., 2004; 2009). Consuming heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho- social behaviour, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora *et al*, 2008). It can also lead to serious consequences on health such as kidney disease, damage to the nervous system, diminished intellectual capacity, heart disease, bone fractures, and death (Jarup, 2003). Previous studies have shown heavy metal contamination of foods; such as rice containing lead, ranged from 0.00-61.17mg/kg and in other food crops and fruits consumed in Owerri (Orisakwe *et al.,*2012). Otitoju *et al.,* (2012) also reported high concentrations of lead and mercury in all samples collected for heavy metal analysis of pumpkin leaves in Uyo, Akwa-Ibom state Nigeria.

4. Conclusion

Monitoring and systematic gathering of information on heavy metal levels in the environment and our food samples are essential components of any pollution control system in order to guarantee food security among the populace. It is essential that agricultural activities and other human activities which may increase heavy metal contamination of food stuffs be controlled.

We recommend that growing conditions, harvesting, processing methods and post-harvest treatments should be carefully controlled to prevent heavy metal contaminations. Hence there is need to certified raw materials for standard in term of quality before using it in the frying process of cocoyam chips. Similarly, street vended fried cocoyam chips should be packaged in sealed nylon to minimized recontamination through vendor handling.

In conclusion, this study gave an insight to the quality and safety status of street vended fried cocoyam chips and provided an opportunity for fried cocoyam chips processors, intending investors, relevant research and regulatory bodies to have guide towards establishment of quality standards. Results of the heavy metals analysis show that contamination during the processing of street vended cocoyam chips are due to low quality of raw materials used and local technology.

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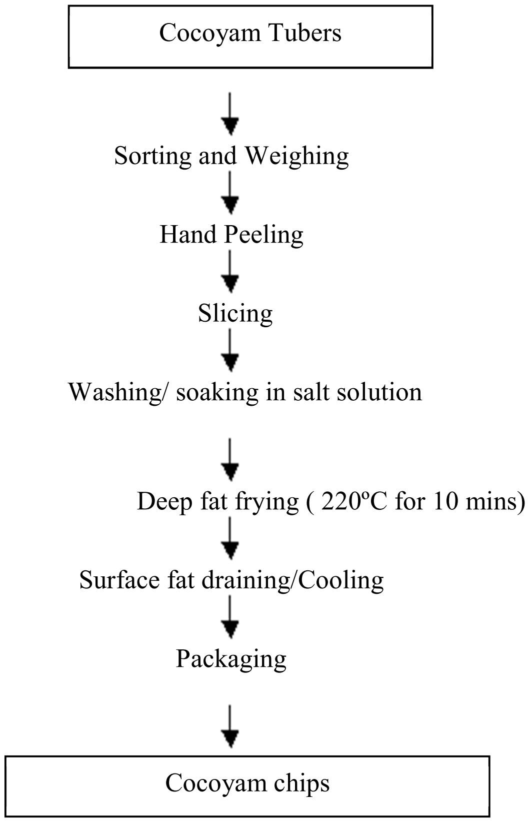

Fig 1: Flow Chart for Fried Cocoyam chips.

Table 1: Heavy metal content (Kg/L) in the raw materials used in fried cocoyam chips

INGREDIENTS	PROCESSORS	LEAD	CADMIUM	ARSENIC	IRON
WATER	AGO INIJA	0.000±0.00	0.003±0.00	0.809±0.00 [b]	0.000±0.00
	AGO ILARO	0.000±0.00	0.000±0.00	0.799±0.00 [b]	0.000±0.00
	OKE ODO	0.000±0.00	0.000±0.00	0.800±0.00 [b]	0.000±0.00
SALT	AGO INIJA	0.013±0.00	0.155±0.00	0.308±0.00	12.787±0.00
	AGO ILARO	0.013±0.00	0.127±0.00	0.312±0.00	14.567±0.00
	OKE ODO	0.013±0.00	0.130±0.00	0.300±0.00	16.010±0.00
VEGETABLE	AGO INIJA	0.000±0.00	0.082±0.00	0.259±0.00	5.063±0.00
OIL	AGO ILARO	0.000±0.00	0.056±0.00	0.257±0.00	5.063±0.00
	OKE ODO	0.000±0.00	0.058±0.00	0.250±0.00	5.054±0.00

Note: Means on the same column with different superscript are significantly different at $p<0.05$.

Table 2: Arsenic content (mg/kg) of samples collected at different stages of fried cocoyam chips processing.

STAGES	AGO INIJA	AGO ILARO	OKE ODO
COCOYAM CORMS	0.2252±0.00[b]	0.224±0.00 [a]	0.223±0.00[b]
PEELING	0.225±0.00[b]	0.223±0.00[a]	0.222±0.00[b]
SLICING	0.225±0.00[a]	0.223±0.00[a]	0.222±0.00[a]
WASHING	0.225±0.00[c]	0.224±0.00[c]	0.222±0.00[b]
SALTING	0.225±0.00[c]	0.224±0.00 [c]	0.222±0.00[c]
FRYING	0.225±0.00[d]	0.225±0.00 [d]	0.223±0.00[d]
COOLING	0.225±0.00 [d]	0.225±0.00 [e]	0.223±0.00[d]
PACKAGING	0.226±0.00 [e]	0.225±0.00[f]	0.223±0.00[e]

Note: Means on the same column with different superscript are significantly different at p<0.05.

Table 3: Iron contents (mg/kg) of samples collected at different stages of fried cocoyam chips processing

STAGES	AGO INIJA	AGO ILARO	OKE ODO
COCOYAM CORMS	0.759±0.00[b]	0.759±0.00[c]	0.800±0.00 [c]
PEELING	0.759±0.00[b]	0.759±0.00[c]	0.800±0.00 [c]
SLICING	0.759±0.00[b]	0.759±0.00[c]	0.800±0.00 [c]
WASHING	0.759±0.00[b]	0.759±0.00[c]	0.800±0.00 [c]
SALTING	0.958±0.00[c]	0.959±0.00[d]	0.959±0.00 [d]
FRYING	0.953±0.00[a]	0.952±0.00[a]	0.953±0.00[a]
COOLING	0.953±0.00[a]	0.952±0.00 [a]	0.953±0.00 [a]
PACKAGING	0.953±0.00[a]	0.952±0.00 [b]	0.953±0.00 [b]

Note: Means on the same column with different superscript are significantly different at p<0.05.

Table 4: Cadmium content (mg/kg) of samples collected at different stages of fried cocoyam chips processing

STAGES	AGO INIJA	AGO ILARO	OKE ODO
COCOYAM CORMS	0.000±0.00	0.000±0.00	0.000±0.00
PEELING	0.000±0.00	0.000±0.00	0.000±0.00
SLICING	0.000±0.00	0.000±0.00	0.000±0.00
WASHING	0.000±0.00	0.000±0.00	0.000±0.00
SALTING	0.000±0.00	0.000±0.00	0.000±0.00
FRYING	0.001±0.00	0.001±0.00	0.001±0.00
COOLING	0.001±0.00	0.001±0.00	0.001±0.00
PACKAGING	0.001±0.00	0.001±0.00	0.001±0.00

Note: Means are in standard deviation, means on the same column with different superscript are significantly different at p<0.05.

Table 5: Mean values of metal contamination (mg/kg) street vended cocoyam chips.

VENDOR	LEAD	ARSENIC	CADMIUM	IRON
Sango under bridge	0.000±0.00	0.225±0.00 [c]	0.001±0.00	0.800±0.00 [d]
Sango toll gate	0.000±0.00	0.225±0.00 [c]	0.001±0.00	0.800±0.00 [d]
Abule-Egba I	0.000±0.00	0.225±0.00[b]	0.000±0.00	0.661±0.00 [c]
Abule-Egba II	0.002±0.00	0.225±0.00[d]	0.001±0.00	0.659±0.00
Iyana-Ipaja I	0.000±0.00	0.225±0.00[d]	0.000±0.00	0.653±0.00[a]
Iyana-Ipaja II	0.000±0.00	0.221±0.00[a]	0.000±0.00	0.653±0.00[a]
Oshodi I	0.000±0.00	0.225±0.00[d]	0.000±0.00	0.656±0.00 [b]
Oshodi II	0.003±0.00	0.225±0.00 [d]	0.000±0.00	0.655±0.00[b]

Note: Means on the same column with different superscript are significantly different at p<0.05.