Trace Metal Pollution Study on Cassava Flour's Roadside Drying Technique in Nigeria

E.O. Obanijesu and J.O. Olajide

Abstract Cassava flour, generally consumed in Africa as food, is a major source of carbohydrate. Its common drying technique in Nigeria is sun drying for cost optimization whereby the flour (in powder form) is spread by the roadside for moisture content reduction process. This research was carried out at five major traffic highways in Nigeria to study the level of trace element pollution introduced through this drying method, identifying the sources of the pollutants mainly as automobile exhaust emission (major) and street dust (minor). At each site, ten samples (from the four corners and the center) were collected, mixed, digested and analyzed using Graphite Furnace Atomic Absorption Spectroscopy (FAAS) technique to determine the concentration of ten elements (Fe, Cd, As, Pb, Ni, Co, Cu, Cr, Mn and Zn). Analysis of certified standard reference material IAEA-V-10 Hay (Powder) was carried out to ensure accuracy and precision of the technique. Except for zinc, all samples have comparatively high concentrations. Specifically, Fe, As, Pb, Cu and Cd have concentrations as high as 7.2, 5.70, 17.16, 4.57 and 0.39 g/70 kg respectively as against the maximum human uptake limits of 0.01, 0.014, 0.08, 0.11 and 0.03 g/70 kg respectively.

The results show that even though, cassava flour is a rich source of the essential and beneficial minerals required for healthy living, it's drying technique exposes it to the excessive intake of some of these trace metals which could be hazardous to human health. Alternative drying techniques are recommended.

Keywords Trace metals · Drying technique · Cassava flour · FAAS · Health impacts

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1 Introduction

Cassava flour (popularly known as “Lafun”) as a food in Nigeria is a rich source of carbohydrate which contains essential and beneficial mineral needed for body morphological processes. Carbohydrates, often referred to as the major fuel of the tissues (Robert et al. 2000), release energy needed by the body to function properly in its daily activity. The ancient means of preserving this food source is sun-drying and it is still practice in Nigeria whereby the flour is spread by the roadside in order to reduce the cost of drying. The dried foodstuff can then be stored for a long period of time without deteriorating. However, through this drying technique, the foodstuff is subject to air pollution through the trace metal released from the exhaust pipes of passing-by vehicles. Air pollution is the transfer of harmful amounts of natural and synthetic materials into the atmosphere as a direct or indirect consequence of human activities (Vesilind et al. 1993).

Because the emissions of these pollutants occur near ground level, they are not diluted and dispersed as effectively as pollutants emitted from chimneys. The emissions of these pollutants are dependent principally upon the type (diesel or petrol), the quality (Table 1) and the quantity of fuel consumed, the combustion technology employed and the mode in which the road vehicle is driven. Further studies have shown that the extent of contamination of the roadside food also depends on the volume of traffic and nearness to the highway (WHO 1992; Brewer 1997).

The presence of these fugitive particles increase the inorganic component of the cassava flour such as the poisonous group like Lead, Arsenic, Cadmium (Aribike and Akinpelu 2000) and the beneficial group like the nutritive minerals e.g. zinc, calcium, manganese, copper, iron and Nickel (Robert et al. 2000). However, though, some of these inorganic elements are essential to man, their presence in excessive amount in food taken into the body may cause morphological abnormalities, reduce growth, increased mortality rate and mutagenic effect in human (Prasad 1996).

These metals, when taken into the body through food contamination cause damages to human health (Table 2). A greater part of the damage caused is irreversible (Ogunkola and Agboola 2004) thereby leaving the situation more harmful.

Table 1 Concentration of metals in common brands of fuel sold in Nigeria

	Levels of metals							
Super brand of petrol	Na	K	Cr	Mn	Fe	Cu	Zn	Pb
National	7.1	12.5	12.5	4.7	25.3	2.0	4.0	615
A.P	11.5	9.5	19.0	6.5	14.0	3.0	3.5	605
Texaco	4.0	16.5	22.0	4.0	8.0	3.0	3.0	695
Mobil	3.5	19.5	19.0	5.0	9.0	3.0	4.0	792
Aviation gas	7.0	13.0	19.0	4.2	25.5	2.5	6.5	915
Total	3.5	15.5	27.0	4.5	8.5	4.0	5.0	655

Source: (Shalangwa 2004)

Table 2 Effects of excessive intake of trace metals

Trace metal	Toxic effects on human health
Manganese	Parkinson disease results into symptoms which are slowness, poverty of movement, rigidity and postural instability (Nelson and Cox 2000)
Zinc	Gastro intestinal irritation and vomiting occurs, dehydration, nausea, muscular in coordination if even and cough (Robert et al. 2000)
Iron	Tissue damages, stiffness, pains in ankles wrist, knee and finger joints. It also causes greyish skin pigmentation (Nelson and Cox 2000)
Copper	Genetic disease, skin and mucous irritation, liver disease and haemolytic anaemia (Nelson and Cox 2000)
Cobalt	Vomiting, nausea, vision blurring and heart problems. It could lead to thyroid damage, sterility, hair loss, diarrhoea and eventually death (Robert et al. 2000)
Chromium	Dermatitis, ulceration of the skin and perforation of the nasal septum, chronic catarrh and its carcinogen (ATSDR 2006)
Nickel	Causes cancer of the lungs, nose, larynx and prostrate, it leads to heat disorders, birth defects, asthma and allergic reactions such as skin rashes (Trombetto et al. 2005)
Cadmium	Poisoning occurs frequently with zinc. The end-result is painful and rheumatic in nature (Nelson and Cox 2000). High level of this poisonous metal damages the lungs severely and causes death
Mercury	Damages the brain, causes trouble breathing, birth defect, pneumonia, gum problem, hallucination, memory loss, tremor of hand, tongue and eyelids (NJSDH 2006)
Arsenic	Destroys the blood vessels and causes skin cancer (ON 2000)
Lead	Highly toxic element, its intake leads to lead poisoning which induces changes in porphyrin metabolism and produces clinical symptoms resembling acute intermittent which causes anaemia for it accumulates in the bone marrow where red blood corpuscles are formed (Obioh et al. 1998; Padgett and Corash 1998)

In recognition of the various sources of these pollutants into the petroleum products (Table 2), the internationally recommended dietary range (Table 3) coupled with the consequences of their presence above the upper limits (Table 4), this research work is carried out to study the quantity and effects of these trace metals on cassava flour spread along the roadside obtained from some towns in Nigeria. Samples were taken from five different cites widely spread with different vehicular density within Nigeria (Table 5). Recommendations are also made based on the obtained results.

2 Methodology

2.1 Sample Collection and Preparation

Ten samples were collected at each spot from the corners and centre on a bright sunny day from cassava flour spread to dry. At each city, samples were collected from five different locations and properly mixed to represent a city. To avoid further

Table 3 The source of trace metals into the automobile exhaust

Pollutant	Sources
Lead	Lead alkyl in leaded gasoline as antiknock agent to increase octane number
Zinc	Wear from tyres or brake from automobiles and vehicle exhaust and as a result of zinc containing in its lubricating oil
Manganese	Organic forms of manganese present in automotive gas oil existing as a gasoline additive
Cadmium	Mineral combined with other elements such as oxygen, chlorine or sulphur
Nickel	Usually present as catalyst during refining operations such as catalytic cracking
Cobalt	Deposits from dead plants and animal and also from soil or earth crust
Arsenic	From soil humus and earth crust

Table 4 US recommended dietary allowances

Trace metal	Recommended dietary range/ adequate level (mg/day)	Tolerable upper intake level (mg/day)
Iron[a] (Fe)	6–15	40–50
Cobalt[a] (Co)	3–5	6–10
Copper[a] (Cu)	2–3	4–10
Chromium[a] (Cr)	0.1–1	2–3
Manganese[a] (Mn)	2–5	6–11
Zinc[a] (Zn)	12–15	10–40
Cadmium[b]	0.00	0.00
Arsenic[b]	0.00	0.00
Lead[b]	0.00	0.00

[a]NAS (1998).
[b]Robert et al. (2000).

Table 5 Table showing collection with traffic classification

Sample	Town	State	Traffic classification
1	Lafia	Nasarawa	High traffic density fast movement
2	Owo	Ondo	Moderately high traffic density slow movement
3	Fiditi	Oyo	High traffic density slow movement
4	Ibilo	Kogi	Moderately low traffic density slow movement
5	Sekona	Osun	Traffic density fast movement
6	Control	–	No traffic

contamination during sampling, transport and storage, the cassava flour samples were kept in labelled polyethylene bags.

2.2 Digestion

Each sample was ground to powder to increase the reaction surface area followed by screening to ensure homogeneity. Two grams of each sample was placed in a round bottom flask and 10 ml of concentration Nitric acid was added. The solution was well shaken to ensure even distribution and the solution was heated on an electro mantle consistently between 95–100 °C as observed by the thermometer. More solution of 10 ml concentrated nitric acid was added to the solution after every 15 min until there were no more brown fumes generated from the solution indicating complete digestion of the food sample. The solution was allowed to cool after which 10 ml of concentrated hydrochloric acid was added followed by filtration into the beaker using funnel and filter paper. Distilled water was added to the filtered solution to make up 50 ml solution. This procedure was repeated for each sample and the resulting solutions sent to a laboratory for Atomic Absorption Spectrophotometry (AAS) analysis.

3 Results and Discussion

The analysis results are presented in Table 6 while graphically represented in Fig. 1. Generally speaking, trace metal contents in all the samples are above the recommended dietary level except for the control which was not exposed to such situation. This confirms that the passing–by vehicles contribute enormously to this metallic poisoning.

The level of pollution in sample 3 (Fiditi) is high because there is high traffic density but slow movement on the account of the roughness of the road, the resulting situation creates a rapid vehicular build up which reaches a peak at about 8:00 and 18:00 h. In a situation of high traffic density or 'go-slow' it is most unlikely that smokes from automobile exhaust accumulate on the sample.

Similar trend is observed in sample 1 (Lafia) which also has high traffic density but smooth road. The pollution was not as much as that of Fiditi however for there was no hold-up to encourage accumulation.

In sample 2 (Owo), high pollution value was also recorded because of the moderately high traffic, slow movement and convergence at this area with it's build up and consequent pollution of the atmosphere.

Table 6 Trace metal concentrations of the samples

	Sample					
Trace element	1	2	3	4	5	6
Iron (Fe)	7.20	8.00	12.80	3.10	2.30	0.01
Cadmium (Cd)	0.386	0.28	0.43	0.06	0.31	0.00
Arsenic (As)	5.70	7.20	9.10	7.90	0.41	0.00
Lead (Pb)	17.16	23.41	25.06	11.40	9.86	0.00
Nickel (Ni)	0.40	0.40	0.50	0.90	0.20	0.20
Cobalt (Co)	0.02	0.02	0.07	0.01	0.00	0.00
Copper (Cu)	4.57	4.85	10.00	3.31	2.52	0.01
Chromium (Cr)	0.04	0.02	0.04	0.02	0.00	0.00
Manganese (Mn)	0.32	0.16	0.33	0.19	0.13	0.07
Zinc (Zn)	0.02	0.03	0.04	0.00	0.01	0.00

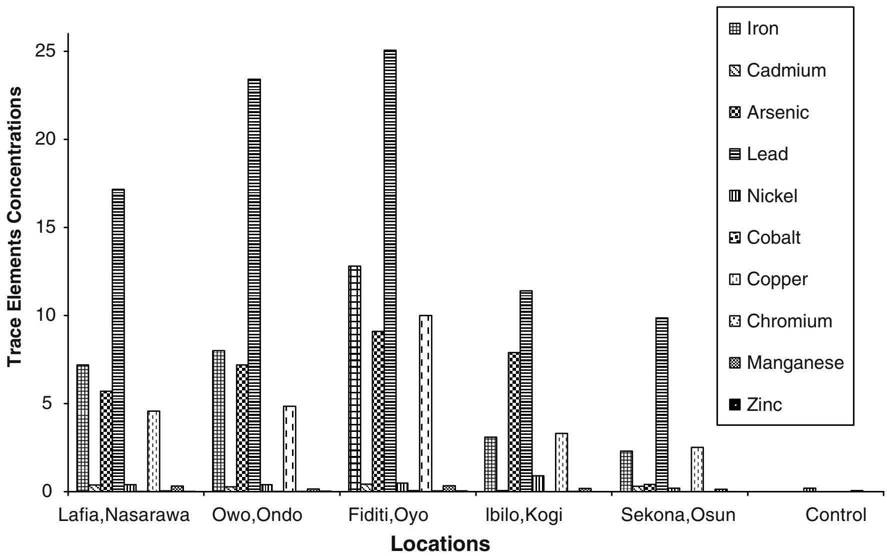

Fig. 1 Trace metal concentration levels against locations

The low values recorded for sample 5 (Sekona) has to do with low traffic density and fast movement because of the large aerial space with low traffic density and for sample 4 (Ibilo) the low value obtained is due to the moderately low traffic density and slow movement of automobile.

4 Conclusion

The results of the study show that concentration levels of some trace metals in cassava flour which is a staple food in Nigeria is very high in three of the study areas and thus may have harmful effect if consumed by humans. The source of these excessive trace metals in the cassava flour could be directly linked to vehicular movement. Areas with high traffic density or 'go-slow' have high concentration levels of some trace metals, whereas, areas with low traffic density have low concentration levels of the trace metals analyzed.

5 Recommendation

Based on this result, it is advisable to discourage people from applying this technique for cassava drying. This could be achieved through public education (e.g. seminars) by making people be aware of the consequences of there actions. While an alternative but cheap drying technique is researched into, fabricated and recommended for their use in replacement. Furthermore, preventive measures such as governmental environmental policies should be put in place and implemented to ensure strict compliance.

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