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Effect of processing on variations of some toxic metals in edible portion of *Dacryodes edulis* (African pear) in Akwa Ibom State, Nigeria

Emmanuel U. Dan and *Uwemedimo E. Udo

Department of Chemistry, Faculty of Science, University of Uyo, PMB 1017, Uyo, Nigeria.

ABSTRACT

Man has benefited greatly by obtaining essential minerals directly when eating fruits in the raw, boiled, or roasted form. In this study, the effect of processing on variations of some toxic metals composition in the edible portion of raw, boiled, and roasted Dacryodes edulis (African pear) fruits grown in different parts of Akwa Ibom State in Nigeria was investigated using atomic absorption spectrophotometry. The mean concentrations (in mg/kg) of these metals were as follows: lead (0.68, 0.50, 0.32), cadmium (0.60, 0.46, 0.40), copper (9.80, 8.00, 9.60), nickel (0.82, 0.46, 0.44) and chromium (0.76, 0.58, 0.52) for the raw, boiled and roasted form respectively. These results reveal that the raw samples contained the highest concentration of the metals followed by the boiled and roasted form. The results so obtained were within the recommended maximum acceptable levels proposed by the joint FAO/WHO Expert committee on Food and are comparable with those available in the literature. This study reveals that processing methods like boiling and roasting have profound effect on the level of accumulation these metals and thus can help to a reasonable extent in reducing the levels of toxic metals in the edible portion of Dacryodes edulis, a fruit consumed in most homes in Africa.

Keywords: Atomic absorption spectrophotometry, *Dacryodes edulis*, edible fruit, processing methods, metals.

INTRODUCTION

Fruits constitute one of the important sources of vitamins to man and animals. The contamination of these fruit by toxic metals due to soil and atmospheric contamination poses threats to quality and safety. It has reported that high concentrations of toxic metals like cadmium (Cd), lead (Pb), mercury (Hg), etc, in edible fruits and vegetables are directly the cause of high prevalence of upper gastrointestinal cancer [1]. Toxic metals accumulate in fruits in different forms and the rate of their mineral uptake is highly influenced by some factors namely: plant species, P^H, cationic exchange capacity (CEC), binding ability to different soil components (clay, oxide, and organic matter), soil texture etc, [2].

Dacryodes edulis is a dioecious; small to medium-sized tree reaching 20 to 25 m high, and it is low branching [3]. The decoction of the leaves of the plant is employed in traditional medicine in the treatment of certain disorders of the digestive tract, toothache and earache. The leaf and stem or stem bark are used to cure dysentery and anaemia [4]. The root bark is used for leprosy in Congo Brazaville [5], while resin from the bark heals scars and other skin problems in Nigeria [6, 7]. In Nigeria, the stem and root are also used as chewing sticks for oral hygiene, while the leaves are employed to cure skin diseases, such as rashes, scabies, ringworm and wound [8, 9]. The fruit and seed of the plant are rich in oil which contains lipid and fatty acid reported to exhibit considerable nutritional value [10, 11].

Different parts of the plant such as the leaf, stem, root and fruit have been reported to produce essential oil of the monoterpene, sesquiterpene, diterpene and triterpene types [6, 12, 13]. Other reports include: antibacterial effect of the essential oil [14], heavy metal levels [15], nutritional composition and microbial spoilage [16], antibacterial constituents of the leaves [17] but there is no report on the effect of processing on variations of toxic metals in the fruit of *Dacryodes edulis*. This paper therefore, posits to study the effect of processing on the variations of selected toxic metals in the edible portion of this highly consumed fruit.

MATERIALS AND METHODS

Fruit collection: Substantial quantities of fruits from African pear (*Dacryodes edulis*) were collected from five (5) different Local government areas within Akwa Ibom State of Nigeria, namely: Ikono (IKO), Eastern Obolo (EOB), Eket (EKE), Ikot Ekpene (IKE) and Uyo. The samples were divided into three (3) groups representing the raw (R_1), boiled (R_2) and roasted (R_3) groups. The fruits were stored in polythene bags, properly identified, labeled appropriately, and taken to the laboratory for appropriate analysis.

Fruit Sample Preparation:
For the Raw group, the fruit samples were scrapped to separate the tissue from the seed. The tissue was then oven-dried at 70 ^oC until a constant weight was achieved. The dried tissue was milled to pass through a 2 mm mesh sieve and kept for digestion. To obtain roasted sample, the sample was roasted in ash and when soft, the edible portion was scrubbed off, milled and oven dried to complete dryness before grinding it into powdery form and kept for digestion. To obtain the boiled group of samples, the fruits were placed in hot water for 10 minutes, when soft, the edible portion was scrubbed off, milled, oven dried, and ground into powdery form and kept for digestion.

Fruit sample digestion:
Most samples require digestion before analysis so as to reduce organic matter interference by destroying all or most of the organic matter present in the sample and to convert all the metals present in the sample into such a form that they can be analyzed by the Atomic absorption spectrophotometer (AAS). Sub-samples of the milled sample were dry-ashed. Dry-ashing of the tissue was carried out by placing 1 g of the finely ground material in a silica dish and placed in a muffle furnace where it was burnt to ash at 180-220 ^oC for 4 hours. It was then cooled and the ash dissolved in 5ml of 2N HNO_3, filtered into a 50ml volumetric flask and diluted to volume with distilled water. A blank was also prepared following the same procedure but the fruit sample was not added.

Determination of toxic metals in the fruit samples:
The sample digests of the fruits were analyzed for lead, cadmium, copper, nickel and chromium by Atomic Absorption Spectrophotometry (AAS) equipment (MODEL GBC Aranta Pm) according [18] and [19]. Suitable working blanks were prepared from the solutions used in digesting the samples. Necessary dilutions were made using distilled water so as to bring the concentrations of the metals into suitable concentration range. Readings were then taken from the equipment.

RESULTS AND DISCUSSION

The results of levels (mg/kg) of lead (Pb), cadmium (Cd), copper (Cu), nickel (Ni) and chromium (Cr) in the edible portion of *Dacryodes edulis* obtained from different locations Akwa Ibom State, Nigeria is shown in table 1. The result is very interesting as most of the sample analyzed recorded permissible limits for fruits as specified by national and international regulations on food quality [20]. The raw samples of the fruit in all cases had the highest level of the metals investigated except for chromium (Cr) in EKE. Copper and Nickel recorded the highest level of 12.0 mg/kg and 1.12 mg/kg respectively.

The levels of lead (Pb) in all the samples analyzed were between 0.9 mg/kg and 0.1 mg/kg. Although the level of lead decreases in the order $R_1 > R_2 > R_3$ in all cases, sample UYO had the highest level of 0.9 mg/kg Pb. This may be attributed to the rapid increase in pollution occasioned by industrial activities which emanate from indiscriminate dumping of lead-containing waste in the soil where the fruits were obtained [21]. The result reveals that the level of Pb was reduced in R_2 and R_3. This may be attributed to the presence of nitrate in water and ash where the fruit was processed. Nitrate renders sulphate very soluble and dissolves into the aliquot of the processing medium (water, ash), and thus reduce the level of Pb.

Cadmium (Cd), like mercury (Hg) is a non-essential element in foods and waters and it is always accumulated in kidney and liver. R_1 in EKE sample had the highest content of 0.90 mg/kg Cd. Although the amount is high, the reason is not far-fetched as it is primarily due to environmental contamination by heavy industries situated in that study area. Various values have previously been reported for Cd in this fruit which include 0.22 and 0.31mg/kg [19] and [22] respectively The result in table 1 reveals that the level of cadmium in the samples showed a similar trend as that of lead except IKE samples where $R_3 > R_2 > R_1$. Like mercury oxide (HgO), Cadmium oxide decomposes when subjected to high temperature (> 220 ^{o}C) to give free cadmium [23] made available for detection. Excess of Cadmium has been reported to cause renal tubular dysfunction accompanied by osteomalacia (bone softening) and other complications which can lead to death [24-26].

Copper though needed in our body and daily food can be harmful if present in excess amount as it acts as a hemolytic agent [27]. Copper is widely distributed in food and is the prosthetic group of some enzymes e.g. phenols, oxidase, and ascorbic acid oxidase. It causes acceleration in the rate of reversion of true rancidity in fat. The concentration of Cu in all the samples tested is in the range of 6.0 and 13.0 mg/kg; with R_3 in EOB having the highest. Although the trend does not follow a particular pattern, the concentration of the metal in most cases seems to be higher in R_3 than R_1 and R_2. This may be due to the fact that during processing, the media used (water and ash) added some amount of copper to the sample, hence increasing its concentration. Also, it could be due to the form the element is present. As CuO, it decomposes during boiling, and roasting thereby setting the metal in free form for detection by the instrument.

The result for Ni in all cases studied were similar except for IKE, which shows that the metal content was highest in R_1, followed than others (table 1). The range was between (0.10 – 1.20) mg/kg with sample R_1 from EKE recording the highest. This result is consistent with 0.80 mg/kg - 1.82 mg/kg reported in other fruits and vegetables from same locations [28]. The result also shows that apart from EKE, UYO also recorded high concentration of this metal. This can be accredited to the indiscriminate dumping of sewage sludge, large scale use of PVC plastics, nickel – cadmium batteries into the soil where this fruit is planted. It can also be observed from the result that, processing of pear via boiling or roasting can reduce the level of Ni content. Although the level of this metal in the sample studied has not reached or exceeded the toxic limit (i.e. values are < 1.3 mg/kg) by), periodic assessment should be encouraged to avoid bio-accumulation and the likely consequences [29].

Levels of chromium in the samples analyzed followed the trend of Ni, except for EKE. The range lies between 0.30 mg/kg in R_3 (UYO) and 1.00 mg/kg for R_1 (EOB). Although the levels of chromium in all the samples studied were within the WHO acceptable limit (0.4 – 1.00 mg/kg), it can be inferred that the concentration reduced during processing either by boiling or roasting. High concentration of chromium in fruits can cause dermatitis and even kidney and lung cancer. Similar results have been obtained for chromium in the case of raw *Solanum incanum* (bitter apple) which recorded 1.60 mg/kg while the boiled form had 1.56 mg/kg Cr [22].

Table 1: Levels (mg/kg) of copper (Cu), lead (Pb), cadmium (Cd), nickel (Ni) and chromium (Cr) in *Dacryodes edulis* from Akwa Ibom State, Nigeria.

		COPPER (Cu)			LEAD (Pb)			CADMIUM (Cd)			NICKEL (Ni)			CHROMIUM (Cr)		
LOCATION	**MC (%)**	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
IKO	56.61	0.30	0.20	0.10	0.20	0.20	0.10	9.00	5.00	6.00	0.50	0.20	0.10	0.80	0.60	0.50
EOB	62.60	0.60	0.50	0.20	0.80	0.50	0.50	10.00	11.00	13.00	0.80	0.60	0.40	1.00	0.70	0.50
EKE	47.79	0.80	0.40	0.20	0.90	0.70	0.60	10.00	12.00	11.00	1.20	1.10	1.00	0.60	0.80	0.90
UYO	71.01	0.90	0.60	0.50	0.80	0.50	0.30	12.00	10.00	11.00	1.00	0.80	0.20	0.70	0.50	0.30
IKE	54.75	0.80	0.80	0.60	0.30	0.40	0.50	8.00	6.00	7.00	0.60	0.60	0.50	0.70	0.60	0.40

MC (%) = moisture content of the pear before processing; R_1 = Raw, R_2 = Boiled, R_3 = Roasted.

CONCLUSION

Man has benefited greatly by obtaining essential minerals directly when eating fruits like *Dacryodes edulis* (African pear) in the raw, boiled, or roasted form. In this work, the effect of processing on variations of some toxic metals (Pb, Cd, Ni, Cu and Cr) composition in the edible portion of raw, boiled, and roasted *Dacryodes edulis* (African pear) fruits grown in different parts of Akwa Ibom State in Nigeria was studied using atomic absorption spectrophotometry. The mean concentrations (in mg/kg) of these metals showed that the raw samples contained the highest concentration of the metals followed by the boiled and roasted form. The results obtained have been shown to fall within the recommended maximum acceptable levels proposed by the joint FAO/WHO Expert committee on

Food and are comparable with those available in the literature. The decrease in levels of the metals in the processed samples is attributed to the component of the processing medium which enhances reduction of metal contents in the fruits. Although sample location, soil pollution and other factors may also be responsible for the variation in levels of these metals, this study further confirms that processing methods like boiling and roasting have profound effect on the level of these metals and thus can help in reducing the levels of toxic metals in *Dacryodes edulis*.

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