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Evaluation of chemical composition of *Dacryodes edulis* (african pear) seed oil at different stages of fruit maturation

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Nutritional and industrial processes have increased the demand for oils and this in turn has led to the search for oils from different types of seeds for possible development and use. It is in this vein that the fruit pulp of *Dacryodes edulis* was extracted with n-hexane (soxhlet extraction at 65°C). The proximate composition, antinutrient and mineral content of freshly harvested *D. edulis* fruit pulp from 4 weeks after anthesis (WAA) to fruit maturation were assessed in this study. Data obtained for the proximate composition at matured stages of fruit development revealed high amount of fat (53.4 ± 1.35%; moisture (47.2 ± 1.20%); crude protein (17.0 ± 0.48%); carbohydrate (21.70 ± 0.98%); low crude fiber (1.60 ± 0.75%) and ash content (8.0 ± 0.81%) which contained higher amount of minerals such as of Fe (62.71 ± 0.34 ppm), Mn (21.05 ± 0.18 ppm), Cu (10.12 ± 0.17 ppm) and low in Pb (6.17 ± 0.13 ppm), Ni (1.8 ± 0.56 ppm), Ca (0.41± 0.07%), Cr and Cd were not detected throughout the development stages at 20 WAA as compared to immature stages of 4, 6, 8, 10, 12, 14 and 16 WAA. The level of antinutrient factors are oxalate (5.2 ± 0.91 mg/100 g); phytate (0.32±0.02 mg/100 g) and cyanogenic glycosides (0.14 ± 0.02) which recorded lower content, except tannins (82.11 ± 0.33) mg/100 g which recorded significant ($p < 0.05$) higher content at 20 WAA when compared with immature stages in 4, 6, 8, 10, 12, 14 and 16 WAA. This study revealed the nutritional profile of the fruit pulp as good sources of plant protein, carbohydrate and fat, with a reduction in the level of some anti-nutrients in matured fruits which are potentials that could be exploited by food and pharmaceutical industries.

Key words: *Dacryodes edulis*, proximate, antinutrient, n-hexane, anthesis.

INTRODUCTION

In Africa,fruits are in high demand, and this is because they are complemented with food to ensure a balanced diet. Fruits serve as sources of fat,carbohydrate, vitamins and minerals hence, they also become important when

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important when the functions of these nutrients are being considered in the body (Olusanya, 2008). Fat and oil are used in a variety of ways, for food texturing, baking and frying, and also used industrially, in the manufacture of soap, detergent, cosmetics and oil paints. In plants, oil is deposited in the seeds mostly in the endosperm along with carbohydrates where they jointly nourish the embryo (Ajibesin et al., 2008). It is also found in some plants mesocarp (palm fruits). Nutritional and industrial processes have increased the demands for oils and this in turn has led to the search for oils from different types of seeds (Ajibesin et al., 2008).

Dacryodes edulis (also called African plum, African pear or Safou) is an indigenous fruit tree in the humid lowlands and plateau regions of West, Central African and Gulf of Guinea countries. *Dacryodes edulis* belongs to the *Burseraceae* family (Kengue and Nyagatchou, 1990; Anonymous, 2011a). It is an evergreen tree indigenous to the central Africa and Gulf of Guinea regions. The genus name is derived from the Greek word '*Dakruon*'(a tear) in reference to the resin droplets that appears on the bark surface of its species. The species-specific name *edulis* means edible (Kengue and Nyagatchou, 1990; Anonymous, 2011a). The genus *Dacryodes* comprises about 40 species, occurring in the American, Asian and African tropics. In Africa, about 20 species have been described (Anonymous, 2011b). In Southeast Nigeria, the trees are grown around homesteads and flowering takes place from January to April. The major fruiting season is between May and October (Kengue and Nyagatchou, 1990). The role of fruits to a healthy and nutritious diet, the world over is a well-established fact. *D. edulis* is a tree cultivated widely for its edible and nutritious fruits. Generally, the fruit may be cooked in hot water, or roasted/baked in an oven at about 50°C. The cooked fruit can be eaten with maize, plantain, cassava, cocoyam, bread, etc.

The entire plant of *D. edulis* has pharmaceutical properties that are variously exploited by many African communities (Kengue, 2002). Oral treatment against leprosy and it is also gargled as mouthwash for the treatment of tonsillitis. In the western parts of Cameroon, the bark is crushed and used in concoctions against dysenteries while in central Cameroon, the bark is used to treat a toothache. The leaves are boiled in combination with *Lantana camara*, *Cymbopogon citratus* and *Persea Americana*, yielding a steam bath taken to treat fever/headaches and malaria in the Republic of Congo. The leaves made into a plaster have been recently reported to treat snake bites in South West Cameroon (Jiofack et al., 2010). The leaves are also crushed and the resultant juice used to treat skin diseases such as scabies, ringworm, rashes, while twigs from branches are sometimes used as chewing sticks (Igoli et al., 2005; Ajibesin et al., 2008; Okwu and Nnamdi, 2008). The leaves and seed are used in Nigeria for animal feed (Ajibesin et al., 2008). The resin from the bark has long been reported to treat parasitic skin diseases and jiggers in Nigeria, whereas when applied in lotions and body creams it smoothens the skin. The resin is also used in some communities as incense and is believed to send off evil spirits in Nigeria (Sofowora, 2008). *D. edulis* is one of the tropical trees whose fruits contain oils in its pulp and seed kernel. The pulp which is commonly eaten raw or cooked; it is also usually processed for the constituent oil which is popularly referred to as *atile* oil in some parts of Nigeria, using cold-pressed method of oil extraction. The properties and qualities of the oil have been investigated to some extent (Danjouma et al., 2006) and the oils have been shown to have potential industrial uses in production of pharmaceutical and personal products and, as a thermal fluid among others (Ajiwe et al., 1998). However, unlike some other oil-bearing materials such as groundnut, soyabean, palm pulp and palm kernel, the extraction of oils from elemi pulp and kernel are not being carried out at commercial level at present, despite ready availability of the fruit in large quantity in Nigeria and elsewhere in sub-Sahara Africa. This situation would improve if information on the composition and safety consumption of the pulp oil are available. Hence, this present study investigated the proximate, antinutritive and mineral composition of *D. edulis* fruit pulp at different stages of fruit development.

MATERIALS AND METHODS

Matured fruits of *D. edulis* were collected from private farmland in Ondo Town, Ondo State, Nigeria. The fruits were authenticated by the Department of Botany, University of Medical Sciences, Ondo. A voucher specimen of each plant was thereafter deposited in the herbarium of the same department. The plant grows in tropical climate and flower at the beginning of the rainy season (January – April) and bears fruit during 2-5 months after flowering (May – October).

Preparation of sample

Forty fruits were collected randomly (to provide enough fruits for oil extraction) from each of the studied trees (of between 4-8 years old) at biweekly intervals starting from the fourth week after fruit set until senescence. The collected fruits which were of variable sizes (4 to 12cm), dark-blue to violet in color and the pulp were 3.5 to 9.0mm thick, were cleaned with a moist soft cotton wool and then the seeds were carefully separated from the fruits. Part of the separated nuts was immediately used for oil extraction, while the remaining part was dried at 65°C for 4 h in an oven, crushed with a laboratory mortar and pestle and kept in a well-labelled airtight polyethylene bags or screw-capped bottles at 4°C for subsequent biochemical analysis.

All reagents used were of analytical grade purchased from Sigma Chemicals Co, London, and BDH Chemicals Ltd., England.

Extraction of oil

The soxhlet extraction method was employed. The sample (5 g)

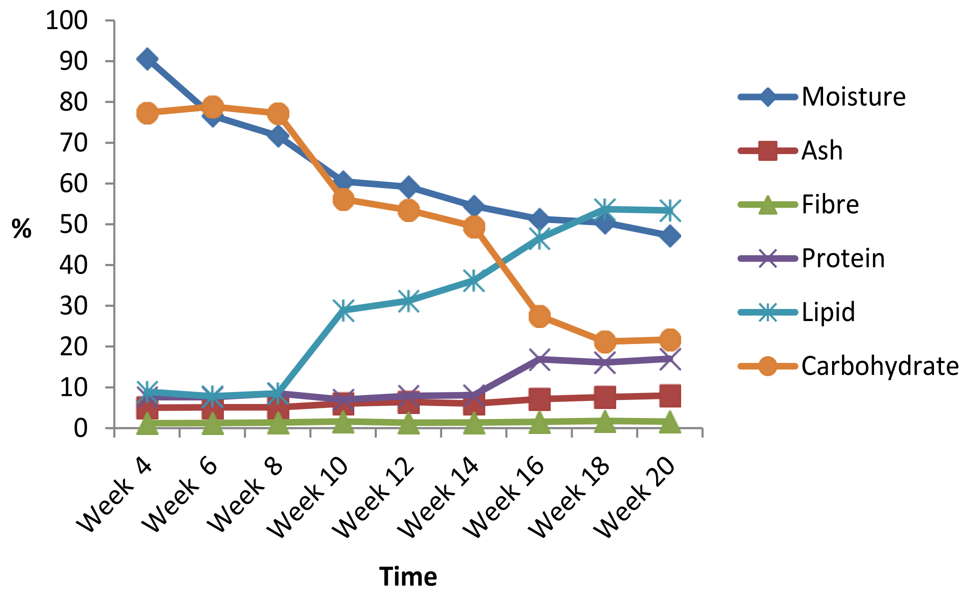

Figure 1. Proximate composition of *D. edulis* 4-20 WAA of fruits development. Values are mean ± SEM (* = P<0.05).

was weighed into a weighed filter paper and folded neatly. This was placed inside the pre-weighed thimble (W_1). The thimble with the sample (W_2) was inserted into the soxhlet apparatus and extraction under reflux was carried out with the n-hexane (40-60°C boiling range) for 6 h. At the end of extraction, the thimble was dried in the oven for about 30 min at 100°C to evaporate off the solvent and was cooled in a desiccator and later weighed (W_3). The percentage fat extracted from a given quantity of sample was then calculated.

Calculations

% Crude fat (W/W) = [LOSS IN WEIGHT SAMPLE [($W_3 – W_1$) **/** original weight of sample ($W_2 – W_1$)] x 100

Proximate composition analysis

The proximate compositions of the wet and dry samples are analyzed for the moisture content, carbohydrate, crude lipids, protein, ash and crude fiber by the methods of the Association of Official Analytical Chemists (AOAC, 1990).

Antinutrient screening

Quantitative phytochemical analyses of anti-nutrients were determined using the methods of Sofowora (1993). The mineral content was according to methods as described by AOAC (1990). All determinations were done in duplicates.

Statistical analysis

All the experiments were done in triplicates. The mean and standard deviations were reported. Data were subjected to analysis of variance (ANOVA). Significance of mean difference was determined using least significant difference (LSD).

RESULTS

The proximate composition of *D. edulis* fruits are shown in Figure 1. The *D. edulis* fruits were found to have a higher amount of lipids, carbohydrate and ash content at the matured stage of fruits development (Table 1).

The levels of iron (Fe), manganese (Mn), chromium (Cr), nickel (Ni), lead (Pb), cadmium (Cd) and copper (Cu) in *D. edulis* are shown in Figure 3. The results show that Fe and Mn have the highest levels, while Cr and Cd were not detected from immature to matured fruits (Table 2).

The results (Figure 2) reveal that the levels of phytate, oxalate and hydrocyanic acid were very low in concentration and tannin was higher when compared with the other anti-nutritional factors assessed (Table 3).

DISCUSSION

Determination of the proximate composition of plants is important because it predicts the profitability of a given plant as potential source of nutrients. High oil content in plant seeds implies that processing them for oil would be economical (Ikhuoria et al., 2008). The oil yield found in the studied plants compares favorably well with the oil yields reported for some commercial plant oils such as

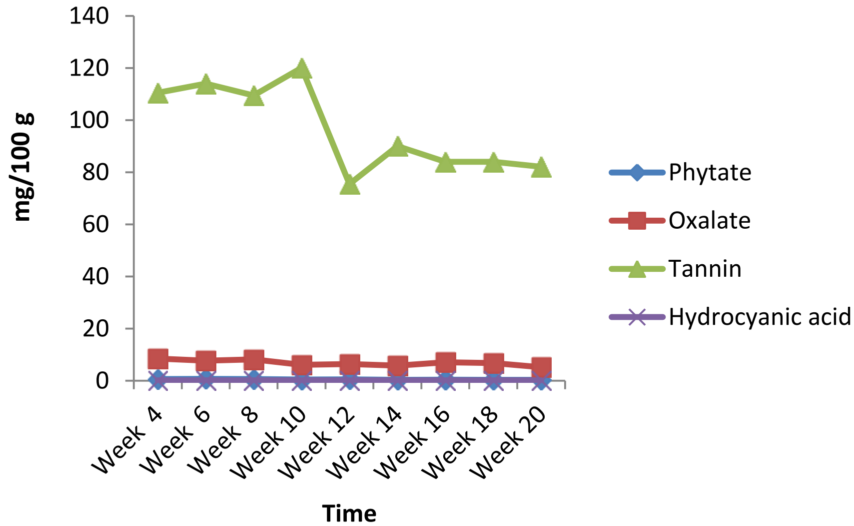

Figure 2. The anti-nutritional content of *D. edulis* 4-20 WAA of fruits development. Values are mean ± SEM (* = P<0.05).

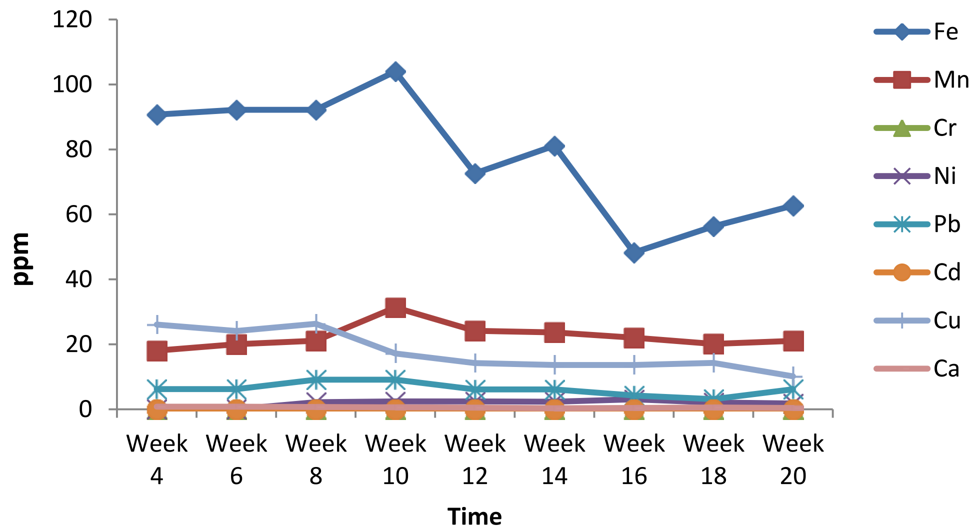

Figure 3. The elemental content of *D. edulis* 4-20 WAA of fruits Development. Values are mean ± SEM (* = P<0.05).

cottonseed (36%), groundnut (40%), oil palm (22%) and corn oil (3.4%) (Rossel, 1987; Edem et al., 2009).

The fat content (within 4th and 10th WAA) showed slight variation but increased rapidly as the week increases for both plants. This suggests a slow formation of the chemical constituents during the fruit development (Nwosuagwu et al., 2009). An increase in the fat content from the (12th – 20th WAA) showed full maturity. This agreed with earlier findings by Nwosuagwu et al. (2009) and Fonteh et al. (2005), which correspond to the period of significant external color change (blue-black). This results supports the fact that *D. edulis* pulp are relatively richer source of lipids than other conventional sources such as soybean (17.0 to 20.0%), oil palm (20 to 22%) and cotton seed (28 to 32%), and can replace some in culinary uses (Mbofung et al., 2002).

The moisture content (on a wet weight basis) of *D. edulis* fruit pulp decreases with maturation and was consistent with earlier studies (Nwosuagwu et al., 2009; Nwaoguikpe et al., 2012). The decrease in the moisture

Table 1. Proximate composition of the *D. edulis* at different stages of fruit development.

Week	Moisture content (%)	Ash content (%)	Fibre Content (%)	Protein content (%)	Lipid content (%)	Carbohydrate content (%)
4	90.7 ± 2.04	5.0 ± 0.009	1.22 ± 1.29	7.6 ± 0.91	8.9 ± 2.01	77. 38 ± 0.93
6	76.6 ± 1.10	5.1 ± 0.13	1.26 ± 0.68	7.5 ± 1.70	7.8 ± 1.88	78.84 ± 0.86
8	71.7 ± 0.93	5.1 ± 0.94	1.36 ± 0.39	8.5 ± 1.34	8.5 ± 1.13	77.24 ± 1.74
10	60.5 ± 0.99	6.0 ± 0.31	1.64 ± 0.82	7.0 ± 2.11	28.9 ± 0.99	56.16 ± 1.81
12	59.2 ± 1.8	6.4 ± 1.01	1.32 ± 0.86	7.9 ± 0.79	31.2 ± 1.71	53.47 ± 2.35
14	54.5 ± 0.46	6.0 ± 0.38	1.39 ± 0.79	8.1 ± 0.09	36.2 ± 2.81	49.51 ± 1.81
16	51.3 ± 1.31	7.1 ± 0.61	1.56 ± 0.23	16.9 ± 0.86	46.5 ± 0.57	27.54 ± 1.36
18	50.4 ± 0.84	7.6 ± 0.37	1.76 ± 0.44	16.1 ± 1.33	53.7 ± 1.76	21.24 ± 2.04
20	47.2 ± 1.20	8.0 ± 0.81	1.60 ± 0.75	17.0 ± 0.48	53.4 ± 1.35	21.70 ± 0.98

Data are the average of 3 replicates ± SE

Table 2. Elemental composition of the *Dacryodes edulis* pulp at different stages of development.

Week	Fe (ppm)	Mn (ppm)	Cr (ppm)	Ni (ppm)	Pb (ppm)	Cd (ppm)	Cu (ppm)	Ca (%)
4	90.71 ± 0.13	18.04 ± 0.34	Nd	Nd	6.18 ± 0.08	Nd	26.07 ± 1.21	0.809 ± 0.09
6	92.19 ± 0.05	20.04 ± 0.04	Nd	Nd	6.22 ± 0.13	Nd	24.08 ± 0.31	0.804 ±0.11
8	92.07 ± 0.47	21.08 ± 0.10	Nd	2.17 ± 0.17	9.11 ± 0.48	Nd	26.31 ±0.81	0.685 ±0.08
10	104.0 ± 0.34	31.32 ± 0.44	Nd	2.41 ± 0.4	9.13 ± 0.06	Nd	17.17 ± 1.21	0.601 ± 0.04
12	72.61 ± 0.03	24.14 ± 0.08	nd	2.41 ± 0.4	6.08 ± 0.04	Nd	14.24 ±0.31	0.50 ± 0.09
14	81.11± 0.41	23.64 ± 0.14	Nd	2.33 ± 0.56	6.08 ± 0.02	nd	13.62 ± 0.43	0.314 ± 0.01
16	48. 22± 0.07	22.04 ± 0.34	nd ±	3.07 ± 0.41	4.22 ± 0.008	Nd	13.71 ± 0.31	0.424 ± 0.01
18	56.28 ± 0.81	20.11± 0.10	Nd	2.07 ± 0.07	3.08 ± 0.14	Nd	14.28 ± 1.03	0.557 ± 0.07
20	62.71 ± 0.34	21.05 ± 0.18	Nd	1.80 ± 0.56	6.17 ± 0.13	Nd	10.12 ± 0.17	0.411± 0.07

Data are the average of 3 replicates ± SE; Nd= not detected.

content and the concomitant increase in the fat content in the studied plants demonstrated a close negative trend and showed that the two constituents remained negatively constant for fruits widely differing in oil content (Bezard et al., 1991). In this study, the crude protein content of *D. edulis* extracts (within 4 -20 WAA) significantly increased (p< 0.05).

The crude protein value at 20 WAA agrees with the results of Nwosuagwu et al. (2009) and Kinkela et al. (2006). In contrast, it is higher than the range values (24.0 to 60.0%) reported by the authors (Ayuk et al., 1999; Mbofung et al., 2002). The variation in the present study and those reported by earlier studies could be attributed to the difference in the methods of analysis employed, genetic makeup and racial origin of the fruit (Silou, 1996). This equally emphasized the rich source of the fruits in plant proteins with a high content of available lysine [27.0 – 39.0 mg/100 g protein (Mbofung et al., 2002)].

The crude fiber content significantly increased (p<0.05) with an increase in development but had a slight variation (within 4 and 14 WAA), suggesting a period of slow formation of the indigestible carbohydrate. The fibre content within weeks 16 and 20 WAA were lower than that previously reported (Nwosuagwu et al., 2009). The state of development at the time of harvest and geographical growth location of the fruit plant could influence variation (Itoh et al., 1975).

D. edulis fruit pulp ash content showed an increase as the fruit increase in maturity, although a slight variation occurs at the early stage of maturity. This agrees with previously reported works on the plant (Fonteh et al., 2005). The carbohydrate content decreased (P<0.05) with maturation. The metabolism of the polysaccharides in the cell starch hydrolysis which contribute to the increase in the total sugars observed in climacteric fruits could have been responsible for this decrease (Biale and Young, 1962). Also, the decrease may be attributed to the changes in the quantity of cell wall materials during ripening (Nwosuagwu et al., 2009).

The most common antinutritional factors in fruits are oxalate, tannins, phytic acid and hydrocyanic acid

Table 3. Anti- nutritional composition of *Dacryodes edulis* pulp at different stages of fruit development.

Week	Phytate (mg/100 g)	Oxalate (mg/100 g)	Tannins (mg/100 g)	Hydrocyanic (mg/100 g)
4	0.66±0.11	8.5±0.91	110.53 ± 0.66	0.16 ± 0.04
6	0.67±0.11	7.7±0.51	114.1± 0.83	0.15 ± 0.04
8	0.61± 0.04	8.2±0.46	109.50 ± 0.16	0.15 ± 0.01
10	0.42±0.01	6.1±0.31	120.12 ± 0.6	0.17 ± 0.06
12	0.54±0.01	6.4±0.13	75.51 ± 0.87	0.13 ± 0.03
14	0.32±0.03	5.8 ± 0.84	90.03 ± 0.31	0.14 ± 0.03
16	0.36±0.08	7.1 ± 0.46	84.00 ± 0.41	0.14 ± 0.01
18	0.30±0.01	6.8 ± 0.01	84.10 ± 0.94	0.14 ± 0.02
20	0.32±0.02	5.2 ± 0.91	82.11 ± 0.33	0.14 ± 0.02

Data are the average of 3 replicates ± SE.

(Ibanga and Okon, 2009). A daily intake of 450 mg/100 g of oxalic acid has been reported to reduce the bioavailability of such metal as calcium. Phytic intake (4.00 – 9.00mg/100g) reduces iron (Fe) absorption by 4-5 folds in humans (Ibanga and Okon, 2009). The anti-nutrients compositions of *D. edulis* fruit pulp were generally low. In matured fruits (20 WAA), phytate and cyanic levels were low. These are in agreement with the results obtained from previous work (Ibanga and Ekon, 2009). But it should be noted that the concentration of anti-nutrients are reduced during processing and as such, there might be a reasonable concentration of anti-nutrients in raw fruits that make consumption of the raw fruits harmful to health. It is therefore, safe to consume the fruits when cooked or boiled (Akwaowo et al., 2000; Ibanga and Ekon, 2009). As seen in the results, the immature fruits contain higher levels of these anti-nutrients than the matured. It may be unsafe to consume immature fruits of *D. edulis.* The oxalate concentration in D. edulis was within normal range as stipulated by WHO throughout the maturation period (Udosen and Ukpana, 1993).

In the elemental study, the results reveal that the fruits of *D. edulis* did not contain chromium (Cr) and cadmium (Cd) throughout the maturation of the fruit, but traces of lead (Pb) and nickel (Ni) were detected in the studied plants which were below the maximum permissible level (Table 2). According to WHO, the permissible limit of lead is 10 ppm, cadmium 3.0 ppm and chromium 2 ppm (WHO, 1991). Iron (Fe) content was prominently higher than all the metals analyzed in the fruit, followed by manganese (Mn), copper (Cu) and calcium (Ca) in *D. edulis* fruit pulp. Cu plays an important role in the metabolism of Fe and as a cofactor in the enzymatic systems. Cu deficiencies lead to impairment of Fe absorption. In severe cases of copper deficiency, the development of anemia has been documented (James, 2009). Mn in fruits shows that *D. edulis* can be used to treat bones disease (James, 2009). On the basis of the results of this study, *D. edulis* fruit is rich sources of Fe, Cu and Mn. Hence, this fruit having these trace elements are helpful in maintaining various functions of human body.

The presence of heavy metals in fruits can cause serious diseases to the consumers. Pb causes adverse effects on physiological and behavioral activities in living beings. Its chronic toxicity causes kidney dysfunction, osteomalacia and obstructive lung disease (IARC, 1994). Cadmium is another carcinogen associated with the risk of serious health hazard (IARC, 1994). Liver and kidney are considered as the main target organs in acute and chronic Cd exposure (Asagba and Obi, 2003). On the basis of the low heavy metal content of the studied plant, this makes the fruit pulp safe for consumption which is in agreement with previous findings.

Conclusion

D. edulis pulp oil is consumed to a limited extent in Nigeria but of which no large-scale use is off, partly because there is little information on their nutritive values. These oilseeds can be exploited as sources of edible and industrial oils. Furthermore, this study has shown that the pulp oil is comparable to other currently used vegetable oils, and has satisfactory nutritional value.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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