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# Proximate, mineral and antinutrient composition of dika nut (*Irvingia gabonensis*) kernel

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**ABSTRACT**

Proximate composition, mineral composition and anti-nutrient factors were determined in the hull and cotyledons of the kernel of dika nut (*Irvingia gabonensis*) on dry weight basis. Higher values (g/100 g) protein, fat, ash, fiber, dry matter, fatty acid and calorific value were recorded in the cotyledon. In minerals, the levels in cotyledon were higher than hull in (mg/100 g): Na, K, Ca, Mg, Zn, Cu, Mn, Co, Fe, Cd, Ni, and P and in [K (Ca + Mg)], Ca/P and Ca/Mg. In the anti-nutrients, hull was higher in tannin, oxalate, phytate, phytin phosphorus, saponins, alkaloids and phytin phosphorus as a percentage of total phosphorus. The levels of Phy: Zn, Ca: Phy and Ca: Phy/Zn was good enough in the hull and cotyledon for the body to absorb calcium and zinc for its physiological activities. Significant differences existed between the hull and the cotyledon in all the parameters determined with high positive $r_{xy}$ at $r_{=0.05}$.



## Introduction

*Irvingia gabonensis* (locally called *Oro*) belongs to the Ixonanthaceae family[1], formerly in the Irvingiaceae family. *Irvingia* Hook f (after Dr E G Irving, R N, who died at Abeokuta, Nigeria in 1855). *Irvingia gabonensis* (O' Rorke) Baill is the wild mango or dika nut, with mango- like fruits[2]. *I gabonensis* requires well drained clay, loamy soil rich in humus. The tree grows to an average height of 15-20 m. It flowers and produces fruit between November and January. The harvesting period is between April- June, the fruit is picked by hand or plucked with a sickle. Two varieties have been identified as follows: var *gabonensis*, fruits with sweet edible scantily fibrous pulp, bole fluted or cylindrical; lateral branches ascending, making the crown spherical or narrow; and var *excelsa* (Mildbr) Okafor, fruits with bitter inedible very fibrous pulp; bole buttressed; lateral branches horizontal, making a wide umbrella – shaped crown[2].

The fruit is widely used as a complement to other foods in most parts of southern Nigeria. Its kernels are a major raw material in the preparation of *ogbono* soup or as a condiment in the preparation of sauces used with African foods prepared from major staples such as *amala, eba*, pounded yam, etc.[3]. Some reported pioneering work on the uses were[4], ecological studies[5, 6]; other works included the nutritional studies of pulp and kernel[3] and nutritional value of the pulp[7].

In this work, the followings were determined in kernel hull and cotyledons of *I gabonensis:* proximate composition; energy values as contributed by protein, fat and carbohydrate; mineral composition, some anti-nutrient factors and the calculated Phy: Zn, Ca: Phy and Ca: Phy/Zn. This type of work is important because the hull is often wasted during the drying process of the kernel; this work was therefore carried out to see if food nutrients were wasted in the process. This type of comparative work had not been reported for this seed earlier.

## Materials and methods

### *Sampling*

Dried kernels of *I gabonensis* were purchased at the market in Lokoja, Nigeria.

### *Sample treatment*

The kernels were brought into the laboratory, all foreign matters (e g stone) were removed; immature kernels removed, dehulled to separate hull and cotyledons and further oven-dried at 55 $^0$C for 5 h. The cooled dried samples were ground using mortar and pestle into a fine powder, kept in plastic rubbers in the freezer (-4 $^0$C) pending analysis.

### *Proximate composition analysis*

The samples were analyzed for proximate composition (moisture, ether extract, fiber and ash)[8]. Nitrogen was determined by the micro-Kjeldahl method[9] and the percentage of nitrogen was converted to crude protein by multiplying by 6.25. Both soluble carbohydrate and organic matter were determined by differences. The calorific values were obtained by multiplying the carbohydrate, protein and crude fat by the Atwater factors of 17, 17 and 37 respectively[10]. The crude fat was converted into fatty acid by multiplying with conversion factor of 0.80[11].

### *Mineral analysis*

The minerals were analyzed from solutions obtained by first dry ashing the samples at 550 $^0$C. The Na and K contents were determined by Flame photometry (Jenway Ltd, Dunmow, and Essex, UK) and P by Vanado-molybdate method[8]. Ca, Mg, Fe, Zn, Cu, Mn, Co, Cd and Ni were determined using atomic absorption spectrophotometer (Buck Scientific, East Norwalk, CT, USA).

### *Tannin quantification*

Tannin determination was as described by Makkar and Goodchild[12].

### *Phytin and phytin-phosphorus analysis*

Phytin–phosphorus was determined and phytin content was calculated by multiplying the value of phytin-phosphorus by

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3.55[13]. Each milligram of iron is equivalent to 1.19 mg of phytin-phosphorus.

***Oxalate analysis***

The method of Day[14] was used to determine oxalate.

***Flavonoid determination***

This was done by the method of Bohm and Kocipai-Abyazan[15].

***Saponin determination***

The method used was that of Oguntokun *et al*[16].

***Alkaloids determination***

The method of Harborne[17] was used in this determination.

All determinations were done in duplicate.

***Other calculated parameters***

The energy values as contributed by protein, fat and soluble carbohydrate of the samples were reported as follows: percentage proportion of total energy due to protein (PEP %), percentage proportion of total energy due to fat (PEF %), percentage proportion of total energy due to carbohydrate (PEC %) and percentage utilizable energy due to protein (UEDP %). In the minerals, the following ratios were calculated: [K/ (Ca + Mg)] in milliequivalent, Na/K, K/Na, Ca/P and Ca/Mg for all the samples[18]. The Phy: Zn, Ca: Phy and Ca x Phy: Zn values were calculated[19].

***Statistical analysis***

All data generated were analyzed statistically[20]. Calculated for were the mean (X and Y), standard deviation (SD) and coefficient of variation percent (CV %). Subjected to further analysis were the hull/cotyledon for the determination of linear correlation coefficient ($r_{xy}$), coefficient of determination ($r_{xy}^2$) (or degree of association), linear regression coefficient ($R_{xy}$), coefficient of alienation ($C_A$) or lack of relationship and index of forecasting efficiency (IFE). To see if any significant relationship existed in any of the parameters among the samples, the $r_{xy}$ was compared with the table value (critical value) at $r_{=0.05}$ and n-2 degrees of freedom.

**Results and discussion**

***Proximate composition***

Table I shows the proximate composition of the samples. Generally the values were close when compared on pair wise basis as seen in the levels of the coefficient of variation percent (CV %) with their range from 0.07-10.9. However, levels of protein, fat, ash, fiber, dry matter, calculated fatty acid and energy (or 7/10, 70 % of the parameters) were higher in the cotyledons whilst soluble carbohydrate, moisture and organic matter (or 3/10, 30 % of the parameters) were higher in the hulls; incidentally carbohydrate was the most varied (10.9 %) whereas organic matter was the least varied (0.07 %).

**Table I. Proximate composition (g/100 g) of the seed hull and cotyledon *I gabonensis* (dry weight)**

| Parameter | Hull | Cotyledon | Mean | SD | CV % |
|---|---|---|---|---|---|
| Crude | 17.9 | 19.6 | 18.8 | 1.20 | 6.41 |
| Crude fat | 23.7 | 25.9 | 24.8 | 1.56 | 6.27 |
| Total ash | 2.40 | 2.50 | 2.45 | 0.07 | 2.89 |
| Crude fiber | 20.7 | 21.5 | 21.1 | 0.57 | 2.68 |
| Carbohydrate | 29.3 | 25.1 | 27.2 | 2.97 | 10.9 |
| Moisture | 6.00 | 5.40 | 5.70 | 0.42 | 7.44 |
| Dry matter | 94.0 | 94.6 | 94.3 | 0.42 | 0.45 |
| Fatty acid | 18.9 | 20.7 | 19.8 | 1.27 | 6.43 |
| Organic matter | 97.6 | 97.5 | 97.6 | 0.07 | 0.07 |
| Energy(KJ/100g) | 1678 | 1719 | 1699 | 29.0 | 1.71 |

From literature, the total kernel results were (g/100 g dry weight, dw): protein 10.8, lipid 60.0, ash 15.6, dry matter 95.1 and fiber 2.40[3]. The protein quantities would contribute positively to the requirement of the consumers; the fiber values were reasonable and the indigestible cellulose they contain may absorb water and provide roughage for better functioning of the alimentary system as well as combine with intestinal cholesterol for excretion in the faeces[12]. The energy content ranged from 1.68-1.72 MJ (mega Joule) showing them to be good sources of concentrated energy, due to their high protein, fat and carbohydrate contents. Energy from cereals range from 1.3-1.6 MJ/100 g[22].

Table II shows the various energy values as contributed by protein, fat and carbohydrate. Whilst the fat had the highest contribution (52.2-55.8 %), protein had the least contribution (18.1-19.3 %). The fat contributions of 52.2-55.8 % of total energy far outstrip the 30 % recommended energy from fat particularly for adults[23]. The utilizable energy due to protein (UEDP %) for the samples (assuming 60 % utilization) ranged from 10.9-11.6. These values were higher than the recommended safe level of 8 % for an adult man who requires about 55 g protein per day with 60 % utilization; this means the protein energy contribution would be more than enough to prevent protein energy malnutrition (PEM) in an adult fed solely on dika nut kernel as a main source of protein.

**Table II. Energy values as contributed by protein, fat and carbohydrate in *I gabonensis* seed hull and cotyledon**

| Parameter | Hull | Cotyledon | Mean | SD | CV % |
|---|---|---|---|---|---|
| Calculated energy* | 1678 | 1719 | 1699 | 29.0 | 1.71 |
| PEP % | 18.1 | 19.3 | 18.7 | 0.85 | 4.54 |
| PEF % | 52.2 | 55.8 | 54.0 | 2.55 | 4.71 |
| PEC % | 29.7 | 24.9 | 27.3 | 3.39 | 12.4 |
| UEDP % | 10.9 | 11.6 | 11.3 | 0.49 | 4.40 |

*Measured in kJ per 100 g of sample using Atwater factors; PEP = proportion of total energy due to protein;
PEF = proportion of total energy due to fat; PEC = proportion of total energy due to carbohydrate.
UEDP = utilization energy due to protein.

***Minerals***

The mineral levels of the samples are all shown in Table III. The cotyledon was consistently higher in 16 (94.1 %) out of 17 (100 %) parameters considered under the mineral composition. In the African yam bean seeds where three cultivars were involved in this type of study the hull mineral level values were as thus: $A_3$ (70 %), $B_3$ (80 %) and $C_3$ (40 %)[24] whose results were in sharp contrast to the result in *I gabonensis*. The CV % were more scattered than in the proximate composition with values ranging from 0.88-130. All the minerals were lower than the RDA[25] levels. However, they will contribute well to other food sources. The lower level of Na than K agreed with what is required in plants[26]. The Fe level was extremely low (0.11-0.18 mg/100 g dw). Cd level of 0.01-0.12 mg/100 g dw could be due to an onset of pollution of the environment. Both Na and K are involved in many biochemical activities in the body but the Na/K values of 0.73-0.76 were slightly higher than 0.60 required to avoiding high blood pressure[18]. The Ca/P and Ca/Mg weight ratios ranged between 0.12-0.17 and 0.72-0.73 respectively. These values were below the recommended value of 1.0[25]. The [K/ (Ca + Mg)] obtained was 0.83-0.85 milliequivalent. To prevent hypomagnesemia, Marten and Andersen[27] reported that the milliequivalent of [K/ (Ca + Mg)] must be less than 2.2; this is the case in this report. Mn was high here unlike what obtains in some animal sources[28].

***Anti-nutrient factors***

Some anti- nutrient factors are shown in Table IV. Here seven out of eight parameters (or 87.5 % out of 100 %) had their values in the hull greater than in the cotyledon. Only the variations in tannin and saponin were high at 54.7 %-67.9 % respectively. The Phy levels were less than the values reported for 13 spices (390-6210 mg/100 g) obtained in Nigeria[29]; seven varieties of Nigerian garden egg fruits (507-2788 mg/100 g)[30]; many other Nigerian foods such as legumes (14-344 mg/100 g), cereals (112-287 mg/100 g), spices (35-184 mg/100 g) and tubers/roots (0.0-1070 mg/100 g)[31]. In 17 wild leguminous crop seeds, values of Phy ranged from 0.23-1.03 g/100 g[32] which were much higher than in the present report. The present study also had Phy levels much lower than the report of Oke[33], Harland *et al*.[34] and Harland and Oberleas[35] in raw beans, raw and fermented corn products, raw fruits and vegetables, raw and fermented tubers.

**Table III. Mineral composition of *I. gabonensis* seed hull and cotyledon on dry weight (mg/100 g of samples)**

| Parameter | Hull | Cotyledon | Mean | SD | CV % |
|---|---|---|---|---|---|
| Na | 20.2 | 32.2 | 26.2 | 8.49 | 32.4 |
| K | 27.8 | 42.5 | 35.2 | 10.4 | 29.6 |
| Ca | 28.1 | 42.1 | 35.1 | 9.90 | 28.6 |
| Mg | 39.2 | 57.4 | 48.3 | 12.9 | 26.6 |
| Zn | 5.56 | 6.84 | 6.20 | 0.91 | 14.6 |
| Cu | 1.12 | 1.53 | 1.33 | 0.29 | 21.9 |
| Mn | 4.01 | 7.14 | 5.58 | 2.21 | 39.7 |
| Co | 0.01 | 0.24 | 0.13 | 0.16 | 130 |
| Fe | 0.11 | 0.18 | 0.15 | 0.05 | 13.1 |
| Cd | 0.01 | 0.12 | 0.07 | 0.08 | 120 |
| Ni | 0.27 | 0.41 | 0.34 | 0.10 | 29.1 |
| P | 239 | 242 | 241 | 2.12 | 0.88 |
| [K/Ca+Mg]* | 0.83 | 0.85 | 0.84 | 0.01 | 1.68 |
| K/Na | 1.38 | 1.32 | 1.35 | 0.04 | 3.14 |
| Na/K | 0.73 | 0.76 | 0.75 | 0.02 | 2.85 |
| Ca/P | 0.12 | 0.17 | 0.15 | 0.04 | 24.4 |
| Ca/Mg | 0.72 | 0.73 | 0.73 | 0.01 | 0.96 |

*milliequivalent

**Table IV. Some anti-nutrient factors in *I gabonensis* seed hull and cotyledon**

| Parameter | Hull | Cotyledon | Mean | SD | CV % |
|---|---|---|---|---|---|
| Tannin (g/100 g) | 0.52 | 0.23 | 0.38 | 0.21 | 54.7 |
| Oxalate (mg/100 g) | 1.98 | 1.56 | 1.77 | 0.30 | 16.8 |
| Phytate (mg/100 g) | 16.9 | 14.0 | 15.5 | 2.05 | 13.3 |
| Phytin phosphorus (mg/100 g) | 4.76 | 3.95 | 4.36 | 0.57 | 13.2 |
| Saponins (g/100 g) | 0.37 | 0.13 | 0.25 | 0.17 | 67.9 |
| Alkaloids (g/100 g) | 0.41 | 0.35 | 0.38 | 0.04 | 11.2 |
| Flavonoids (g/100 g) | 0.19 | 0.24 | 0.22 | 0.04 | 16.4 |
| Pp as % of P | 1.99 | 1.63 | 1.81 | 0.25 | 14.1 |

The phytin-phosphorus (Pp) in the present study was much lower than in the 17 wild leguminous crop seeds with values of 0.06-0.29 g/100 g[32] compared with present result of 3.95-4.76 mg/100 g. But the present Pp values were close to differently processed *Canavalia ensiformis* and *Mucuna pruriens* seed flours with respective Pp values of 1.4 -5.44 and 1.7-4.3 mg/100 g[36]. The Pp as % of P ranged between 1.63-1.99 which were far lower than in the 17 wild leguminous crop seeds of 11.4-84.1[32] which showed that the P of the present study were only linked to Pp to the tune of 1.63-1.99 which will not affect the utilization of divalent minerals and also will not render unavailable some essential amino acids; also monogastric animals will have no problem in utilizing the dika nut samples.

The tannin content in the samples generally can be considered to be of little nutritional significance. The levels of the tannin in this study (0.23-0.52 g/100 g) were close to the values of 0.3-0.9 g/100 g in *C ensiformis* but much lower than 0.8 – 7.8 g/100 g in *M pruriens*[36].

The oxalate ranged from 1.56-1.98 mg/100 g. The presence of oxalate has undesirable effect on Ca absorption and utilization. This acid combines with Ca to form calcium oxalate, which passes through the intestine unabsorbed. The amount of oxalate formed depends on the amount of oxalic acid in the food[37]. About half of all kidney stones are calcium oxalate, either alone or mixed with the salts of calcium phosphate, magnesium ammonium phosphate and calcium carbonate. Formation of these stones frequently reflects chronic alkalinity of bladder and renal pelvic urine caused by infection with bacteria that hydrolyze urea, releasing ammonia[38]. Oxalate levels in the present report were very low.

Saponins in the samples were in the range of 0.13-0.37 g/100 g. The available literature suggests that the dietary presence of saponins can either be beneficial or deleterious. The nutritional significance of saponins stems largely from their hypocholesterolemic action, leading to the belief that they may prove useful in the control of human cardiovascular disease[39]. Studies with dietary saponins[40] have shown that saponins also readily increase the permeability of the mucosal cells of the small intestine, thereby inhibiting active nutrient transport and facilitating the uptake of materials to which the gut would not normally be permeable. These permeability effects of saponins may not be beneficial. The saponins from *I gabonensis* cannot be said to be high or excessive.

The alkaloids composition ranged from 0.35-0.41 g/100 g or 350-410 mg/100 g. Some alkaloids are said to be of high dietary importance that often goes unnoticed. Some of the toxicological manifestations of potato glycoalkaloids involve gastrointestinal upsets and neurological disorders especially in doses in excess of 20 mg/100 g sample[41]. This will cause some concern in the present samples.

The flavonoid pigments, are water-soluble, and are found dissolved in the water in the cell-sap. A subgroup called anthocyanins is responsible for reds, blues and violets found in a wide variety of fruits[42]. The colour of food is exceedingly important to the consumer.

The Phy: Zn, Ca: Phy and [Ca] x [Phy]: [Zn] molar ratios are depicted in Table V. Oberleas and Harland[43] showed that food with a molar ratio of Phy: Zn less than 10 showed adequate availability of Zn; the present Phy: Zn was within the bracket. Wise[44] suggested that the solubility of the phytates and the proportion of Zn bound in a mineral complex in the intestines depend on the levels of Ca. In his model, Phy precipitation is not complete until dietary Ca: Phy molar ratios attain a value of approximately 6:1. In the present study no Ca: Phy molar ratio was lower than this critical level of 6:1, this meant Zn bioavailability would not be impaired again under this model.

**Table V. Phy: Zn, Ca: Phy and [Ca] [Phy] / [Zn] molar ratios of *I gabonensis* seed hull and cotyledon**

| Parameter | Hull | Cotyledon | Mean | SD | CV % |
|---|---|---|---|---|---|
| Phy:Zn[a] | 0.33 | 0.20 | 0.27 | 0.09 | 34.7 |
| Ca:Phy[b] | 23.3 | 52.5 | 37.9 | 20.6 | 54.5 |
| [Ca][Phy]/[Zn][c] | 0.002 | 0.002 | 0.002 | 0.0 | - |

[a](mg of Phy/MW (molecular weight) of Phy: mg of Zn/MW of Zn.

[b](mg of Ca/MW of Ca: mg of Phy/MW of Phy).

c[mol/kg Ca] [mol/kg Phy]/[mol/kg Zn].

Ellis *et al* [45] and Davies and Warrington[46] indicated that the ratio of [Ca] x [Phy]: [Zn] is a better predictor of Zn availability and noted that if the value was greater than 0.5 mol/kg, then there would be interference with the availability of Zn. All the present values of [Ca] x [Phy]: [Zn] were lower than 0.5 mol/kg, therefore would promote Zn bioavailability. The Ca x Phy: Zn results were in agreement with the report of Adeyeye *et al* [31] in 35 foods of major consumption in Nigeria but much better than the results obtained for 13 Nigerian spices[29] and in seven varieties of Nigerian garden egg fruits[30].

***Statistical evaluation***

Table VI contains the statistical analysis summary of all the results from Tables I-V. All the linear correlation coefficient ($r_{xy}$) were significantly high and positive at $r_{=0.05}$ and n-2 degrees of freedom. All the linear regression coefficient ($R_{xy}$) levels were negative except values from Table III. Taking Table I to explain $R_{xy}$, it meant that when hull value increased by one unit, the cotyledon decreased by - 0.58, etc. The $C_A$ meant coefficient of alienation which were all low (0.38 % - 10.6 %). The index of forecasting efficiency (IFE) was high for all the parameters (89.4-99.62 %).

The IFE measures the reduction in the error of prediction of relationship, e.g. from Table I, the reduction in error of prediction would be 100 minus 99.62 = 0.38, that is the error was only 0.38 %. The higher the IFE the easier to predict the relationship between the two compared results. When $r_{xy}$ is 0.9 or greater, it can be taken that the estimation was accurate enough and the hull might replace the cotyledon in its uses. The coefficient of determination ($r_{xy}^2$), 99.99-100.00 % of the variation in the hull was being explained by the cotyledon; the remaining 0.01- 0.00 % was probable error.

**Conclusion**

The results of these analyses and calculations showed that both hull and cotyledons of *Irvingia gabonensis* were good sources of fat, protein, fiber and carbohydrate; moderate sources of minerals; low in anti- nutrients; both calcium and zinc would be available; the hull could also be used to replace the cotyledons in the uses of cotyledons and hence the hull should not be wasted or thrown off during processing. Cultivation and industrial utilization of the fruits are therefore recommended.

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**Table VI. Summary of the statistical analysis of the data in Tables I-V**

| Table | $r_{xy}$ | $r_{xy}^2$ | $R_{xy}$ | X | Y | $C_A$ | IFE | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1.Hull/Cotyledon | 1.0000 | 1.0000 | -0.58 | 199 | 203 | 0.38 | 99.62 | * |
| 2.Hull/Cotyledon | 1.000 | 1.0000 | -0.52 | 358 | 366 | 0.45 | 99.55 | * |
| 3.Hull/Cotyledon | 0.9944 | 0.9888 | 3.53 | 21.7 | 25.7 | 10.6 | 89.4 | * |
| 4.Hull/Cotyledon | 0.9998 | 0.9996 | -0.06 | 3.39 | 2.76 | 2.0 | 98.0 | * |
| 5.Hull/Cotyledon | 0.9999 | 0.9999 | -0.27 | 7.88 | 17.6 | 1.0 | 99.0 | * |

* Significant at $r_{=0.05}$ and n-2 degrees of freedom; X = mean for hull; Y = mean for cotyledon; $C_A$ = coefficient of alienation percent; IFE = index of forecasting efficiency percent.

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