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Nutrient composition of Nigerian palm kernel from the dura and tenera varieties of the oil palm (*Elaeis guineensis*)

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Abstract

The dura and tenera varieties of the oil palm from Calaro Oil Palm Estate, Akamkpa in Cross River State, Nigeria and NIFOR Experimental Oil Palm Station, Abak in Akwa Ibom State, Nigeria were studied to evaluate their proximate, mineral, toxicant and fatty acid compositions. These parameters were determined for both undefatted and defatted samples. The defatted samples had higher nutrient levels than the undefatted ones. The dura variety had a higher moisture content than the tenera in both locations. Antinutrients, such as hydrocyanic acid and total oxalate, were also higher in the dura variety than the tenera. The mineral analysis of the samples showed high levels of magnesium, manganese, iron, copper, zinc, phosphorus, sodium and potassium. The tenera variety showed higher values of most of these minerals than the dura in both of the locations. Palm kernel therefore appears to be a good source of these mineral elements. Phytate and lead were not detected in any of the samples. The fatty acid profile indicated lauric (C 12:0), oleic (C 18:1) and palmitic (C 16:0) to be the major constituent fatty acids of the palm kernel oil samples. There were no significant differences in fatty acid composition between the varieties or locations.

1. Introduction

The oil palm is a tropical monoecious tree with male and female inflorescence, hermaphrodite-developed in the axil of the leaves. The fruit is a drupe on a large compact bunch and the female inflorescence is reported to be a good source of potassium (Ekpa, 1995). As one of the major oil crops of Nigeria and other West African countries, oil palm contains organic food substances and inorganic elements, upon which life and industries depend. The fruit yields two oils, palm oil and palm kernel oil, each exhibiting differences in composition, properties and applications. The fleshy exocarp (pulp) provides palm oil and, within the pulp, there is a hard-shelled nut with the shell encapsulating the palm kernel which produces the palm kernel oil.

Palm kernel oil is similar to coconut oil in composition and the two are the only sources of lauric oil available to the world market (Berger, Andaner & Applewhite, 1991). Palm kernel cake is the residue obtained after extracting the oil and it is used in livestock feeds. Palm and kernel oils are used for manufacturing of soaps, vegetable oil and margarine (Ekpa, Peter & Udo, 1994). Besides their industrial applications, these oils are used locally as body creams, cooking oils and, medicinally, as antidotes for poisoning, and as surface protectants for minor wounds. Palm oils from the dura and tenera varieties of the oil palm differ in their percentage fatty acid composition (Ekpa et al., 1994) and in their interaction with lauric acid oils (Ekpa & Ekpe, 1996a). They also exhibit markedly different characteristics in their melting point profiles and free fatty acid formation on exposure to light (Ekpa & Ekpe, 1996b). Although studies evaluating the chemical and nutritional values of palm kernel (Lakshmi & Krishna, 1993) and palm kernel oil (Siew & Noraini, 1992) have been reported, there is little information available on the toxicant and mineral composition of palm kernels and palm kernel cakes from the two varieties of the oil palm. The present study therefore compares the nutritional composition of palm kernel oils and cakes from the tenera and dura varieties of the oil palm, to establish, if any, the differences in

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the nutritional compositions of the two oil palm varieties.

The dura and tenera varieties of the oil palm were obtained from Calaro Oil Palm Estate, Akamkpa in Cross River State, Nigeria and NIFOR Experimental Oil Palm Station, Abak in Akwa Ibom State, Nigeria, and analysis was carried out on the defatted and undefatted palm kernel samples for their proximate, mineral, toxicant and fatty acid compositions.

2. Materials and methods

Bunches of palm fruits from the dura and tenera varieties of the oil palm were bought from three different locations in Calaro Oil Palm Estate, Akamkpa in Cross River State and NIFOR Experimental Oil Palm Station at Abak in Akwa Ibom State, Nigeria, respectively. Five bunches of palm fruits from each location were considered as one sample for analysis. The palm fruits were cut with a stainless steel knife to remove them from the stalk and the fruits were picked manually into clean polyethylene bags. The bags were labelled DUA, TUA, DUN, and TUN, where U represents "undefatted kernel" in the fruits: D and T stand for the dura and tenera varieties of the oil palm, respectively, while A and N represent the site of sample collection, in this case Akamkpa (A) and NIFOR (N).

The palm fruit specimens were transported to the laboratory and boiled the same day. The boiled fruits were mashed, using a wooden mortar and pestle to separate the nuts from the fleshy exocarp. The nuts were sun-dried for three days and further dried in the oven (Astell Hearson, London, UK) for 12 h at 45°C to free the kernels. The dried nuts were manually cracked on an aluminium block to obtain the kernels, which were ground in a manual Corn Mill-121 (Landers YCIA, Medellin, Colombia). The ground samples were stored in a glass bottle with a plastic screw-cap and kept in the refrigerator. All the analyses were done in triplicate.

The estimation of moisture, ash, crude fat, crude fibre and crude protein (N×6.25) were done by the standard method of AOAC (1984). Nitrogen-free extract (NFE) was calculated by difference and the calorific values (kilo calories) were calculated by multiplying the crude fat, protein and NFE values by At. water factors of 9, 4 and 4, respectively. Fatty acid analyses of palm kernel oils were carried out on the fatty acid methyl esters (FAMES), prepared by the modified method of Biedermann et al. (1993). The composition of fatty acid was determined from the methyl esters using a gas chromatographic technique on a Carlo Erba Instrument HRGOC 5300 Mega Series [Carlo Erba Instruments, Rodano (MI), Italy].

Separation was on a 50 M CPSil 88 Column (100% cyanopropylpolysiloxane) with a diameter of 0.25 mm and a thickness of 0.2 mm (Crompak, Ravitan, NJ, USA). A flame ionization detector, maintained at 300°C, was used, together with a Pye Unicam automatic digital peak integrator. The column temperature was held at 185°C for 6 min and at 215°C for another 2 mm and the injection temperature was 280°C. One μl of sample in *n*-hexane was injected into the column and hydrogen gas was used as the carrier. Control internal standard analysis was also carried out on commercial FAME standards (Bellefonte, CA, USA).

Mineral digestion was done according to the method of Ekpa, Akpan and Udoh (1993). Sodium and potassium were determined using a flame photometer (Janway flame analyzer P.F. P7) while phosphorus was quantified by the method of AOAC (1984). The atomic absorption spectrophotometer (ASS Unicam 919) was used to determine Ca, Mg, Fe, Zn, Cu, Pb along with reference standards from Unicam Ltd, York Street, Cambridge, UK.

Hydrocyanic acid was estimated by alkaline titration method (AOAC, 1984) and oxalic acid content by the method of Dye (1956), while the estimation of phytic acid was by the method of McCance and Widdowson (1960).

Statistical analysis was by the use of Student *t*-test (Gordon & Ford, 1972) at 95% confidence level.

3. Results

The results of the proximate analysis of the defatted and undefatted palm kernel samples are listed in Table 1. The moisture contents were 6.0 to 14.0 g/l00 g wwt for the undefatted and 6.0 to 14.0 g/dwt for the defatted samples. The ash contents 3.0 to 3.6 g/dwt and 1.5 to 1.9 g/dwt were recorded for the defatted and undefatted palm kernels, respectively. The crude fat, crude fibre and crude protein contents were 41 to 49, 14.7 to 15.5 and 7.5 to 15.4 g/dwt, respectively. The highest values for organic matter and NFE were 90.0 and 58.5 g/dwt for the defatted, and 93.0 and 25.4 g/dwt for the undefatted palm kernels, respectively. The calorific values were 274–560 kcal/g dwt.

Table 2 shows the toxicant levels of the undefatted palm kernels. The dura variety had the highest HCN level of 2.4 mg/100 g dwt, while tenera recorded the lowest value of 1.3 mg/100 g dwt. The total oxalate content was 15.2 to 30 mg/100 g dwt of sample, with the dura variety having the highest, while the soluble oxalate ranged from 9.5 to 16.5 mg/100 g dwt of sample, with the tenera variety having the highest value. Phytate was not detected in any of the samples.

The results of the mineral composition of both the defatted and undefatted palm kernel samples used in this work are shown in Table 3. The mineral levels (mg/100 g dwt) were Ca: 75–214; Cu: 1.7–2.7; Fe: 11.0–22; K: 277–660; Mg: 225–554; Mn: 41–61; Na: 58–120; P:

Table 1
Proximate composition of defatted palm kernel (PKC) and undefatted palm (PK) (g/l00 gdwt)[a,b]

Sample	Location/variety	Moisture (g/wwt)	Ether extract	Ash	Crude protein	Crude fibre	Organic matter	NPF value	Calorific (kcal/100 g)
Defatted	DDA	7.5±0.6**	NDI	3±0.02*	15.4±0.3*	15.5±1.0	89.4±0.65	58.5±0.4*	396±11
palm	TDA	6±0.6	NDI	3.4±0.10*	15.0±0.01*	14.7±0.9	89.6±0.4	61.1±0.1*	304±9
kernei	DDN	14.0±0.8**	NDI	3.0±0.04*	14.5±0.0*	15.0±0.4	84.0±0.3	54±0.1*	274±11
(PKC)	TDN	10±0.4	NDI	3.6±0.0*	14.0±0.0*	15.0±0.2	90.0±0.7	57.6±0.5*	286±12
Undefatted	DUA	7.2±0.3**	42±0.8	1.75±0.0	8.1±0.1	ND2	91.0±0.0	25.4±0.5	512±14*
palm	TUA	6.0±0.2	49±0.4	1.84±0.0	7.8±0.1	ND2	93.0±0.0	21.0±0.3	560±16*
kernel	DUN	14±0.5**	41±0.2	1.5±0.0	7.9±0.2	ND2	84.3±0.3	21.1±0.3	485±13*
(PK)	TUN	10.3±0.6	44.5±0.3	1.9±0.0	7.5±0.1	ND2	87.9±0.2	21.0±0.1	514±15*

[a] Mean ± S.D. of three determinations.
[b] DDA, dura (defatted sample from Akamkpa); TDA, tenera (defatted sample from Akamkpa); DUA, dura (undefatted sample from Akamkpa); TUA, tenera (undefatted sample from Akamkpa); DDN, dura (defatted sample from NIFOR); TDN, tenera (defatted sample from NIFOR); DUN, dura (undefatted sample from NIFOR); TUN, tenera (undefatted sample from NIFOR); ND1, not determined (less than 0.001 g/l00 g dwt); ND2, not determined (the method required defatted sample) and was considered to be the same as in defatted sample. *Significant difference between defatted and undefatted samples ($P < 0.05$). **Significant difference between tenera and dura samples ($P < 0.05$).

Table 2
Level of some toxicants in undefatted palm kernel (PK) (mg/l00 g dwt)[a]

Sample	HCN	Phytate	Oxalate	
			Total	Soluble
DUA	2.4±0.04	–[b]	30±2.2	12±0.5
TUA	2.2±0.10	–	22±2.0	16.5±1.4
DUN	1.94±0.02	–	16±1.0	9.5±0.2
TUN	1.3±0.11	–	15.2±1.3	12±1.0

[a] Mean ± S.D. of three determinations.
[b] Not detected.

260–470; Zn: 2.6–4.3, while Pb was not detected ($\leqslant 0.005$ μg/100 g dwt) in any of the samples. The lowest concentrations of minerals were obtained for the undefatted samples.

The major fatty acids in the palm kernel oil samples (Table 4) were lauric (C 12:0), oleic (C 18:1) and myristic (C 14:0), with lauric acid being the most abundant. Lauric acid ranged from 45.3 to 48.2%, oleic acid 15.3 to 19.2%, while myristic acid was between 16.0 and 17.1%; the other fatty acids ranged from 0.1% for gadoleic (C 20: 1) to 3% for caprylic (C 8:0). Mean values of 46.4, 18 and 16.4 were recorded for lauric, oleic and myristic acids, respectively.

4. Discussion

The results of the analysis (Table 1) show a significant difference ($P < 0.05$) in the moisture content between the tenera and dura varieties of the oil palm. There was, however, no significant change in the moisture contents of the defatted and undefatted samples. The moisture levels in this work are in agreement with those of previous reports (Fetuga, Babatunde & Onyenuga, 1977; Siew, 1989). The defatted samples have significantly higher ash, protein and NFE than the undefatted, and these compare closely with the results of Fetuga et al. and Siew. The tenera variety is richer in fat, ash and organic matter than the dura, while the dura is richer in crude protein, and fibre. The calorific levels were significantly higher in the undefatted than the defatted samples.

Fat-soluble vitamin absorption is aided by dietary fat. The proteins have the functional role of promoting growth, tissue repair and maintenance. The oil is an important source of chemical energy to both man and industry. The vitamin and protein requirements, including the calorific requirement of man, could partially be met by the oil palm fruit. The crude fibre contents agree with those reported by Fetuga et al. (1977) and Lakshmi and Krishna (1993).

Low levels of anti-nutrients are reported in the results (Table 2). The low contents of HCN and oxalate, when compared to other food substances and the absence of phytate in the samples, are of biological significance. HCN is a common food poison, and oxalate and phytate significantly reduce the availability of minerals such as Ca, Zn, Fe and Mg (Aremu & Abara, 1992). There is therefore an indication that a substantial amount of the essential elements present in palm kernel may likely be available for biochemical and nutritional processes (Akpanabiatu, Bassey, Udosen & Eyong, 1998).

The mineral composition (Table 3) is reported for both the defatted and undefatted samples. The defatted samples showed higher levels of all the minerals except lead which was not detected in either of the samples. The Na content was the same in the defatted samples but higher in the dura variety than the tenera of the undefatted samples. The palm kernel samples are rich in Mg, K, P, Fe, Mn and Na and could be used as a good source of these elements to supplement the recommended dietary allowances (Food and Nutrition Board,

Table 3
Mineral composition (mg/l00 g dwt) of defatted palm kernel (PKC) and undefatted palm kernel (PK)[a,b]

Sample	Location/variety	Ca	Mn	Fe	Cu	Zn	P	Pb	Mg	Na	K
Defatted	DDA	107±4.0	61±1.0	22±0.4	2.6±0.05	3.3±0.08	350±16	–	355±22	120±2.5	590±13
palm	TDA	196±10.0	58±0.5	20±0.35	2.3±0.01	4.3±0.04	450±12	–	554±21	120±0.0	660±17
kernel	DDN	114±7.4	58±0.15	17.0±0.7	2.0±0.01	2.7±0.03	350±11	–	360±14	120±0.0	570±20
(PKC)	TDN	214±8.5	52±0.66	13±0.5	2.7±0.03	3.4±0.01	470±12	–	500±22	120±1.5	630±12
Undefatted	DUA	75±2.5	42±0.8	15±0.1	1.8±0.02	2.8±0.06	260±11	–	225±17	74±7.4	350±16
palm	TUA	120±2.5	49±0.4	17±0.05	1.7±0.05	3.4±0.03	310±18	–	311±14	58±4.0	301±13
kernel	DUN	100±3.0	41±0.2	13±0.28	1.7±0.03	2.6±0.02	280±12	–	232±10	94.0±5.0	340±14
(PK)	TUN	146±4.8	44.5±0.3	11.0±0.34	1.7±0.04	2.8±0.04	315±14	–	295±13	61±8.1	277±10

[b] –, Not detected.
[a] Mean ± .S.D. of three determinations.

Table 4
Fatty acid profile of palm kernels from the dura and tenera varieties of oil palm (as percent of oil)

Location[a]	Variety	Caproic (6:0)	Caprylic (C 8:0)	Capric (C 10:0)	Lauric (C 12:0)	Myristic (14:0)	Palmitic (C 16:0)	Stearic (C 18:0)	Oleic (C 18:1)	Linoleic (C 18:2)	Arachidic (C 20:0)	Gadoleic (C 20:1)
A	Tenera	0.1	3.0	2.2	48.2	17.1	9.1	2.3	15.3	2.3	0.13	0.10
	Dura	0.1	3.0	2.3	45.3	16.0	9.4	2.2	19.2	2.8	0.13	0.13
N	Tenera	0.1	2.7	2.0	45.5	16.4	9.6	2.4	18.0	2.7	0.13	0.13
	Dura	0.1	2.7	2.4	46.5	16.0	9.3	2.3	19.0	2.8	0.13	0.13
Mean[b]		0.1±00	3.0±0.2	2.2±0.2	46.4±1.3	16.4±0.5	9.4±0.2	2.3±0.1	18±1.8	2.7±0.24	0.13±0.0	0.12±0.0

[a] A, Akamkpa; N, NIFOR.
[b] ± S.D. means of A and N.

1989) of the individual elements. Most or all ATP-requiring enzymes have ATP in the form of an Mg–ATP complex. Mg is also useful to the body as a minor component of bones and plays a catalytic role in respiration. In growing children, it enhances the retention of Ca in teeth. Calcium and phosphorus levels obtained in this work are lower than those obtained by Fetuga et al. (1977).

The high Fe content is of biological importance since Fe is the major component of essential biological compounds such as transferrin, ferritin and haemoglobin. Some enzymes of the immune system contain iron (Brody, 1994).

There is no available literature on the mineral profile of the tenera and dura varieties of palm kernel.

There was no significant difference in fatty acid composition, either between the two varieties or locations selected for this study. The values obtained for the major constituent fatty acids in this work are comparable to those reported by Rossell, King and Downess (1985) for Nigerian palm kernel oil and are within the ranges specified by Codex Almentarius Commission (1979) for commercial palm kernel oil.

5. Conclusions

Palm kernel samples were evaluated for proximate and mineral compositions of the defatted and undefatted palm kernel. The moisture level in the dura variety was higher than in the tenera while the reverse was the case in oil contents. The keeping quality of the tenera variety is likely to be better than the dura because moisture is involved in the catalytic hydrolysis of fatty acids. The protein, ash and all the minerals were higher in the defatted than undefatted samples. Defatted palm kernel therefore appears to be a good source of these substances. The low levels of anti-nutrients, in addition to the absence of phytate and lead in the palm kernel samples as reported in this work, makes them useful nutritionally, especially as livestock and poultry feeds.

The similarities in fatty acid composition of oils from the two varieties and the absence of any significant variations between locations in this work are advantageous as the two oils are interchangeable in their applications.

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