

Proximal Characterization and Nutritional Approaches of Nkamba Nut Oil (*Ricinodendron africanum* var. Nkamba)

¹M. Dzondo-Gadet, ¹V. Pandzou-Yembe, ¹J.E. Moussounga, ¹P. Ockandji,
¹E. Matouba, ¹A.P. Pambou-Tobi, ¹M. Mvoula Tsieri, ¹T. Kinkela,
¹T. Silou, ²M. Linder and ²S. Desobry

¹Laboratoire de Bioprocédés alimentaires et médicaux,
UMNG-ENSP, BP. 69 Brazzaville, R. Congo

²Laboratoire d'Ingénierie et Biomolécules, ENSAIA-INPL,
Avenue de la forêt de Haye, BP 172, 54505 Vandoeuvre, France

Abstract: To diversify the source of edible oils in central Africa, the nut harvest at Nkamba (D.R. Congo) was investigated to know the nutritive value and the composition of oil extracted. The Nkamba nut named Kingoma-Ngoma (*Ricinodendron africanum* var. Nkamba) contains 65.97±3.00% of oil, 6.61±0.93% of water, 2.5% of ashes, 21.34±2.75% of total carbohydrates and 12.6±0.7% of total proteins. The oil is yellow shiny (L = 91.6; a = -2.3; b = 15.87). It presents characteristics of well unsaturated oils. The indices were acid value 2.47±0.2 (oleic acidity), iodine value 175.39±2.71 mg/100 g of oil; saponification value 226.10±2.78 mg KOH/100 g of oil and peroxide value 1.36±0.49 meq O₂/kg. The profile can be summarized that C18:0 < C16:0 < C18:1 (19.48%); < C18:3 (31.63%); < C18:2 (39.44%). The oil fluid at ambient temperature is not very suitable for frying. According to the ω3 content, oil might have a dietary role in order to prevent cardiovascular diseases. The thermal behavior (DSC) of oil shows a peak at to -27.1°C resulting melting point from saturated and unsaturated fractions with a ΔH of 1.094 J g⁻¹.

Key words: *Ricinodendron africanum*, oil, ω3, Nkamba nut, iodine value

INTRODUCTION

The *Ricinodendron heudelotii* Baill belongs to the family of the Euphorbiaceae. It is a lucid forest tree or shrubby savannas. The tree is located from Guinea gulf including Angola to East of Africa extended to Madagascar (Vivien and Faure, 1985). The fruit of *Ricinodendron heudelotii*, in the South West of Cameroon is commonly named Njansan (Tshiamala-Tshibangu and Ndigba, 1999). In some regions, the fruits and the seeds are edible.

In Cameroon, paste obtained by grinding amends is sometimes used as a thickening agent for soups also incorporated in to baby cereals and cakes (Leakey, 1999). Sometimes the grinded seeds can substitute for the use of peanuts (Fondoun *et al.*, 1999).

Bark had several uses as to treat leprosy, elephantiasis, gonorrhoea, dysentery, diarrhea, coughs, hernia, rheumatism, abscesses, rickets and as an aphrodisiac or an anti-inflammatory. A decoction of leaves is used for fevers. The sap of the plant is used for eye infections and decoctions of leaves are used as a febrifuge (Tchoundjeu and Atagana, 2006).

In the South West of Democratic Republic of Congo (Bas Congo), the tree is named Kingoma-Ngoma. It means "little Kingoma" as kingoma was named like this because of its uses principally for confecting tam tams. So, Kingoma-Ngoma serves for little tam tams. Kingoma was identified as *Ricinodendron heudelotii* Baill (Silou *et al.*, 2000). Logically Kingoma-Ngoma have a phylogenetic link with that family. Its fruit contains a so-called Nkamba nut.

There is no available study on properties of Nkamba nut such as nutritional value of the nut nor its fatty acids composition. In the present study, researchers try to carry out the composition of the Nkamba nut, the composition of fatty acids extracted using Soxhlet Method and the thermal behavior of this last one.

MATERIALS AND METHODS

Proximate composition: To determine the composition of Nkamba nut seed as oil content, crude proteins (micro-Kjeldahl), moisture, crude fiber and researchers use the current methods of Pearson (1976). The level of ashes was determined also by current methods (Pomeranz and

Meloan, 1994). The total carbohydrates were got by difference. Each determination was in triplicate. The minerals were determined by atomic absorption spectrophotometry (Perkin-Elmer, Model 2380, USA). The 1g of dry matter ground into ashes in muffle furnace at 550°C for 8 h until a white residue of constant weight was obtained. The minerals were extracted from ash by adding 20 mL of 2.5% HCl heated in a steam bath to reduce the volume to about 7.0 mL and this was transferred quantitatively to 50 mL volumetric flask. It was diluted with deionized water, stored in clean polyethylene bottles and mineral content. The instrument was calibrated with standards solutions.

Seeds and oil extraction: Seeds harvested from Nkamba (South West of D.R. Congo;10E5S) were crushed in a coffee grinder (Moulinex Model SeB PREP'LINE 850). The 30 g of ground seed were placed into a cellulose paper cone and extracted using n-Hexane (60°C) in a 2 L Soxhlet extractor for 5 h. The solvent was removed using Rotary Evaporator Model N-1 (Eyela, Tokyo Rikakikal Co., Ltd. Japan). Residual solvent was removed by drying in an oven at 60°C for 1 h; flushing with 99.9% nitrogen.

Color determination: Colors of nut and defatted nut were determined on a micro flash 200d (data color international) which converts colors in numbers CIELAB (CIE, 1986) and giving to them the values ranged behind letters (L*, a*, b*).

The color of the oil was determined in triplicate using the Lovibond Method. Color was measured using the Lovibond (Lovibond PFX195, VWR International France). Each sample was taken in a cube and placed in the space provided in the tint meter. A sample of 5 mL was analyzed at 45°C (Bhattacharya *et al.*, 2008) and the gardner was automatically read on the apparatus. For each sample, the difference of color between the reference was determined by the following equation:

$$\Delta E = [(L^t - L_0)^2 + (a^t - a_0)^2 + (b^t - b_0)^2]^{\frac{1}{2}}$$

where, L* [L* = 0 (black) and L* = 100 (white)]; a* [-a* = green and +a* = red]; b* [-b* = bleu and +b* = yellow].

Determination of fatty acid composition: Fatty Acid Methyl Esters (FAME) were obtained by transmethylation of total lipid aliquots (50 mg) with 1 mL of boron trifluoride in methanol (8% w/v) for 10 min in a shaking water bath heated at 90°C as described by Ackman (1998) earlierly to submit the samples to gas chromatography analysis.

The analysis of FAME was carried out by Gas Chromatography in a Perichrom TM 2000 System

(Saulx-les-Chartreux, France), equipped with a Flame Ionization Detector (FID) and a fused silica capillary (25 m×0.25 mm ×0.5 µm, BPX70 SGE Australia Pty., Ltd.). Column temperature was kept at 145°C for 20 min then warmed up from 145-210°C flowing out at 5°C min⁻¹ and hold at 210°C for 15 min. The ended injection port was maintained at 230°C and the detector at 260°C. The fatty acids were identified by comparison of their retention times with appropriate standards PUFA-1 Marine source (Supelco, No. 4-7033, Bellefonte, PA-USA), PUFA-2 Animal source (Supelco, No. 4-7015-U, Bellefonte, PA-USA). Each measure was in a triplicate.

The indices of Nkamba nut oil: The usual indices determinate in oils were acid value (AOAC (12), Standard Method 969.1), iodine value (AOAC (12), Standard Method 993.20), saponification value (AOAC (12), Standard Method 965.33) and peroxide value (AOAC (12), Standard Method 920.160).

Thermal properties of Nkamba nut oil: Thermal analyses were performed with a Perkin-Elmer Differential Scanning Calorimeter, DSC-7, equipped with a thermal analysis data station (Perkin-Elmer Corp., Norwalk, CT, USA). Nitrogen was the purge gas and flowed at 20 mL min⁻¹. The calorimeter was calibrated according to standard procedures established in the manufacturer user book using indium and distilled water. Samples of 15 mg were weighed into aluminum pans and cooled and/or heated at 2.5°C min⁻¹ from -60°C to +60°C. The heat of fusion enthalpies ΔH (J/g) were calculated for each peak by the Pyris Software (Perkin-Elmer Corp., Norwalk, CT, USA). DSC measurements were carried out in triplicate.

Viscosity measurement: The dynamic viscosity of Nkamba nut oil was measured with a Malvern Kinexus Pro. Samples were paced in a CP2/50 SC0029SS plateau with a temperature increasing from 5-45°C, at 1°C min⁻¹. The applied stress was constant at 50 Pa (Abdulkarim *et al.*, 2007).

Student's t-test was used for statistical validity of results and the coefficient of variation between each measurement do not exceeded 2%.

RESULTS AND DISCUSSION

Chemical composition: The Nkamba nut contains 65.97±3.00% of oil and of 6.61±0.93% of water with 2.5% of ashes. The level of total carbohydrates is relatively low 21.34±2.75%. The nut is poor in crude proteins level 12.6±0.7% (Table 1). The nut is very reach in lipids. Minerals could be ordered as Sodium<Phosphates<Potassium<Calcium<Sulphates.

Colors aspects: The nut is yellow shiny as show by the corresponding numbers (Table 2). The de-oiled nut remained on yellow but goes on the white. The oil is really white slightly yellow. The gadner read on the apparatus is 3.2 with a ΔE of 15.797.

Indices values: The indices values of the oil respect the norm Food Codex: 2.47±0.2 (oleic acidity), iodine 175.39±2.71 mg/100 g of oil; saponification value 226.10±2.78 mg KOH/100 g of oil and peroxide value 1.36±0.49 meq O₂/kg. The oil presents characteristics of very unsaturated oils with high number of Iv and Sv (Table 3).

Fatty acid content: The profile in fatty acids indicates good proportions in fatty acids as oleic acid (19.48%); linoleic acid (39.44%) and linoleic acid (31.63%). The profile can be summarized that C18:0 < C16:0 < C18:1 < C18:3 < C18:2 (Table 4). The oil is a fluid at ambient temperature. The level of C 18:3 is over 2 so, the oil is not very suitable for frying. The ω3 (31.63%) level gave a dietary role to the oil on order to prevent cardiovascular diseases.

Many nuts have their fatty acid composition dominated by one kind of. For example, kumunu (Coulasedulis), walnut and hazelnut oils are rich in C18:1 over 60%. Kaso or conofor (*Tetracarpidium conophorum*) is rich in C18:3 over 70% (Tchiegang *et al.*, 2001). Generally the oil extracted from nuts like this

presents a disequibrated fatty acid profile. The originality of Nkamba nut oil is that the level of C18:2 neighboring C18:3 both over 30%. This composition led to the good ratio (1.25) of ω6/ω3 suitable for health care.

Nutritional behavior: The chemical composition of Nkamba nut carry out its nutritional value. The nut is a source of energy as the lipids rate was the more important compared to peanut, safou or soybean (Table 5). Carbohydrate content shows that Nkamba nut (21.34%) can not be classified in high starch content food as rice or maize. Unfortunately, the nut is poorly provided in total proteins (2.6%). So, it will be difficult to use the deoiled nut for animal feeding.

The benefits aspects of long chain polyunsaturated fatty acids intake in human were essentially for energy, growth, organ differentiation, immune function and cellular metabolism. Main recommendations from the World Health and North Atlantic Treaty Organizations are 0.3-0.5 g day⁻¹ of EPA/DHA (Kris-Etherton *et al.*, 2002).

The International Society for the Study of Fatty Acids and Lipids has proposed an adequate intake of EPA plus DHA to be 0.65 mg day⁻¹ and even more in the case of pregnant and lactating women (Arab-Tehrany *et al.*, 2012). The rich content in C18:3ω3 (31.63±1.64) and C18:2ω6 (39.44±1.90) gave the importance of consumption of the oil of Nkamba nut.

Table 1: Proximal composition of Nkamba nut

Compositions	Content
Parameters	
Moisture (%)	6.61±0.93
Lipids (%)	65.97±3.00
Total proteins (%) (N _T ×6.25)	21.34±2.75
Ashes (%)	2.6±0.7
Total carbohydrates (%)	6.2±0.7
Minerals (mg/100 g)	
K	1190.28±1.53
P	920.98±0.02
Ca	500.38±3.336
Na	30.20±0.002
Mg	1450±1.01

Table 2: Colors aspects of Nkamba nut and oil

Samples	L*	a*	b*	Gadner	ΔE
Crushed nut	46.61	1.25	17.91	-	15.7969174
Deoiled nut	61.24	0.26	11.96	-	-
Oil	91.60	-2.30	15.87	3.2	-

Table 5: Comparison of a few seed and fruit chemical composition

Compositions	Safou ^a (%)	<i>Ricinodendron heudelotii</i> (%) ^b	<i>Ricinodendron africanum</i> var. Nkamba (%)	Soybean (%) ^c	Peanut (%) ^c
Moisture	12.04	5.75±0.07 ^a	6.61±0.81	9.82±0.21	4.45
Lipids	31.90	62.53±0.71	65.97±3.11	18.56±0.35	40.83
Ashes	10.80 ^c	13.26±0.49	3.58±0.28	4.81±0.08	2.77
Proteins	25.90	35.15±0.33	2.60±0.63	40.40±1.82	26.50
Carbohydrates	5.86	0.084	21.34±0.11	9.94±1.94	25.40

^aLam *et al.* (1987); ^bTchoundjeu and Atangana (2006) and ^cAzeredo *et al.* (2004)

Table 3: Indices of Nkamba nut oil

Indices	Values
Iodine value (Iv)	175.39±2.71
Peroxide value (Pv)	1.36±0.49
Acidity (oleic)	2.47±0.20
Saponification value (Sv)	226.10±2.78

Iv (mg/100 g); Pv (meq O₂/kg); Sv (mg KOH/100 g)

Table 4: Fatty acid composition of Nkamba nut oil

Fatty acids	Level (%)
C16:0	6.11±0.91
C18:0	3.03±0.21
ΣSFA	9.14
C18:1ω9	19.48±1.27
ΣMUFA	19.48
C18:2ω6	39.44±1.90
C18:3ω3	31.63±1.64
ΣPUFA	71.07
R (PUFA/SFA)	7.78
ω6/ω3	1.25

Table 6: Thermograms of same non-conventional oils from Central Africa

Parameters	Nkambanut	Peke ^a	Gumbo ^b
Pic 1 (°C)	-27.100	+2.5300	-24.80
ΔH (J g ⁻¹)	+1.094	-12.2872	7.04
Pic 2 (°C)	-	+39.6600	-1.98
ΔH (J g ⁻¹)	-	+9.9260	12.35
Pic 3 (°C)	-	-	+6.55
ΔH (J g ⁻¹)	-	-	2.02

^aSilou *et al.* (2004) and ^bNzikou *et al.* (2006)

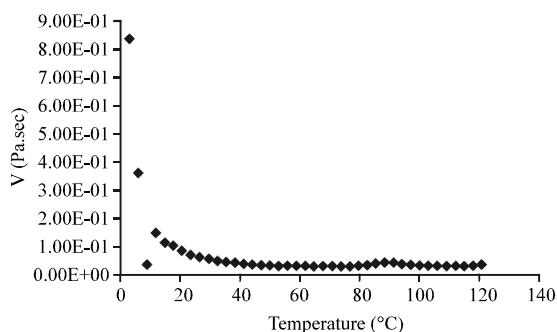


Fig. 1: Viscosity of Nkamba nut oil

Thermal analysis of Nkamba nut oil: The thermal Behavior (DSC) of oil shows a peak at to -27.1°C with a ΔH of 1.094 J g⁻¹. It seems that the peak is the resulting melting points from saturated to unsaturated fractions. Generally, it was admitted that at the left of peak, oil is in solid state and in liquid state at the right. The comparison with proximal oils in the region (Peke, *Irvingia gabonensis* and Gumbo; *Abelmoschus esculentus*) shows that each oil gave own or particular properties (Table 6).

Viscosity: Generally, vegetable oils have their high viscosity at room temperature. It was admitted that there is high correlation between DSC measurement and viscosity change with temperature appears clearly. But the only melting point obtained in the experiments did not explain totally the thermal behavior. Indeed, Fig. 1 shows a rapid decrease of viscosity under 10°C and then a low decrease with temperature. The value of 9 mPa.sec confirmed its liquid state at room temperature. The oil is fluid with $y = 0.47x + 0.18$; $R^2 = 0.943$. Above the melting point, the viscosity change with temperature follows the Arrhenius equation:

$$\ln \eta = \ln C + \frac{K}{T} \quad \text{with } K = \frac{E_a}{R}$$

from which the activation energy is calculated as 8.5 kcal/mol.k.

CONCLUSION

The Nkamba nut had a good nutritional value according to its chemical composition. The content of ω3

and ω6 of oil increase the importance at the nutritional point of view. The oil is yellow and fluid at room temperature. But it could not be used for frying because it's the linoleic acid level is over 3%. The high benefit for health, for adults and even for infants must stimulate African people to the consumption of the nut. The oil must be extracted at economical point of view to reduce the importations and increase the added value of the product.

REFERENCES

- Abdulkarim, S.M., K. Long, O.M. Lai, S.K.S. Muhammad and H.M. Ghazali, 2007. Frying quality and stability of high-oleic *Moringa oleifera* seed oil in comparison with other vegetable oils. *Food Chem.*, 105: 1382-1389.
- Ackman, R.G., 1998. Remarks on official methods employing boron trifluoride in the preparation of methyl esters of fatty acids of fish oils. *J. Am. Oil Chem. Soc.*, 75: 541-545.
- Arab-Tehrany, E., M. Jacquot, C. Gaiani, M. Imran, S. Desobry and M. Linder, 2012. Beneficial effects and oxidative stability of ω-3 long-chain polyunsaturated fatty acids. *Trends Food Sci. Technol.*, 25: 24-33.
- Azeredo, H.M.C., J.D.A.F. Faria, M. Aparecida and A.P. da Silva, 2004. Minimisation of peroxide formation rate in soybean oil by antioxidants combinations. *Food Res. Int.*, 37: 689-694.
- Bhattacharya, A.B., M.B. Sajilata, S.R. Tiwari and R.S. Singhal, 2008. Regeneration of thermally polymerized frying oils with adsorbents. *Food Chem.*, 110: 562-570.
- CIE, 1986. Colorimetry. CIE Publication, Vienna.
- Fondoun, J.M., T. Tiki-Manga and J. Kengue, 1999. *Ricinodendron heudelotii* (Djansang): Ethnobotany and importance for forest dwellers in Southern Cameroon. *Plant Genet. Resour. Newslett.*, 117: 1-11.
- Kris-Etherton, P.M., W.S. Harris, L.J. Appel, A.H. Association and N. Committee, 2002. Fish consumption, fish oil, ω-3 fatty acids and cardiovascular disease. *Circulation*, 106: 2747-2757.
- Lam, H.J., U. Omoti and D.A. Okiy, 1987. Characteristics and composition of the pulp oil and cake of the African pear, *Dacryodes edulis* (G. don). *J. Sci. Food Agric.*, 38: 67-72.
- Leakey, R.R.B., 1999. Potential for novel food from agroforestry trees: A review. *Food Chem.*, 66: 1-14.
- Nzikou, J.M., M. Mvoula-Tsieri, E. Matouba, J.M. Ouamba, C. Kapseu, M. Parmentier and S. Desobry, 2006. A study on gumbo seed grown in Congo Brazzaville for its food and industrial applications. *Afr. J. Biotechnol.*, 5: 2469-2475.

- Pearson, D., 1976. General Methods in the Chemical Analysis of Food London. Longman Group Ltd. London, pp: 6-26.
- Pomeranz, Y. and C. Meloan, 1994. Food Analysis: Theory and Practice. 3rd Edn., Chapman and Hall, New York, pp: 778.
- Silou, T., G. Rocquelin, G. Gllon and T. Molangui, 2000. Characterization of safous (*Dacryodes edulis*) in central africa. II: Chemical composition and nutritional characteristics of safous from the district of boko (congo-brazzaville). individual tree variation. *Rivista Italiana Delle Sostanze Grasse*, 77: 85-89 (In Italian).
- Silou, T., S. Biyoko, S. Heron, A. Tchaplá and M.G. Maloumbi, 2004. Caracteristiques physico-chimiques et potentialites technologiques des amandes de *Irvingia gabonensis*. *Riv. Ital. Sostanze Grasse Ann.*, 81: 49-56.
- Tchiegang, C., C. Kapseu and M. Parmentier, 2001. Chemical composition of oil from *Tetracarpidium conophorum* ((Mull. Arg.) Hutch. and Dalz.) nuts. *J. Food Lipids*, 8: 95-102.
- Tchoundjeu, Z. and A.R. Atangana, 2006. Ndjanssang *Ricinodendronheudelotii* (Baill.). In: Mungongo, Williams, J.T., R.W. Smith, N. Haq and Z. Dunsiger (Eds.). Southampton Centre for Underutilised Crops, UK., pp: 44-45.
- Tshiamala-Tshibangu, N. and J.D. Ndigba, 1999. Utilisation des produits forestiers autres que le bois (PFAB) au Cameroun cas du projet forestier Mont Koupe. *Tropicultura*, 16-17: 70-79.
- Vivien, J. and J.J. Faure, 1985. Trees Dense Forests of Central Africa. Ministry of Foreign Affairs, Cooperation and Development, Paris, ISBN: 97892902 80651, Pages: 565.