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Research Article

Nutritional Value of "*Kumu*" (*Bombax aquaticum*) and Characterization of Oil Extracted

[1]M. Dzondo-gadet, [2]R. Kama Niamayoua, [2]S. Nsikabaka, [1]J.P.L. Ossoko, [2]J. Enzonga, [1, 3]N.P.G. Pambou-tobi, [2]T. Silou and [3]S. Desobry
[1]Laboratoire de Bioprocédés Alimentaires et Médicaux, UMNG-ENSP,
[2]Equipe Pluridisciplinaire de Recherche en Alimentation et Nutrition, Faculté des Sciences et Techniques, UMNG, BP. 69, Brazzaville, Congo
[3]Laboratoire d'Ingénierie de Biomolécules (LIBio), ENSAIA-Université de Lorraine, 2 Avenue de la forêt de Haye, TSA 40602, BP 54518, Vandoeuvre-lès-Nancy, France

Abstract: Some quality characteristics of seed oil extracted from *Kumu*; (*Bombax aquaticum*) or "white peanut" harvest at Nkamba (DR Congo) were investigated. Herein, *Kumu* was chemically characterized regarding nutritional value, fatty acids, crude fat and chemicals indices. Furthermore, viscosity, absorptivity at 232 and 270 nm, color and DSC profil were evaluated. Data showed that the wild sample gave higher nutritional contribution related to a higher content of carbohydrates (54.74%±0.05), followed by fat (36.97±0.30%), proteins (5.68%±0.2), moisture (5.89%±0.12) and ash (2.61%±0.34). The physical properties of the oil extracts showed the state to be liquid at room temperature (25±1°C) and the color of the oil yellow clear (L* = 57.85; a* = 5.73; b* = 76.55). The dynamic viscosity of the oil was 12 mPa.sec. Among the chemical properties of the oil extracts, acid value (8.18±0.82 mg de NaOH/g), saponification number (162.31±0.15 mg KOH/100g of oil), iodine value (25, 59 m /100 g of oil) and peroxide value (6.86±0.31 meqO_2/Kg) compared well with those of heated oils samples. The fatty acid composition consisted 54.89% palmitic acid (C16:0), 8.87% docosahexaenoic acid (C22:6ω3), 7.54% oleic acid (C18:1ω9), 6.09% Linoleic acid (C18:2), 3.19% Stearic acid (C18:0), 2.17% α-Linolenic acid (C18:3ω6), 0.89% Arachidonic acid (C20: 4). For a ''good nutritional quality'' with high health benefits, it also gave better PUFA/SFA and ω6/ω3 ratios. The thermal Behavior (DSC) of oil shows two peaks at +4.7 and +19.1°C for fusion and one peak at -4.3°C for crystallization. Absorptivity at 232 and 270 nm increased rapidly after heating.

Keywords: *Aquaticum*, *Bombax*, characterization, *Kumu* white peanut, oil

INTRODUCTION

Bombax aquaticum is a plant of the family of Bombacaceae. It grew up in Congo, Cameroun, Gabon, Nigeria and Madagascar (Pieraerts, 1917).

Commonly it named *Kumu* in DR Congo or *Pindi dia* bibamba (peanut of white people) in the south west of Congo-Brazzaville. So it was called white peanut by analogy to groundnut. The neighboring species *B. buonopozens*e is named in Nigeria *Akpu* in Igbo, *Gurjiya* in Hausa and *Ogbolo* in Yoruba (Nwagba *et al*., 2013).

The tree of *Kumu* was growing as well in the wet tropical zones as in the dry tropical zones. It could attain 30 to 40 m height; with a diameter ranging from 40 to 70 cm. *Bombax aquaticum* have a branching trunk, protected by a greenish smooth bark, which covers a soft and spongy wood. The branches are covered with the alternate sheets, composed of 5 to 7 oval pointed leaflets, directly inserted on the branch. The fruit is a greenish with ovoid capsule and then resembles that of the cocoa-tree. The family contained several species as *Bombax buonopozense* P. Beauv; *Bombax ceiba* L; *Bombax insigne* Wall; *Bombax mossambicense* A. Robyns; *Bombax reflexum*; *Bombax angulicarpum*; *Bombax buesgenû*; *Bombax flammeum*; *Bombax brevicuspe*.

The more studied was *B. buonopozense* with conical buds which contains many seeds that are 5 to 6 mm in length, all of which have a cotton-like fibre covering. This was one of difference between the two species as *Aquaticum* have not the cotton fiber; and *Buonopozense* presents.

The small tree is used to make the fence or the palisade. The fruits of contain seeds with hull whose almonds have a content of significant oil and was eaten roasted or crude as groundnut. In Nigeria, in the wild plant an edible floral part is used as vegetable (Nwagba *et al*., 2013). Traditionally, the plant is used for its capacity of anti angiogenic. It is also used in the treatment of the diabetes. The leaves are taken as a decoction for the treatment of malaria, feverish and

Corresponding Author: M. Dzondo-gadet, Laboratoire de Bioprocédés Alimentaires et Médicaux, UMNG-ENSP, BP. 69, Brazzaville, Congo

pains. The roots are used as antimicrobial and stomach aches (Iwuanyanwu *et al*., 2012) and antidiarrheal activity (Akuodor *et al*., 2011).

The aim of this work was to carry out the proximal composition of the white peanut. In addition, we have characterized the oil extracted as there is no available paper published. The work is ended by thermal behavior and rheological aspects.

MATERIALS AND METHODS

Raw material and oil extraction: The *Kumu* "white peanut" harvested from Nkamba (south west of democratic republic of Congo) was crushed in a coffee grinder (Moulinex model SeB PREP'LINE 850). Thirty gram of powder were placed into a cellulose paper cone and extracted using n-Hexane (60°C) in a 2 L soxlhet 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.

Proximate composition and energetic value: The samples of *Kumu* "white peanut" were analyzed for crude proteins, crude fat, moisture and crude fiber using the Pearson procedures (Pearson, 1976). The crude protein content (N×6.25) of the samples was estimated by the macro-Kjeldahl method; the crude fat was determined by extracting a known weight of powdered sample with petroleum ether, using a Soxhlet apparatus. The moisture content and. the level of ashes were determined also by current methods (Pomeraz and Meloan, 1994). Total carbohydrates were calculated by difference. Energy was calculated according to the following equation:

Energy (kcal) = 4× (g protein)
+ 4× (g carbohydrate) + 9× (g fat)

Each determination was in triplicate.

Color determination: The colors of the natural and defatted seeds were measured using a CIE (1986) colorimeter (data color International, microflash 200 days). This system uses three values to describe the precise location of a color inside a three-dimensional visible color space. The measurements were displayed in L*, a* and b* values ((L* = 0 (black) to 100 (white), a* = -a* (green) to +a* (red) and b* = -b* (blue) to +b* (yellow)). The colorimeter was calibrated with the standards white and black before color measurements.

The color of the oil 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 tintometer. A sample of 5 mL was analyzed at 45°C (Atanu *et al*., 2008) and the Gardner was automatically read on the apparatus. The total color change (ΔE) was calculated using Eq. (1), where the subscript '0' indicates the initial color of the seeds before defatted as a reference. Color was measured three times in triplicate:

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

Determination of fatty acid composition: Fatty Acid Methyl Esters (FAMEs) from seeds were prepared according to the Ackman method (Ackman, 1998). The transmethylation was performed using 1.5 mL of BF_3 in methanol (8%, w/v) and 1.5 mL of hexane at 100°C. After the extraction of FAMEs with hexane, they were washed with distilled water and analyzed with a split mode by gas chromatography (CG-2010 Plus, Shimadzu, Kyoto, Japan) equipped with a flame ionization detector and a capillary column (60 m, 0.25 mm i.d. ×0.20 μm film thicknesses). Oven temperature was set at 200°C; detector and injector temperatures were at 250°C. Helium was the carrier gas at a flow rate of 0.79 mL/min. A temperature program of column was initially set at 120°C for 2 min, then rose to 180°C for 2 min at a rate of 2°C/min and kept at 220°C for 25 min. FAMEs (PUFA1 from marine source and PUFA2 from vegetable source; Supelco, Sigma-Aldrich, Bellefonte, PA, USA) were used as standards to identify fatty acids. The percentage of FAMEs was calculated from the total area of all peaks. The results were presented as triplicate analyses.

The indices of *Kumu* oil: The usual indices determinate in oils were acid value (AOAC, standard method 969.1), iodine value (AOAC, standard method 993.20), saponification value (AOAC, standard method 965.33) and peroxide value (AOAC, standard method 920.160). p-Aniside value was measured according to AOAC standard Cd 18-90. The value of absorptivity at 232 and 270 nm (K232 and K270) was determined by spectrophotometry according to recommendations in AOCS (1997) Official Methods.

Thermal properties of *Kumu* 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. 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 aluminium pans and cooled and/or heated at 2.5°C/min from -60 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. The peak enthalpy value (assumed that

peak enthalpy = | value from computer-generated data|) was expressed as Joules per gram of oil samples and calculated from the area below the crystal-lisation peak according to Tan and Man (1999).

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

Statistics: 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: Data on the chemical composition of *Kumu*; "white peanut" (Fig. 1) namely, macronutrients are presented in Table 1. It can be seen that seeds of *Kumu*; "white peanut" are composed of 36.97±0.03% of oil (dry weight basis), 5.68±0.2% of moisture, 2.61% of ash. These seeds are poor in protein (5.68±0.7%) but rich in carbohydrates (54.74±0.05%) such as *Garcinia mangostana* fruits (43.5±2.09) (Ajayi *et al*., 2007). The *Kumu*; "white peanut" seeds contain a relative high percentage of total lipid content compared to seeds such as *Washingtonia filifera* seeds (16.30±0.29%) (Nehdi, 2011) and see in Table 2.

When we compare *Kumu* seeds with the other seeds, the main difference in the content was on the carbohydrates level (Table 2).

The content of proteins of these seeds varies from 9.52% for rice; 27.44% for *Pistacia atlantica*; 26.50% for groundnut and 40.4% for soybean (Edet *et al*., 1985; Onyeike and Acheru, 2002; Deepa *et al*., 2008; Redondo-Cuenca *et al*., 2006). Then *Kumu* seeds are poorly provided in proteins neighboring those of *Pistacia atlantica.* At the point of view of carbohydrates, the *Kumu* content close to that of rice, then could be classified as a good source of sugars need daily for the human body. Then *Kumu* seeds could be also classified in starch family. Generally the high level of carbohydrates limits uses in oil extraction.

Fig. 1: *Kumu* seeds

Table 1: Proximal composition of *Kumu* seed (*Bombax aquaticum* var Nkamba)

Parameters	Content
Moisture%	5.89±0.12
Lipids %	36.97±0.03
Crude proteins % (N_T x 6.25)	5.68±0.20
Ash %	2.61±0.34
Total carbohydrates %	54.74±0.05
Crude fibers	2.94±0.21
Energy (kcal)	574.41±3.75

Values are means±standard deviation of triplicate determinations

Colors aspects: In this study, we compared L*, a* and b* parameters of Crushed peanut, Deoiled peanut and *Kumu* peanut oil. CieLab coordinates (L*, a*, b*) of the three samples studied are shown in Table 3. *Kumu* peanut oil showed a higher CieLab coordinates (L* = 57.85 and a* = 5.73 and b* = 78.55). The crushed peanut is white glossy as shown by the corresponding numbers of L* = 25.37 and a* = 4.04 and b* = 11.19 (Table 3). The de-oiled powder remained on yellow but goes on the white. It well known that color is an important indication of product composition, purity and degree of deterioration (Kabri *et al*., 2011). The *Kumu* seed oil is equilibrated and pure.

Indices values: The indices values of the oil are in adequation with the norm Food Codex: 8.18±0.82 (oleic acidity), iodine 25.59±0.08 mg/100 g of oil; saponification value 162.32±0.15 mg KOH/100 g of oil and peroxide value 6.86±0.31 meqO_2/kg. The oil presents characteristics of unsaturated oils liked confirmed by the level down of iodine value (Table 3). But it could find application in cosmetics with a high saponification value. The maximum of Totox is fixed at 25; then we are a low number du to the fresh ship of oil (Rubio-Rodríguez *et al*., 2012). The *Kumu* seed oil is no oxidized at this step. Even when hated 1 h at 250°C

Table 2: Comparison with a few current seeds

	Seeds				
Parameters (%)	*Pistacia atlantica*[a]	*Groundnut*[b]	*Bombax aquaticum* var Nkamba[e]	*Rice*[c]	*Soybean*[d]
Lipids	52.00	40.83	36.97±0.03	2.50±0.50	18.56±0.35
Proteins (N×6.25)	27.44	26.50	5.68±0.20	9.52±0.34	40.40±1.82
Carbohydrates	36.48	25.40	54.74±0.05	73.50±13.21	9.94±1.94
Moisture	3.78	4.45	5.89±0.12	13.10±0.15	9.82±0.21
Ashes	5.56	2.77	2.61±0.34	1.42±0.06	4.81±0.08

[a]: Edet *et al*. (1985); [b]: Onyeike and Acheru (2002); [c]: Deepa *et al*. (2008); [d]: Redondo-Cuenca *et al*. (2006); [e]: Present study

Table 3: Colors aspects of *Kumu* seed oil

Samples	L*	a*	b*	ΔE
Crushed peanut	25.37	4.04	11.19	-
Deoiled peanut	42.20	3.08	8.97	17.12
Oil	57.85	5.73	76.55	-

Table 4: Indices of *Kumu* seed oil

Indices	Normal	Heated at 250°C
Iodine value (Iv)	25.59±0.08	-
Peroxide value (Pv)	6.86±0.31	9.54±2.53*
Acidity (oleic)	8.18±0.82	10.01±2.34
Saponification value (Sv)	162.32±0.15	-
Para-Aniside value (PA v)	3.95±0.22	15.57±3.76**
Totox value	17.67	34.65±6.11**

IA mg NaOH/g; IP méq O_2/kg; Totox v = 2Pv + PAv; *: $p<0.05$; **: $p<0.01$; Values are means±standard deviation of triplicate determinations

Table 5: Fatty acid composition of *Kumu* seed oil

Fatty acids	Normal (%)	Heated at 250° (%)
C16: 0	54.89±0.19	54.03±0.32
C18: 0	3.19±0.21	3.89±0.11
C18: 1 ω 9	7.54±0.78	8.84±0.83
C18: 1 ω 7 (11t)	0.73±0.21	0.97±0.17
C18: 2 ω 6	6.09±0.99	5.79±0.45
C18: 3 ω 6	2.17±0.66	1.06±0.59
C20: 4 ω 6	0.89±0.31	0.28±0.14
C22: 6 ω 3	8.87±0.95	5.74±0.85
Others	15.63	19.30
∑SFA	58.08	57.92
∑MUFA	8.27	9.91
∑PUFA	18.02	12.87
R (PUFA/SFA)	0.31	0.22
ω6/ω3	1.03	1.24

the frying temperature, there were the slight amount generally ranged under the AFNOR values except totox value (Table 4).

Fatty acid content: Table 5 shows the fatty acid profile and total lipids of *Kumu* seed oil. The fatty acids level indicates a predominance of saturated fatty acids with palmitic acid 54.89±0.19% (Table 5). But there is a well proportion of unsaturated fatty acid as oleic acid (7.54±0.78%) and docosahexaenoic acid DHA (8.87±0.95%). The oil do not contain of linolenic acid so it is suitable for frying. When heated at 250°C, the fatty acid profile does not change a lot. Despite of the high level of palmitic acid, the oil is fluid at ambient temperature. The omega 3 level (8.87±0.95%) could produce a dietetary approach in order to prevent cardiovascular diseases. Generally the long chain polyunsaturated acids are found in fish oils (Arab-Tehrany *et al*., 2012). But vegetable oil could contain both Eicosapentanoic Acid (EPA) and Docosahexaenoic Acid (DHA) (Nzikou *et al*., 2006). The International Society for the Study of Fatty Acids and Lipids has proposed an adequate intake of EPA and DHA to be 0.65 mg/day and even more in the case of pregnant and lactating women (Arab-Tehrany *et al*., 2012). So, the fatty acid profile of white peanut oil, with a good ratio (1.03) of ω6/ω3 could be suitable for health care.

Comparison with some known oils: When we compared *Kumu* seed oil with current oils, we have found that there was the more palmitic acid content (54.89±0.19%) before palm (43.14%) and safou pulp oils (42.4%) (Table 6). *Kumu* seed oil is poorly provided in linoleic and oleic acids; respectively 6.09 and 7.54%. The more important in this oil is its original content in DHA (8.87%). The similarity with groundnut stop at the simple resemblance as this last one contains 47.05% of oleic acid and 30.77% of linoleic acid. When we regard linolenic acid content, *Kumu* seed oil (2.17%) is far from Canola oil (8.9%) and soybean oil (7.9%) and nearer safou pulp oil (1.2%). With this low content of C18:3, *Kumu* seed oil could be used for frying.

Evaluation of hydroperoxides level: According to Besbes *et al*. (2005), the formation of hydro-peroxides is coincidental with conjugation of double bonds in polyunsaturated fatty acids, measured by absorptivity in the UV spectrum at 232 and of secondary product of oxidation that are absorbed at about 270 nm.

To investigate the thermal oxidation induction, we have heated the oil at 250°C (frying temperature) for 1 h. The level of byproducts from oil oxidation was very low. It well known that the proximal products peaked at $\lambda = 232$ nm and the distal products peaked at $\lambda = 270$ nm (Table 7). We have found in proximal products the value of 0.175 and when heated there was a slight amount up to 0.0729 ($p<0.05$). The numbers obtained demonstrated that the oil was very stable when heated may be due to the high saturated fraction. The distal products were at trace state. Indeed the oil was not oxidized in the time of our experiments. The early oxidized products in oil (0.729) were higher than the

Table 6: Comparison of fat content between *Kumu* seed oil and current seed oils (Dzondo-Gadet *et al*., 2005)

Seeds	C16: 0	C18: 0	C18: 1	C18: 2	C18: 3	C22: 6
Groundnut	10.6	2.41	47.05	30.77	0.14	-
Canola	5.56	1.38	58.25	22.17	8.90	-
Sunflower	6.27	4.86	19.69	67.44	0.03	-
Olive	14.31	2.48	66.68	13.91	0.50	-
Soya	11.03	3.91	23.04	56.84	7.90	-
Maize	10.69	2.00	25.46	59.35	0.92	-
Palm	43.14	5.41	38.72	10.59	0.27	-
Safou	42.40	2.50	27.80	25.20	1.20	-
Pistacia atlantica	25.20	1.80	45.80	25.40	0.80	-
Bombax aquaticum	54.89	3.19	7.54	6.09	2.17	8.80

Table 7: Hydro peroxides level

DO	λ = 232 nm	λ = 270 nm
Normal	0.175	0.023
Heated 1 h at 250°C	0.729*	0.097

Table 8: Thermograms of same non conventional oils from central Africa

	Nkamba nut[a] (reported values)	*Kumu*	*Gumbo*[b] (reported values)
Peak 1 (°C)	-27.100	+4.70	-24.80
ΔH (J/g)	+1.094	+59.89	+7.04
Peak 2 (°C)		+19.10	-1.98
ΔH (J/g)		+15.96	+12.35
Peak 3 (°C)		-4.30	+6.55
ΔH (J/g)		11.33	+2.02

[a]: Dzondo-Gadet *et al*. (2014); [b]: Nzikou *et al*. (2006)

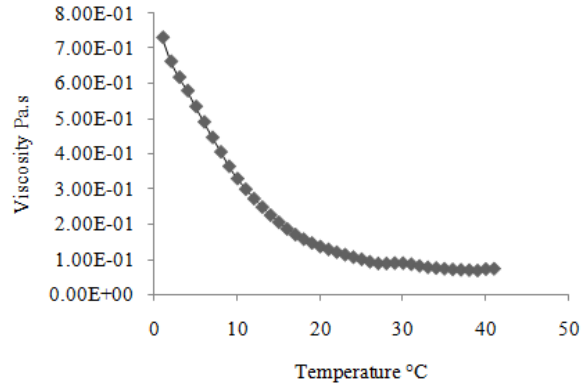

Fig. 2: Viscosity of *Kumu* seed oil

later products (0.097). The natural content of oil (vitamin, polyphenols…) lead to limit its alteration. We were in native oils with a high protective potential as polyphenol, phytosterols as α tocopherol was present and lows slowly the effects of oxidation agents. The combined effect of fatty acid content, antioxidative potential and heating time could explain our results in agreement with Arab-Tehrany *et al*. (2012) Who said that "The ability of α tocopherol to have an antioxidant, neutral, or pro-oxidant effect in foods depends on temperature, lipid composition, physical state (bulk phase or emulsion) and its concentration". The numbers we have found were correlated with indices measurement.

Thermal analysis of *Kumu* seed oil: The thermal Behavior (DSC) of *Kumu* seed oil shows 3 peaks to -4.3, 4.7 and 19.1°C, with a ΔH of -11.33 +59.89 and +15.56 J/g, respectively. The first point with negative numbers seems to be a resultant of PUFA or unsaturated TGA fraction. The negative value of ΔH (-11.33 J/g) seems to indicate one crystallization point. The others are fusion points. The second point could be the resultant of MUFA fraction. The third point seems to be attributed to the SFA or saturated TGA fraction. Generally it was admitted that at the left of peak, oil is in solid state and in liquid state at the right. So the oil is naturally fluid at ambient temperature. The comparison with proximal oils in the region (Nkamba nut oil and Gumbo oil (*Abelmoschus esculentus*)) shows that each oil gave own or particular properties (Table 8).

Viscosity: Generally, there is high correlation between DSC measurement and viscosity change with increasing temperature. Vegetable oils have their high viscosity at room temperature. In our work, the 3 melting points are below to the room temperature. It was still complicated by the presence of two phenomena as crystallization and fusion. Figure 2 shows a rapid decrease of viscosity under 10°C (from 70 to 31 mPa.sec) and then a low decrease with temperature. The value of 12 mPa.sec confirmed its liquid state at room temperature. The oil is fluid despite of high SFA fraction with y = -0.13X + 0.513 R^2 = 0.99. 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 40.57 kcal/mol/K.

CONCLUSION

The *Kumu* seed had a good nutritional value according to its chemical composition. The oil content of ω3 (DHA) like those of fish oil increase the importance at the nutritional point of view. The oil is yellow-clair and fluid at room temperature. It could be used for frying because it's the linolenic acid level is below 3%. When heated at 250°C the oil does not change a lot confirming its high stability.

The high benefit for health, for adults and even for infants, must stimulate African people to the consumption of *Kumu*. The exploitation of this seed could bring economical advantages and may be could increase the added value.

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