***Original Research Article***

**Chemical characterisation of shea nut (*vitelaria paradoxa*) kernel oil from high-producer trees in the tchôlogo region (ivory coast)**

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ABSTRACT

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| **Aims:** The aim of the study was to determine the chemical characteristics of the oil from the kernel of shea nuts from high-producer trees in the Tchôlogo region, with a view to proposing appropriate ways of adding value**Study design:** Eight composite nut samples were analysed.These are: large ellipsoid tchologo (LELT); large spheroid tchologo (LSPT); large oblong tchologo (LOBT); large ovoid tchologo (LOVT); thin ovoid tchologo (MOVT); thin spheroid tchologo (MSPT); thin ellipsoid tchologo (MELT); thin oblong tchologo (MOBT).**Place and Duration of Study:** University of Nangui Abrogoua, Abidjan, Côte d’Ivoire, from September 2024 to January 2025**Methodology:**. The work consisted of determining the oil content, saponification, iodine, acid and peroxide indices, the main fatty acids and vitamins A.D.E.K of the oil obtained from shea nuts.**Results:** The results showed that the shea nut kernel oil content of the 8 samples ranged from 40.83% to 50.03%. Shea nut kernel oil contains a high level of unsaturated fatty acids, with high proportions of linolenic acid (21.23% to 39.34%) and high saponification values (216.11% to 291.35%).The oils are also rich in vitamins A and D**Conclusion:** These oils are of lesser quality for food use because they contain a high level of free fatty acids, resulting in high acid values. The almond oil in the MOVT sample has a high saponification value and is suitable for making soap. |

1. INTRODUCTION

Shea (*Vitellaria paradoxa C. F. Gaertn*) is a plant of the Sapotaceae family that grows wild in West Africa within a geographical zone extending from Mali to northern Sudan and from Togo to southern Uganda [1,2]

In Côte d'Ivoire, shea stands are found both in the zone of diversity (far north of the country) and in the marginal zone (pre-forest transition zone) of its distribution area, which, a priori, should correspond to genetic richness [3]

 Shea butter is highly valued in the food, cosmetics and pharmaceutical industries [4,5,6,7] because of its high unsaponifiable content [8], which gives it numerous outlets on international markets [9].

 According to surveys by [3], 639 elite shea trees are preserved in situ on farmers' farms in the Bagoué and Tchologo regions, covering the departments of Boundiali, Kouto, Tengrela, Ferkéssedougou, Kong and Ouangolodougou.

These elite shea trees, which have been geo-referenced and selected by the producers themselves, generally on the basis of criteria such as high fruit yield, sweet taste of the pulp, fruit size and earliness of flowering in the year, now constitute the basic genetic material for improving shea in Côte d'Ivoire [3]

However, the oil from the kernels of the nuts of these elite trees has not yet been characterised. Only the fruit pulp of these trees has been biochemically characterised [10]. The aim of this study is to investigate the chemical characteristics of the shea nut kernel oil from high-producer trees in the Tchôlogo region, with a view to proposing appropriate ways of adding value to the product.

2. material and methods

**2.1 Plant material**

The study was carried out on shea nuts extracted from mature fruits collected from 80 Potentially High Producer Shea trees (KPHP) in the Tchologo region.

**2.2 Sampling method**

Harvesting was carried out during the fruiting period of the trees (May to July) when the fruit is ripe. The fruit was collected from the underside of each tree. 80 trees were selected at random, including 40 trees with the thin leaf shape morphotype and 40 trees with the broad leaf shape morphotype. For each leaf shape morphotype, 10 trees were selected by fruit shape (spheroid, ellipsoid, ovoid, oblong). Under each tree per fruit shape, 20 fruits were collected, giving a total of 200 fruits per shape. Thus, for each leaf shape morphotype, 800 fruits for the 4 fruits shape morphotypes were sampled, i.e. 1600 fruits for the 2 leaf shape morphotypes. The nuts from the 20 fruits per tree for each leaf shape morphotype formed the composite sample for each tree. Thus, for the 2 leaf shape morphotypes, a total of (8) composite nut samples were taken. The kernel oils from these composite samples were extracted and used for the various chemical analyses.

**2.3 Determination of oil chemical parameters**

The oil content, expressed as a percentage of oil in relation to dry weight (% oil/dry weight), was obtained by the Soxhlet method according to [11]. The acid value, iodine value and saponification value of the oils were determined using the [12]. The peroxide value was determined in accordance with ISO 3960: 2007. The refractive index was determined using a refractometer according to the method described in [13]. The chromatographic profile of the fatty acids was carried out according to the NF ISO 6320 (1978) method using an HP 6890 series GC system gas chromatograph. The method of [14] was used for the determination of vitamins A, D, E and K in shea oil samples.

**2.4 Statistical processing**

The data were processed with SPSS version 16.0 software using an analysis of variance with 2 classification criteria (fruit shape and leaf shape). The means of the chemical parameters determined by the Newman and Keuls test with a threshold of 5% were used to compare the different samples.

3. results

**3.1 Chemical composition of the oil from the kernels of the different shea varieties**

Statistical analysis revealed a highly significant difference at the 5% level in the parameters measured, with the exception of the refractive index in all samples (Table I). Refractive index values ranged from 1.23 to 1.48.

The Thin Sphéroid Tchologo (MSPT), Thin Ellipsoid Tchologo (MELT) and Large Ellipsoid Tchologo (LELT) samples recorded the highest oil contents statistically. They were 49.73%, 50.02% and 50.03% respectively. However, the Large Ovoid Tchologo (LOVT) sample gave the lowest oil content (40.83%).

In terms of acid value content, the lowest value (11.61) was observed in the Thin Oblong Tchologo (MOBT) sample and the highest contents were found in the Thin Ovoid Tchologo (MOVT) and Large Ovoid Tchologo (LOVT) samples. These values were 14.45 and 14.17 respectively.

The Large Oblong Tchologo (LOBT) sample gave the highest iodine value (88.14) and the lowest value (76.83) was recorded in the Large Sphéroid Tchologo (LSPT) sample.

The highest saponification value (291.34) was found in the MOVT sample and the lowest (216.11) in the LSPT sample.

Finally, the LOVT and MOVT samples recorded the statistically highest peroxide values. These were 4.09 and 4.32 respectively. On the other hand, the lowest peroxide values were found in the MSPT and LOBT samples.

**Table I:** Chemical composition of the oil from the kernels of different shea varieties

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **SAMPLE** | **Oil content (%)** | **acid value**  | **Iodine value** | **Saponification value** | **Peroxide value** | **Refraction index** |
| **LELT** | 50.03±0.01f | 13.16±0.10b | 83.33±0.48b | 247.21±0.92d | 3.18±0.07c | 1.44±0.02a |
| **LOBT** | 46.67±0.42d | 12.61±0.47b | 88.14±0.98e | 242.77±0.60c | 2.38±0.17ab | 1.48±0.02a |
| **LOVT** | 40.83±0.04a | 14.17±0.04c | 84.05±0.07b | 236.62±0.03b | 4.09±0.01e | 1.45±0.02a |
| **LSPT** | 47.27±0.07e | 13.33±0.17b | 76.38±0.26a | 216.11±0.05a | 3.71±0.03d | 1.46±0.01a |
| **MELT** | 50.02±0.01f | 13.16±0.10b | 83.33±0.48b | 247.21±0.92d | 3.18±0.07c | 1.45±0.02a |
| **MOBT** | 45.67±0.42c | 11.61±0.49a | 86.64±0.27d | 245.77±0.81d | 2.58±0.18b | 1.33±0.06a |
| **MOVT** | 43.34±0.02b | 14.45±0.07c | 86.77±0.04d | 291.35±0.78e | 4.32±0.02e | 1.46±0.01a |
| **MSPT** | 49.73±0.04f | 13.02±0.02b | 85.09±0.14c | 237.79±0.29b | 2.15±0.21a | 1.23±0.33a |

*Means with different letters in the same column are significantly different at the 5% threshold according to the Student Neuman Keuls test.*

***LELT****: large ellipsoid tchologo;* ***LSPT****: large spheroid tchologo;* ***LOBT****: large oblong tchologo;* ***LOVT****: large ovoid tchologo;* ***MOVT****: thin ovoid tchologo;* ***MSPT:*** *thin spheroid tchologo,* ***MELT****: thin ellipsoid tchologo,* ***MOBT****: thin oblong tchologo*

**3.2 Fatty acid composition of the oil from the kernels of different shea varieties**

 The chromatographic profile of the fatty acids in the oil from the almonds of the different shea varieties revealed 14 fatty acids, namely linolenic acid, stearidonic acid, arachidic acid, linoleic acid, arachidonic acid, eicosapentaenoic acid, eicosenoic acid, lauric acid, myristic acid, palmitic acid, myristic acid and palmitic acid, arachidonic acid, eicosapentaenoic acid, eicosenoic acid, lauric acid, myristic acid, palmitic acid, palmitoic acid, stearic acid, oleic acid and docosahexaenoic acid. The majority fatty acids were linolenic acid, stearidonic acid and arachidic acid. A significant difference was observed for all fatty acids in all samples (Table II).

 The highest linolenic acid content (39.33 mg/100g) was recorded in the Thin Ellipsoid Tchologo (MELT) sample and the lowest (21.23 mg/100g) in the Thin Oblong Tchologo (MOBT) sample.

 The Thin Oblong Tchologo (MOBT) sample had the highest stearidonic acid content with a value of 21.27 mg/100g. On the other hand, the Large Ovoid Tchologo (LOVT) sample gave the lowest stearidonic acid content (10.71 mg/100g).

 In terms of arachidic acid, the Tchologo Thin Ovoid (MOVT) and Tchologo Thin Spheroid (MSPT) samples provided the highest levels statistically. These were 26.84 mg/100g and 27.13 mg/100g respectively. The Large Ellipsoid Tchologo (LELT) sample recorded the lowest value statistically (19.23 mg/100g).

The highest linoleic acid content (7.27 mg/100g) was observed in the Mince Ellipsoïde Tchologo (MELT) sample.

 The Tchologo Large Ellipsoid (LELT) and Tchologo Thin Ellipsoid (MELT) samples gave the lowest levels (1.83 mg/100g) of arachidonic acid. However, the highest content (7.64 mg/100g) was recorded in the Thin Spheroid Tchologo (MSPT) sample.

The highest eicosapentaenoic acid content (5.82 mg/100g) was found in the Large Oblong Tchologo (LOBT) sample. The LELT and MELT samples gave the lowest levels of eicosapentaenoic acid. The values were 1.31 mg/100g and 1.41 mg/100g respectively.

 The Large Ellipsoid Tchologo (LELT) sample had the highest palmitoic acid content with a value of 4.39 mg/100g. On the other hand, the Thin Ovoid Tchologo (MOVT), Thin Oblong Tchologo (MOBT) and Thin Sphéroid Tchologo (MSPT) samples recorded the lowest palmitoic acid levels. They were 2.10 mg/100g, 2.22 mg/100g and 2.46 mg/100g respectively.

 Finally, the highest stearic acid content (5.65 mg/100g) was recorded in the Large Spheroid Tchologo (LSPT) sample and the lowest (2.61 mg/100g) in the Large Ovoid Tchologo (LOVT) sample.

**TABLE II** : Fatty acid content of the oil from the kernels of different shea varieties

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **Linolenic acid (mg/100g)** | **stearidonic acid (mg/100g)** | **arachidic acid (mg/100g)** | **linoleic acid (mg/100g)** | **arachidonic acid, (mg/100g)** | **eicosapentaenoic acid (mg/100g)** | **eicosenoic acid (mg/100g)** |
| **LELT** | 38.34±0.16g | 18.21±0.05d | 19.23±0.12a | 3.39±0.14a | 1.83±0.14a | 1.31±0.07a | 1.11±0.02a |
| **LOBT** | 22.23±0.28b | 20.27±0.14f | 20.44±0.14b | 5.31±0.07c | 2.71±0.07b | 5.82±0.14e | 2.21±0.07b |
| **LOVT** | 35.54±0.14f | 10.71±0.07a | 22.44±0.29d | - | 2.35±0.14b | 2.69±0.14b | - |
| **LSPT** | 23.71±0.14c | 13.27±0.07c | 23.12±0.04e | 7.27±0.07d | 5.35±0.14d | 2.89±0.14b | - |
| **MELT** | 39.34±0.16h | 19.21±0.05e | 19.33±0.12a | 3.39±0.14a | 1.83±0.14a | 1.41±0.07a | 1.13±0.04a |
| **MOBT** | 21.23±0.28a | 21.27±0.14g | 21.44±0.14c | 4.31±0.07b | 3.71±0.07c | 4.82±0.14c | 3.21±0.07c |
| **MOVT** | 29.64±0.19d | 18.76±0.14d | 26.84±0.14f | - | 7.49±0.08e | 5.44±0.16d | - |
| **MSPT** | 31.63±0.14e | 12.23±0.05b | 27.14±0.04f | - | 7.64±0.14f | 2.41±0.07b | - |

- *not determined*

*Means with different letters in the same column are significantly different at the 5% threshold according to the Student Neuman Keuls test.*

***LELT****: large ellipsoid tchologo;* ***LSPT****: large spheroid tchologo;* ***LOBT****: large oblong tchologo;* ***LOVT****: large ovoid tchologo;* ***MOVT****: thin ovoid tchologo;* ***MSPT:*** *thin spheroid tchologo,* ***MELT****: thin ellipsoid tchologo,* ***MOBT****: thin oblong tchologo*

**TABLE II** continued: Fatty acid content of the oil from the kernels of different shea varieties

- *not determined*

*Means with different letters in the same column are significantly different at the 5% threshold according to the Student Neuman Keuls test.*

***LELT****: large ellipsoid tchologo;* ***LSPT****: large spheroid tchologo;* ***LOBT****: large oblong tchologo;* ***LOVT****: large ovoid tchologo;* ***MOVT****: thin ovoid tchologo;* ***MSPT:*** *thin spheroid tchologo,* ***MELT****: thin ellipsoid tchologo,* ***MOBT****: thin oblong tchologo*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **sample** | **lauric acid (mg/100g)** | **myristic acid (mg/100g)** | **palmitic acid (mg/100g)** | **palmitoic acid (mg/100g)** | **stearic acid (mg/100g)** | **oleic acid (mg/100g)** | **docosahexaenoic acid (mg/100g)** |
| **LELT** | - | 0.09±0.01a | - | 4.39±0.21c | 5.37±0.14d | 0.83±0.21b | 0.28±0.14ab |
| **LOBT** | 1.20±0.07c | 0.52±0.14c | 0.13±0.03bc | 3.22±0.07b | 5.60±0.21e | 0.60±0.21b | 0.31±0.14ab |
| **LOVT** | 0.14±0.04a | 0.07±0.02a | 0.07±0.03ab | 3.38±0.14b | 2.61±0.14a | - | 0.30±0.14ab |
| **LSPT** | 0.51±0.14b | 0.15±0.04a | 0.05±0.04ab | 3.16±0.04b | 5.65±0.21f | 0.45±0.21b | 0.15±0.04a |
| **MELT** | - | 0.13±0.03a | - | 3.39±0.21b | 4.37±0.14c | 0.68±0.14b | 0.43±0.21ab |
| **MOBT** | 1.30±0.07c | 0.37±0.07bc | 0.17±0.02c | 2.22±0.07a | 4.60±0.21c | 0.75±0.14b | 0.41±0.14ab |
| **MOVT** | 0.47±0.14b | 0.38±0.06bc | 0.06±0.03ab | 2.10±0.02a | 3.76±0.29b | 0.57±0.17b | 0.08±0.02a |
| **MSPT** | 0.49±0.07b | 0.29±0.07ab | 0.07±0.02ab | 2.46±0.07a | 3.16±0.07b | 0.52±0.04b | 0.73±0.07b |

**3.3 Vitamin composition of the oil from the kernels of different shea varieties**

The main fat-soluble vitamins detected in the oil of the kernels of the different shea varieties were vitamins A, D, E and K. A significant difference was observed at the level of vitamins in all the samples (Table III).

The Large Oblong Tchologo (LSPT) sample had the highest vitamin A content (24.21 mg/100g). However, the lowest vitamin A content (10.20 mg/100g) was found in the Large Ovoid Tchologo (LOVT) sample.

 The highest vitamin D content (36.34 mg/100g) was recorded in the Thin Oblong Tchologo (MOBT) sample and the lowest (20.40 mg/100g) in the Thin Ovoid Tchologo (MOVT) sample.

 The Tchologo Ellipsoid Thin sample (MELT) gave the highest vitamin E content (16.39 mg/100g). However, the lowest vitamin E content (10.10 mg/100g) was provided by the Thin Ovoid Tchologo (MOVT) sample.

 Finally, the highest vitamin K content (24.84 mg/100g) was given by the Large Ovoid Tchologo (LOVT) sample and the lowest (14.42 mg/100g) by the Thin Ovoid Tchologo (MOVT) sample.

**TABLE III**: Vitamin content of the oil from the kernels of different shea varieties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample** | **Vitamin A (mg/100g)** | **Vitamin D****(mg/100g)** | **Vitamin E****(mg/100g)** | **Vitamin K****(mg/100g)** |
| **LELT** | 17.71±0.21c | 27.38±0.14d | 14.89±0.14d | 18.73±0.14b |
| **LOBT** | 19.73±0.14e | 34.84±0.14f | 12.22±0.14c | 23.22±0.07d |
| **LOVT** | 10.20±0.07a | 25.81±0.14c | 11.26±0.07b | 24.84±0.14e |
| **LSPT** | 24.21±0.07g | 27.68±0.14d | 11.33±0.14b | 19.69±0.14c |
| **MELT** | 16.71±0.21b | 28.38±0.14e | 16.39±0.56e | 19.73±0.14c |
| **MOBT** | 18.23±0.84d | 36.34±0.56g | 12.57±0.07c | 25.72±0.77f |
| **MOVT** | 16.21±0.07b | 20.40±0.07a | 10.48±0.21a | 14.42±0.14a |
| **MSPT** | 20.82±0.14f | 23.35±0.10b | 10.10±0.07a | 23.71±0.21d |

*Means with different letters in the same column are significantly different at the 5% threshold according to the Student Neuman Keuls test.*

***LELT****: large ellipsoid tchologo;* ***LSPT****: large spheroid tchologo;* ***LOBT****: large oblong tchologo;* ***LOVT****: large ovoid tchologo;* ***MOVT****: thin ovoid tchologo;* ***MSPT:*** *thin spheroid tchologo,* ***MELT****: thin ellipsoid tchologo,* ***MOBT****: thin oblong tchologo*

**4. DISCUSSION**

Shea kernels are distinguished by their high fat content, ranging from 40.83% to 50.03%. These yields are higher than those of certain oilseeds such as cashew (46% and 48%), groundnut (40%) and cotton (16 to 28%) [15]. The saponification value indicates the saponification potential of a fatty substance. Its high value in an oil makes it a recommended raw material for soap manufacture. The saponification indices obtained in the different shea oils are very high, ranging from (216-291). Our results are in agreement with those of [16] who showed that the saponification indices in coconut oil and palm kernel oil are between (248-265) and (230-254) respectively. The saponification indices obtained in shea oils are also higher than that of *Ricinodendron heudelotii* oil [17]. The peroxide value is a quality criterion that makes it possible to determine the oxidation state of oils, to monitor the initial stages of oxidative deterioration and to determine the odour of the oil [18].The peroxide values obtained ranged from 2.38 to 4.32 mEq O2/kg of oil, and the oil was not oxidised. The peroxide values obtained for the oil of the different shea varieties are in line with those of [19], which recommends less than 10 mEq O2/kg for vegetable oils. However, the peroxide values obtained in our shea butter oils are higher than those observed by [20], which vary between 0.96 and 1 mEqO2/kg. This difference can be explained by the fact that we did not use the same extraction methods according to [21], to be used in the food industry, shea butter must have a peroxide value of less than 10 meq O2/k. Shea oils can therefore be used in the food industry. The iodine index is a purity criterion that tells us the degree of saturation of the fatty acids contained in a given oil. The iodine values of our oils ranged from 76.38 to 88.14 mg/100 g, so they are unsaturated. The iodine values obtained are higher than those reported by [22] and [23] (44.07 and 40.20 mg/100 g) in safflower pulp oil in Nigeria. However, they are lower than those of [24] (80mg/100g), and [25] (79.6 mg/100g) who worked on safflower pulp oil in Cameroon and Gabon. The iodine indices of shea oils are close to those of olive oil (75-94) and rapeseed oil (97-107) [26]. The acid number is also a criterion of oil quality. It is used to determine the free fatty acid content, stability and purity of the oil. The acid number values for shea oils range from 11.61 mg KOH/g to 14.45 mg KOH/g. These values are higher than those recommended by [19], which is 4 mg KOH/g of oil. We can conclude that our oils contain a high quantity of free fatty acids. This could be due to the method of preservation. The refractive index is also an important criterion for identifying oils. It provides information about the purity and group of the oil. The refractive index obtained in this study was between 1.455 and 1.467. These values are within the range established by the [19]. These indices are similar to those reported by [27] and [20] and close to that of olive oil (1.467-1.470) [28]. The chromatographic profile of the fatty acids revealed that the shea nut kernel oils from the 8 samples are rich in unsaturated fatty acids with high proportions of linolenic acid, stearidonic acid and arachidic acid. The high unsaturated fatty acid content of the oils could be explained by their high iodine values. Oils rich in unsaturated fatty acids are of vital importance from a nutritional and health point of view [29]. Indeed, the consumption of polyunsaturated and monounsaturated fatty acids has been recommended to improve the lipid profile, unlike that of saturated fatty acids, which contributes to increased cholesterol levels, obesity and certain cardiovascular disorders such as atherosclerosis [30]. The oils obtained are also rich in vitamins A, D, E and K. Vitamin A helps stimulate collagen production for firmer, more elastic skin [31,32]. Vitamin E is a powerful antioxidant that protects the skin from damage caused by free radicals [33]. Vitamin D promotes cell regeneration and helps maintain skin health. Finally, vitamin K. It is involved in blood clotting, which can help reduce bruising and promote faster healing of wounds and skin sores [34,35]

5. Conclusion

This study was carried out to determine the chemical characteristics of the kernel oil of 8 varieties of shea nut with a view to proposing appropriate ways of adding value.

The results showed that the shea nut kernel oil content of the 8 samples ranged from 40.83% to 50.03%. Shea nut kernel oil contains a high level of unsaturated fatty acids, with high proportions of linolenic acid (ranging from 21.23% to 39.34%) and high saponification values (ranging from 216.11 to 291.35). The oils are also rich in vitamins A, D and K. These oils are of lesser quality for food use because they contain a high level of free fatty acids, reflected in high acid indices. In view of these results, the almond oil in the MOVT sample with a higher saponification value is suitable for soap production.

References

1.Salle G, Boussim L, Raynal-Roques A, Brunck F. Shea: state of our knowledge and research perspectives. In Physiology of trees and shrubs in arid and semi-arid zones.1991; 427-439.

2.Hall JB, Aebischer DP, Tomlison HF, Osei-amaning E, Hindle JR. Vitellaria paradoxa: a monograph. School of Agricultural and Forest Sciences.1996; 34-55.

3. Diarrassouba N, N’guessan A, Koffi E, Sangare A. Evaluation of the performance of some quantitative descriptors and their use in structuring the population of a natural shea park in Côte d'Ivoire. Plant Genetic Resource Newsletter.2007; 152: 65-72.

4. Wallace-Bruce Y. Shea butter production in Ghana. Appropriate Technology .1993; 20: 22-39.

5.Soro, Traore K, Kassi NJ. Variability of morphological characters in shea (Vitellaria paradoxa) in northern Côte d’Ivoire. Int. J. Biol. Chem. Sci. 2011; 5(3): 1201-1214

6. Gnanglè PC, Egah J, Baco M.N, Gbemavo CDSJ, Kakaï RG, Sokpon N. Local perceptions of climate change and adaptation measures in the management of shea parklands in northern Benin. Int. J. Biol. Chem. Sci.2012; 6(1): 136-149

7.Kouyaté AM, Dembelé U, Lykke AM. Local oil-bearing woody species: a useful resource for local communities in southern Mali. Int. J. Biol. Chem. Sci. 2015; 9(6): 2754-2763

8. Kapseu C, Jiokap, Nono Y, Parmentier M. Aiélé fruits (canarium schweinfurhiiengl.), olives from sub-Saharan Africa, La Rivista Italiana Delle Sostance Grasse. 2001; Vol XXVIII, : 31-34

9. Yé S, Lebeau F, Wathelet J-P, Leemans V, Destain M. Study of the operating parameters of mechanical pressing of Vitellaria paradoxa Gaertn C. F. (shea) almonds, Biotechnol. Agron. Soc. Environ. 2007; 11(4):267–273.

10.KONE A S. Study of the agro-morphological parameters of different forms of shea fruits and some biochemical parameters of the pulp from these different forms. Master's thesis.2021; 70 p

11 AOAC . Official methods of analysis of Association of Official Analytical Chemist.1990; 15th Edition.

12.AOAC Official Methods of Analysis of Association of Official Analytical Chemists. 2000; 17th ed. Gaithersburg, Maryland, USA.

13.AFNOR .French Agency for Standardization. Compendium of French agro-food standards Paris, la defense.1984; France, 159 p.

14. Billion-Rey F, Guillaumont M, Frederich AY, Aulagner G. Stability of fat soluble vitamins A (retinol palmitate), E (tocopherol acetate), and K1 (phylloquinone) in total parenteral nutrition at home. Journal of Parenteral and Enteral Nutrition.1993; 17(1): 56-60.

15. Silou T. Unconventional fats from the Congo Basin: characterization, biodiversity and quality. Oilseeds & fats Crops and Lipid. 2014; 21 (2): D209, 15p.

16. Bamba S. Contribution to the valorization of extracted fat almonds of Afraegle paniculata (Rutaceae) from Ivory Coast. Doctoral thesis, Nangui Abrogoua University, Ivory Coast. 2016;153 P.

17. Bamba S, Gué LA, Ouattara LH, Traoré Lbd, Katou YS, Kabran GRM, Konan DJ, Belemlilga BM. Chemical and Physicochemical Properties of the Lipid Extract of (Ricinodendron heudelotii) Baill. Almonds (Euphorbiaceae) from Ivory Coast. International Journal of Biochemistry Research & Review Volume 2024; 33 (6): 215-223,

18. Na Z, Yonglin L, Shasha W, Yiwen S, Jia CYG, Altayuly S, Xiuzhu Y. Analytical methods for determining the peroxide value of edible oils: A mini-review, Food Chemistry, Volume 358. 2021; 129834, ISSN 0308-8146, https://doi.org/10.1016/j.foodchem.2021.129834.

19. Codex Alimentarius. Food standards and guidelines. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). 2025; Accessed 08 February 2025.

20. Mégnanou RM, Niamké S. Improving the optimized shea butter quality: a great potential of utilization for common consumers and industrialists. 2015; SpringerPlus 4:667 DOI 10.1186/s40064-015-1454-0

21. Honfo FG, Akissoe N, Linnemann AR, Soumanou M, Van BMA. (2014). Nutritional composition of shea products and chemical properties of shea butter: a review. Critical reviews in food science and nutrition. 2014; (54): 673-686.

22. Ikhuoria EU, Maliki M.. Characterization of avocado pear (Persea americana) andAfrica pear (Dacryodes edulis) extracts. African Journal of Biotechnology.2007; 7: 950-954

23. Akubugwo IE, Ugbogu AE. Physicochemical studies on oils from five selected Nigerian plant seeds. Pakistan Journal of Nutrition. 2007; 6 (1): 75-78

24. Bezard J, Silou T, Kiakouama S, Sempore G. Variation of the glyceridic fraction of safou pulp oil with the state of maturity of the fruit. Revue Française Corps Gras. 1991; 7/8: 233-241.

25. Dzondo-Gadet M, Nzikou JM, Matouba E, Etoumongo A, Linder M, Desobry S. Characterization and nutritional interest of safou pulp oil, Process Biochemistry. 2005; 40 (1): 307-312, https://doi.org/10.1016/j.procbio.2004.01.003.

26. Lapierre J, St-Gelais K. The iodine value of five oils at different temperatures.expojournal.cegepstfe.ca/wp -content/uploads/Articles scientifique. Pdf. 2013;11.

27. Oluba OM, Ogunlowo YR, Ojieh GC, Adebisi KE, Eidangbe GO, Isiosio IO. Physicochemical properties and fatty acid composition of citrullus lanatus (Egusi melon) seed oil. Journal of Biological Sciences. 2008; 8 (4): 814-817.

28. Ali HE, El-Waseif MA. Effect of Treated Olive Fruits by Some Growth Regulators on Physiochemical properties of Extracted Olive Oil. Science International. 201; 4: 105-116.

29. Law M. Dietary fat and adult diseases and the implications for childhood nutrition: An Epidemiologic approach. American Journal of Clinical Nutrition. 2000; 72: 1291-1296.

30. Anita BS, Akpan EJ, Okon PA, Umoren IU.. Nutritive and anti-nutritive evaluation of sweet potatoes leaf. Pakistan Journal of Nutrition. 2006; 5: 166-168.

31 Martin Ask N, Leung M, Radhakrishnan R, Lobo GP. Vitamin A Transporters in Visual Function: A Mini Review on Membrane Receptors for Dietary Vitamin A Uptake, Storage, and Transport to the Eye. Nutrients. 2021;13(11):3987. doi:10.3390/nu13113987.

32. Radhakrishnan R, Leung M, Roehrich H. Mice Lacking the Systemic Vitamin A Receptor RBPR2 Show Decreased Ocular Retinoids and Loss of Visual Function. Nutrients. 2022;14(12):2371. doi:10.3390/nu14122371.

33. Jens JT, Swarna E-M. Vitamin E in human skin: Organ-specific physiology and considerations for its use in dermatology, Molecular Aspects of Medicine. 2007; 28, (5–6): 646-667, ISSN 0098-2997, https://doi.org/10.1016/j.mam.2007.06.001.

34. Schurgers LJ, Vermeer C. Determination of phylloquinone and menaquinones in food. Effect of food matrix on circulating vitamin K concentrations. Haemostasis 2000; 30:298-307.

35. Walther B, Karl JP, Booth SL, Boyaval P. Menaquinones, bacteria, and the food supply: the relevance of dairy and fermented food products to vitamin K requirements. Adv Nutr 2013; 4:463-73.