Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2019; 8(6): 176-180
Received: 04-09-2019
Accepted: 06-10-2019

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# Pigments and calorific power of palm kernel oil produced in Togo: Nutritional and pharmacological interest

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## Abstract
Local vegetable oils are of interest through their food, cosmetic and therapeutic uses. Among these oils, palm kernel oil is used in soap making, diet and traditional medicine. However, palm kernel oil remains little studied and valued in Togo. This study aims to contribute to the valorization of this oil by evaluating its calorific value, its content of chlorophyll pigments and carotenoids. The results obtained have shown that the palm kernel oils analyzed have chlorophylls levels approaching that of olive oil and contains carotenoids. Moreover, the calorific value of these oils is higher than 35000 KJ and therefore nutritionally interesting. From this study, we can conclude that the palm kernel oil produced in Togo is of nutritional and pharmacological interest through its contents in pigments and its calorific value. However, considering its concentration in saturated fatty acids and therefore its cholesterol-lowering character, its use in feeding should be done sparingly.

**Keywords:** Palm kernel oil, chlorophyll pigments, carotenoids, calorific value

## Introduction
Vegetable oils are an important part of the human diet as a source of energy, fat soluble vitamins and essential fatty acids (FAO, 2009; Dahouenon-Ahoussi *et al.*, 2012) [1-2]. These oils include others as coconut oil, peanut oil, soybean oil, palm oil and palm kernel oil (OCDE, 2016) [3]. Many studies have been conducted on vegetable oils. Though, palm kernel oil is still little known (Abalo, 2005) [4] and little studied in countries like Togo. However, palm kernel oil, a vegetable oil obtained from the kernel of the fruit of the palm tree (*Elaeis guineensis*), is widely used in the cosmetics and food industries (Abalo, 2005) [4]. Palm kernel oil belongs to the family of triglycerides. It is obtained by trituration (drying, grinding and pressing) of palm kernels and rarely extracted with chemical solvents. It is yellowish at liquid state and whitish at solid one (Kandji, 2001; Perrier, 2005; Richard, 2011; Mengounou *et al.*, 2016) [5-8]. In West Africa, women make natural soaps containing 90% of palm kernel oil or more. Before 1980, palm nuts produced in Togo were largely exported to neighboring countries by Togolese Office of Agricultural Products (OPAT) (SORGEM, 1979) [9]. But nowadays, women make the transformation which is a technology that farmers have developed over time with rudimentary means. We can therefore say that, like in the case of palm oil (Sy, 2002; Bishop, 2018) [10-11], the palm kernel oil industry is experiencing a real dynamism and valuation involves studies not only on its physico-chemical and organoleptic characteristics but also on its nutritional and pharmacological interest. The production, processing and marketing of palm kernel oil help to fight against poverty (Tchezoum 1995; Abalo, 2005) [4, 12]. Through these exfoliating and cleansing properties, this oil used in bathing leaves skin clean and soft. Regular use of this oil then prevents skin problems. Palm kernel oil is used in cosmetics especially for soaps and creams mixing with other oils. Not oxidized, its use as food margarines and in biscuit, is relates to its flavor nice and fragrance similar to that of the oil in the coconut. In Togo, New Oilseed Industry of Togo (NIOTO) product and crude palm kernel oil from palm kernels from Togo or Benin (Abalo, 2005) [4]. However, considerable amounts of palm nut remain untapped wherever the palm tree flourishes (GIZ, 2015) [13]. This is explained by the lack of valuation of palm kernel oil concomitantly with the unavailability of information on the oil and the techniques of transformation (Boni, 1993) [14]. Though, palm kernel oil produced in hygienic conditions is very useful for human consumption and soap industries with a degree of acidity usually less than 15%. Moreover, the use of palm kernel oil for food requires refining because of its high content of saturated fatty acids (N'goran *et al.*, 2017) [15]. Previous studies on oils and fats, particularly concerned the physico-chemical and organoleptic

characteristics. This finding is even for the few studies on palm kernel oil in Nigeria (Atasie *et al.*, 2009) [16] and Senegal (Mboui, 2019) [17]. However, the characteristics of these oils that confer them nutritional quality, are among others, their content in unsaturated fatty acids, chlorophyll pigments, carotenoid and their calorific value. It is in this context that, to contribute to the development of the palm kernel oil producing in Togo, this study aims specifically to analyze its pigments and calorific value.

## Material and methods

### Sampling

The samples were collected at the production units of palm kernel oil in three regions of Togo (Figure 1). In total thirty-six (36) samples were collected and analyzed.

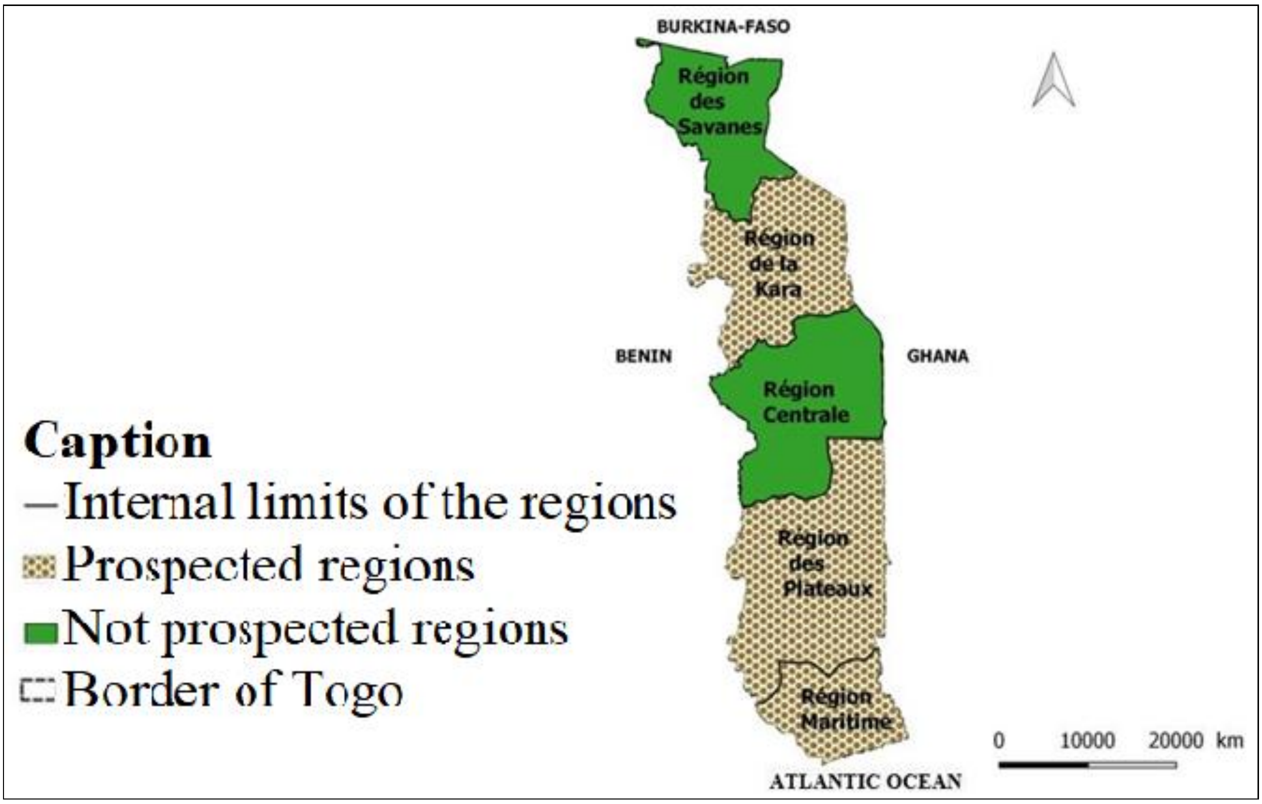


**Fig 1:** Map of Togo showing the prospected areas

### Determination of chlorophyll (a and b) and total carotenoids contents

The components contained in pigmented palm kernel oil were quantified according to the conditions described by Petry and Mercadante (2017) [18] which are to be avoided if possible, after extraction, the exposure of the oil to light, oxygen and acids. The dosage of the pigments was done by UV-Visible spectroscopic method (Wellburn, 1994) [19]. The solution was prepared by introducing 30.25 mg in 10 ml of acetone 100%. The resulting mixture was well vortexed and reading the optical density of the solution thus prepared was made to three different following wavelengths: $\lambda_1$ = 470 nm; $\lambda_2$ = 645 = nm and $\lambda_3$ = 662 nm and the spectrophotometer used is SHANGHAI METASH Type UV-5200PC. In comparison, two reference harvested edible oils on the market have been analyzed in the same conditions. This is the olive oil "GOYA Extra" and sunflower oil "BONITA". Chlorophyll a (C [a]), chlorophyll b (C [b]) and total carotenoids (C [x + c]) were determined using the following three trichromatic formulas:

C [a] = 1 1.75A662-2.35A645;

C [b] = 18.61A645-3.96A662;

C [x + c] = (1000A470-2.27C [a]-81.4C [b])/227.

The results obtained are expressed in µg/g of oil.

### Calorific power

The calorific value (PC) was calculated using the formula Batel *et al*. (1980) [20].

$$PC\ (KJ/Kg) = 47645 - (4.187\ X\ InI) - (38.31\ X\ InS)$$

$$\text{où } InI = Indice\ d'Iode\ et\ InS = Indice\ de\ Saponification$$

### Statistical analysis

All data were entered into the spreadsheet Microsoft Excel 2013. Graph Pad Prism software version 7.00 was used for statistical data processing. The results were expressed as mean value with standard deviation error (SD). The comparison of the oils in pairs was made through the mean values of various parameters. This comparison was performed by Student's t-test. Significant differences were considered at 5% ($P$<0.05).

## Results

### The content of chlorophyll (a)

The content of chlorophyll (a) (Table 1), has varied from 52.22 µg/g (for the oil obtained with the pressure extraction process after roasting the almonds) to 38.47 µg/g (for the oil obtained with the process of extraction by cold pressing near roasting almonds for the manufacturing of soap). On the other hand, significant variations in the chlorophyll a levels were observed at 5% following the oil production processes (Table 1).

**Table 1:** Chlorophyll (a) content of palm kernel oil samples according to production processes

| | Chlorophyll (a) content of the various types of analyzed oils (µg/g) | | | | | |
|---|---|---|---|---|---|---|
| | **OTPA (n=15)** | **OTPB (n=2)** | **OCRATP (n=7)** | **HEPT (n=3)** | **CPOS (n=6)** | **CPOF (n=3)** |
| Min. | 32,03 | 29,74 | 19,07 | 47,19 | 24,14 | 35,52 |
| Med. | 49,94 | 45,91 | 45,98 | 52,22 | 36,81 | 40,85 |
| Max. | 61,61 | 62,07 | 59,29 | 57,25 | 56,03 | 51,83 |
| Mean ± SD | 49,23±7,75[a] | 45,91±22,86 | 42,38±13,12[b] | 52,22±5,03[b,c,d] | 38,47±12,24[a,c] | 42,73±8,32[d] |

-OTPA and OTPB: Oils from traditional process A and B (it consists in bringing the palm nut marzipan paste to a boil at 100 °C in the presence of water, after having previously undergone washing and drying, roasting, grinding, crushing or pressing, decantation).
-OCRATP: Oil collected during the roasting of almonds in the traditional process.
- OEPRA: Oil extracted by pressure after roasting almonds.
-CPOS: Cold pressed oil used for soap production (improved process).
-CPOF: Cold pressed oil used as feed (improved process).
The values are expressed as Mean ± SD. Values with the same letters are significantly different ($P<0.05$).

## The content of chlorophyll (b)

The content of chlorophyll (b) has varied from 58.41 µg/g (for the oil obtained with the pressure extraction process after roasting almonds) to 36.18 µg/g (for the oil obtained with the process of extraction by cold pressing near roasting of almonds for the manufacturing of soap). Significant variations at the 5% level between chlorophyll (b) levels, following oil production processes were also observed (Table 2).

**Table 2:** Chlorophyll b content of palm kernel oil samples according to production processes

| | Chlorophyll (b) content of the various types of analyzed oils (µg/g) | | | | | |
|---|---|---|---|---|---|---|
| | **OTPA (n=15)** | **OTPB (n=2)** | **OCRATP (n=7)** | **HEPT (n=3)** | **CPOS (n=6)** | **CPOF (n=3)** |
| Min. | 24,83 | 19,88 | 04,64 | 53,43 | 12,97 | 30,68 |
| Med. | 56,76 | 46,44 | 47,83 | 58,41 | 33,92 | 37,34 |
| Max. | 69,93 | 73,00 | 71,05 | 63,39 | 63,98 | 59,65 |
| Mean ± SD | 54,63±11,87[a] | 46,44±37,56 | 43,64±21,68[b] | 58,41±4,98[b,c,d] | 36,18±19,72[a,c] | 42,56±15,17[d] |

-OTPA and OTPB: Oils from traditional process A and B (it consists in bringing the palm nut marzipan paste to a boil at 100 °C in the presence of water, after having previously undergone washing and drying, roasting, grinding, crushing or pressing, decantation).
-OCRATP: Oil collected during the roasting of almonds in the traditional process.
- OEPRA: Oil extracted by pressure after roasting almonds.
-CPOS: Cold pressed oil used for soap production (improved process).
-CPOF: Cold pressed oil used as feed (improved process).
The values are expressed as Mean ± SD. Values with the same letters are significantly different ($P<0.05$).

## Total carotenoids content

The total carotenoid content (Table 3) varied from 2.24 µg/g (for the oil obtained with the traditional process A) to 3.46 µg/g (for the oil obtained with the extraction process by cold pressing for the manufacturing of soap). Significant variations at the 5% level between total carotenoid levels, following the oil production processes, were observed only between the oil obtained with the traditional process A and that with the cold-pressure extraction process for the manufacturing of soap (Table 3).

**Table 3**: Carotenoid content of palm kernel oil samples according to production processes

| | Carotenoid content of the various types of analyzed oils (µg/g) | | | | | |
|---|---|---|---|---|---|---|
| | **OTPA (n=15)** | **OTPB (n=2)** | **OCRATP (n=7)** | **HEPT (n=3)** | **CPOS (n=6)** | **CPOF (n=3)** |
| Min. | 0,75 | 0,86 | 1,07 | 2,27 | 1,92 | 2,47 |
| Med. | 2,17 | 2,82 | 2,89 | 3,01 | 3,40 | 3,36 |
| Max. | 4,57 | 4,78 | 5,76 | 3,75 | 5,03 | 3,81 |
| Mean ± SD | 2,24±0,93[a] | 2,82±2,77 | 3,07±1,46 | 3,01±0,74 | 3,46±1,19[a] | 3,21±0,68 |

-OTPA and OTPB: Oils from traditional process A and B (it consists in bringing the palm nut marzipan paste to a boil at 100 °C in the presence of water, after having previously undergone washing and drying, roasting, grinding, crushing or pressing, decantation).
-OCRATP: Oil collected during the roasting of almonds in the traditional process.
- OEPRA: Oil extracted by pressure after roasting almonds.
-CPOS: Cold pressed oil used for soap production (improved process).
-CPOF: Cold pressed oil used as feed (improved process).
The values are expressed as Mean ± SD. Values with the same letters are significantly different ($P<0.05$).

## Pigment content of palm kernel oil compared to sunflower and olive oils

The chlorophyll pigment levels of palm kernel oil were closer to those of olive oil than sunflower oil. However, the results show that the carotenoid contents of palm kernel oil are very low compared to those of sunflower and olive oils (Table 4).

**Table 4:** Comparison of the pigment contents of palm kernel oil with those of sunflower oils "BONITA" and olive "GOYA Extra"

| | Types of oil | | | | |
|---|---|---|---|---|---|
| | Palm kernel oils | | | Sunflower oil (n=3) | Olive oil (n=3) |
| | **OTP (n=15)** | **OCRATP (n=7)** | **CPOF (n=3)** | | |
| Chlorophyll a content (µg/g) | 49,92 ± 1,75[a] | 42,53 ± 9,11[b] | 39,88 ± 16,90[c] | 87,40 ± 0,88[a,b,c,d] | 41,68 ± 0,71[d] |
| Chlorophyll b content (µg/g) | 54,54 ± 1,92[a] | 42,90 ± 14,13[b] | 39,16 ± 8,98[a,c] | 141,70 ± 1,70[a,b,c,d] | 64,95 ± 0,01[b,c,d] |

| | | | | | |
|---|---|---|---|---|---|
| Caroténoid content (µg/g) | 2,35 ± 0,25[a,b] | 3,20 ± 0,54[c,d] | 3,51 ± 1,46[e,f] | 11,25 ± 0,61[a,c,e] | 12,10 ± 0,18[b,d,f] |

-OTP: Oil from the traditional process (it consists in bringing the palm nut marzipan paste to a boil at 100 °C in the presence of water, after having previously undergone washing and drying, roasting, grinding, crushing or pressing, decantation).
-OCRATP: Oil collected during the roasting of almonds in the traditional process.
-CPOF: Cold pressed oil used as feed (improved process).
The values are expressed as Mean ± SD. Values with the same letters are significantly different (*P*<0.05).

## Calorific power

All the processes of our study gave oils with calorific powers higher than 35000 KJ/Kg with a significant variation at the threshold of 5% between the different oils according to the production processes (Table 5). Indeed, the calorific value varied from 37430 KJ/Kg (for the oil obtained by pressure after roasting almonds) to 37759 KJ/Kg (for the oil obtained by cold pressure for the manufacturing of soaps).

**Table 5**: Calorific value of palm kernel oil samples according to production processes

| | Calorific value of the various types of analyzed oils (KJ/Kg) | | | | | |
|---|---|---|---|---|---|---|
| | **OTPA (n=15)** | **OTPB (n=2)** | **OCRATP (n=7)** | **HEPT (n=3)** | **CPOS (n=6)** | **CPOF (n=3)** |
| Min. | 37489 | 37615 | 37314 | 36976 | 37427 | 37583 |
| Med. | 37590 | 37658 | 37583 | 37430 | 37842 | 37591 |
| Max. | 37714 | 37702 | 37750 | 37884 | 37962 | 37629 |
| Mean ± SD | 37596±68,42[a] | 37658±61,02 | 37557±142,9[b] | 37430±453,9[c] | 37759±219,4[a,b,c] | 37601±24,70 |

-OTPA and OTPB: Oils from traditional process A and B (it consists in bringing the palm nut marzipan paste to a boil at 100 °C in the presence of water, after having previously undergone washing and drying, roasting, grinding, crushing or pressing, decantation).
-OCRATP: Oil collected during the roasting of almonds in the traditional process.
- OEPRA: Oil extracted by pressure after roasting almonds.
-CPOS: Cold pressed oil used for soap production (improved process).
-CPOF: Cold pressed oil used as feed (improved process).
The values are expressed as Mean ± SD. Values with the same letters are significantly different (*P*<0.05).

## Discussion

### Content of chlorophyll (a and b) and total carotenoids

chlorophyll (a) content ranged from 38.47 µg/g to 52.22 µg/g. Comparing these values with those obtained under the same analysing conditions with sunflower oils (87.40 µg/g) and olive oil (41.68 µg/g) purchased on the market, we can compare the palm kernel oil produced in Togo to that of olive in relation to chlorophyll (a) content. The same is true for the chlorophyll (b) content, where the contents varied for our oils from 36.18 µg/g to 58.41 µg/g while the contents were 141.70 µg/g for the sunflower oil and 64.95 µg/g for olive oil. However, the total carotenoids contents (2.24 µg/g at 3.46 µg/g) were very lower compared to the sunflower and olive oils used in comparison, which were 11.25 µg/g and 12.10 µg/g respectively. The presence of the pigmented constituents in the palm kernel oil gives it interesting nutritional and pharmacological qualities when comparing the results compared to those of sunflower oil "BONITA" and olive oil “GOYA Extra”. However, compared to these two reference oils and especially, taking into account the work done by Mondé *et al*. (2008) [21] on palm oil produced in Côte d'Ivoire which showed carotenoids contents between 832 and 3575 µg/g, it can be said that palm kernel oil has a very lower carotenoids content. The pigments that we have quantified in palm kernel oil are each of interest to humans. Indeed, the deodorizing power of chlorophylls is well known through toothpastes or chewing gum that contain it. In terms of human health, chlorophylls (a) and (b) are powerful antioxidants that help protect cells in the body against cellular damage caused by free radicals (Donaldson, 2004) [22]. These pigments are globally recognized as the blood detoxifier and the purifier of the intestinal flora. They regulate blood pressure and lower blood cholesterol levels (Vaňková, 2018) [23]. As a natural dye, chlorophylls are widely used in the cosmetics and food industries under the acronym E140. With respect to carotenoids, they are widely known as provitamins (A). Dietary beta-carotene and other carotenoids of provitamin (A) such as α-carotene and cryptoxanthin can be obtained from a certain number of foods such as fruits and vegetables (Mangels *et al*., 1993) [24]. The presence of carotenoids even in small quantities in palm kernel oil is a nutritional and pharmacological asset. It has been shown that the quality of an oil depends, not only on its composition of unsaturated fatty acids, but also on its contents of minor compounds belonging to the unsaponifiable fraction, such as phenols, tocopherols, carotenoids and sterols (Mezghache *et al*., 2010) [25]. Therefore, the palm kernel oil use for food could have beneficial effects on osteoporosis, prevent from aging and strengthens the immune system. Also, acting as antioxydants, carotenoids play a vital role in the defense of the human body (Bohm *et al*., 2002; Donaldson, 2004) [22, 26]. It is estimated that 70.9% of vitamin A intake in developing countries comes from plant-based foods, particularly vegetables and fruits (FAO/WHO, 1988) [27]. But also other food products such as edible oils would increase the availability of vitamin A, which presence in the food intake plays a leading role in the prevention of eye problems.

## Conclusion

Palm kernel oil is an oil of socio-economic interest in Togo. It is cosmetically, nutritionally and therapeutically useful. This work is a contribution to the valorization of this local oil. The results showed that it is a nutritionally and pharmacologically interesting oil with respect to pigments contents and calorific value. However, considering that it is an oil rich in saturated fatty acids and therefore cholesterol-lowering, its food using should be done sparingly.

## Acknowledgements

The authors thank Togolese producers of palm kernel oil for their collaboration during the sampling outings.

## Conflict of interest

The authors declare that they have no conflict of interest in relation to this article.

## Author’s contributions

GAV and BB designed the project and conducted the sampling; DK, GAV, MM, MK and BB performed the experiments, analyzed the data and wrote the manuscript; all the authors gave their agreement to the final version of the manuscript and its publication.

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