Journal of Scientific Research & Reports

21(6): 1-9, 2018; Article no.JSRR.46025
ISSN: 2320-0227

Studies of Physicochemical and Nutritive Properties of Oil Extracts from Local and Improved Varieties of Palm Fruits

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Authors' contributions

This work was carried out in collaboration between all authors. Author LZ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AZ managed the literature searches. Author SN revised the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2018/46025
Editor(s):
(1) Dr. Tzasna Hernandez Delgado, Laboratory of Pharmacognosie, Biology Unit and Prototypes (UBIPRO), National Autonomous University of Mexico, Mexico.
Reviewers:
(1) F. J. Owuna, Usmanu Danfodiyo University, Nigeria.
(2) Ronald Iorio, University of Massachusetts Medical School, USA.
Complete Peer review History: http://www.sdiarticle3.com/review-history/46025

Original Research Article

Received 13 October 2018
Accepted 20 December 2018
Published 17 January 2019

ABSTRACT

Palm tree (*Elais guineensis*) is a tropical plant cultivated as a major agricultural crop for palm oil production but debates related to palm oil's potential unhealthy effects due are still ongoing. The aim of this study was to evaluate the physicochemical and nutritive properties of palm oil extracted from local and improved varieties. Fresh fruit bunches of palm oil from local and improved varieties were collected in traditional and industrial plantations of South East Côte d'Ivoire. The fruits were sorted and washed several time with distilled water, cooked at 100°C in distilled water for 30 min and milled in laboratory mortar. The cooked and milled mesocarps of palm fruits were used for three techniques of oil extraction: Soxhlet extraction (SH), decoction extraction (DW) and soaking extraction (SW). Physicochemical parameters were determined using Association of Official Analytical Chemists (AOAC) and Malaysian Palm Oil Board (MPOB) conventional methods. Fatty acids were quantified by using Gas Chromatography (GC) method. There was a significant difference ($P < 0.05$) between oil contents from improved varieties (20.57 – 23.32%) and local ones (8.80 – 15.58%). Crude palm oil (CPO) samples extracted from local varieties may be considered

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as valuable sources of carotenoids (576.67 – 654.42 µg/g) and tocopherols (755.33 – 772 µg/g) for human nutrition requirements. They were predominantly composed of unsaturated fatty acids (52.21 – 54.34%) while CPO extracted from improved varieties was saturated fatty acids rich (50.97 – 54.17%). In CPO extracted from local varieties, unsaturated fatty acids (UFA) were composed of oleic acid (43.85 – 45.72%) and a relatively low rate of linoleic acid (8.02 – 8.62%). Given that crude palm oil is a major ingredient of many dishes in Côte d'Ivoire, these results are a clear indication that the consumption of CPO extracted from local varieties may have beneficial health effect in nutritional point of view.

Keywords: Crude palm oil; carotenoids; tocopherols; fatty acids.

1. INTRODUCTION

The palm tree (*Elais guineensis*) is a tropical plant cultivated as major agricultural crop for palm oil (PO) production [1]. This production has increased and the United States Department of Agriculture (USDA) estimated to 62.88 million tons the global palm oil production in 2017 which represented an increase of about 4.08 million tons (6.94%) from 2016 [2]. The leading producers of PO are Malaysia and Indonesia accounting for 86% of global production and other PO producing countries are Nigeria, Thailand, Colombia, Papa Guinea, Cote d'Ivoire, India and Brazil [3]. In Côte d'Ivoire, Aboisso (5°28'4" N 3°12'25.6" W) located in South-East of Côte d'Ivoire is the major producing region (28%) of crude palm oil (Fig. 1).

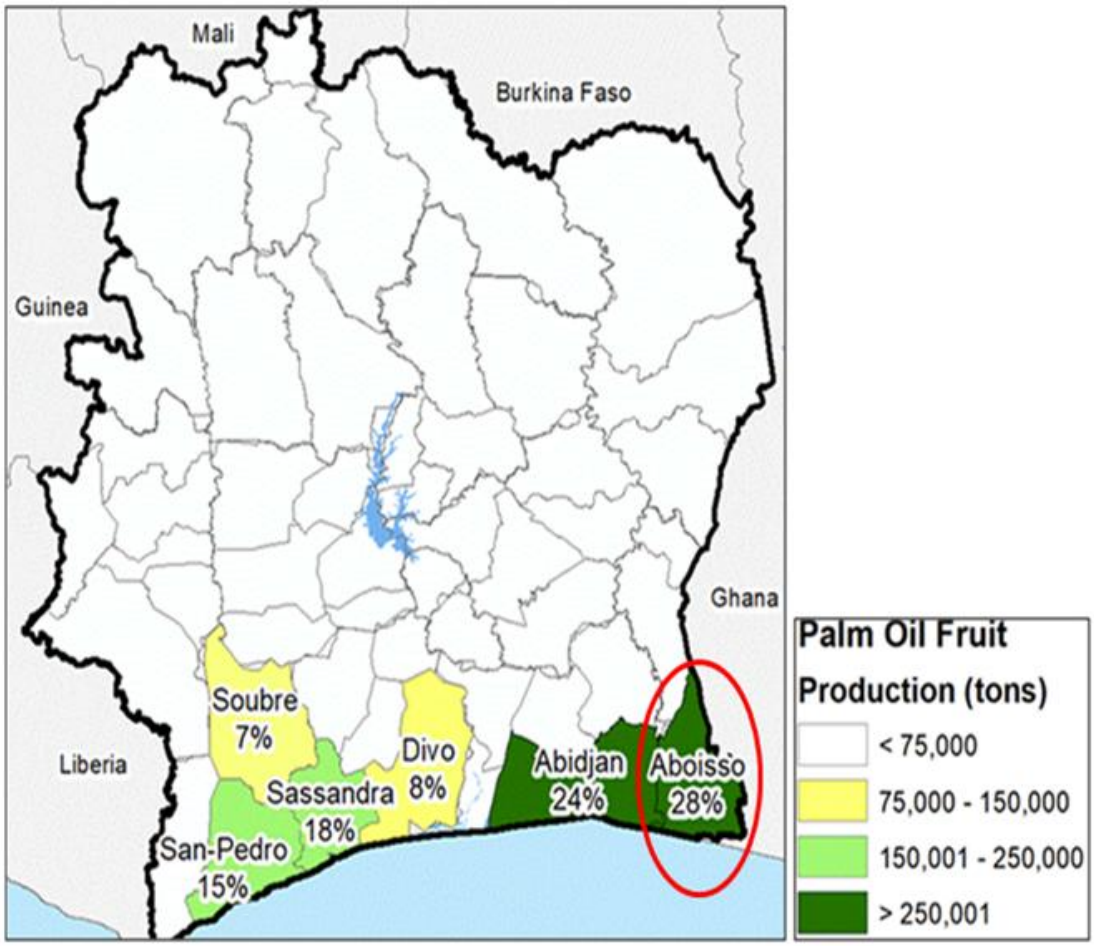

Fig. 1. Palm oil fruit production and areas of production in Côte d'Ivoire

Two types of oil are extracted from palm fruit: palm kernel oil (PKO) extracted from the seeds and palm oil (PO), from the mesocarp. The edible PO known as crude palm oil (CPO) or red palm oil (RPO) extracted either by wet or dry processes contains healthy beneficial compounds such as triacylglycerols (TAGs), tocopherols, carotenoids and phytosterols. Indeed, CPO is known as the richest natural source of carotenoids (500–700 ppm), tocopherols and tocotrienols (600–1200 ppm) contributing to its nutritional and stability properties [4].

Based on the fatty acids profile, palm oil is typically a semi solid fat with palmitic acid content (45%), oleic acid closed to 40% and relatively important amount (11%) of linoleic acid [5]. Palm oil has many uses both in the food and non-food sectors. The food industry accounts for 80% of uses (cooking oil, margarine, baking, pastries) while the oleochemistry accounts for 20% with cosmetics, soaps, lubricants, candles, pharmaceutical, surfactants, agrochemistry and paints products [6]. Despite all the potential uses of PO in human nutrition, debates related to palm oil's unhealthy effects due to high palmitic acid content are still ongoing [7,8]. Furthermore, the palm oil sector is faced to some food processed contaminants such as 3- monochloropropane 1,2-diol (3-MCPD) esters and glycidyl-esters (GEs) known as potential carcinogenic compounds found in refined oils [9]. All these issues could negatively impact the sustainability of palm oil production in tropical Africa and especially in Côte d'Ivoire where the National Agricultural Investment Program (PNIA) decided to increase the production of PO from 400.000 tons in 2017 to 600.000 tons to 2020 [10]. Therefore, the need of labeling and traceability of palm oil from Côte d'Ivoire through the determination of quality indices appears as a challenge. This study aimed to assess the physicochemical and nutritive properties of palm oil from the main producing area located in the South-East.

2. MATERIALS AND METHODS

2.1 Study Area and Sample Collection

Fresh fruit bunches of palm oil from local and improved varieties were collected in traditional and industrial plantations, respectively at Aboisso (5°28'4" N 3°12'25.6" W) located in South-East of Côte d'Ivoire. Aboisso was selected as study area because of high national palm oil production [2] as previously indicated in Fig. 1.

2.2 Palm Oil Extraction

The collected fresh fruit bunches of local and improved varieties were transported to laboratory of Biotechnology (University Félix Houphouet-Boigny, Abidjan, Côte d'Ivoire). The fruits were removed, sorted and washed several time with distilled water. Afterwards, the selected fruits were cooked at 100°C in distilled water for 30 min and milled in laboratory mortar in order to separate the mesocarp from seeds. The cooked and milled mesocarps of palm fruits were used for hexane-based and hot water flotation (HWF) extraction methods [11,12] as described:

Treatment 1 (Soxhlet Hexane or SH): palm oil was extracted from 50 g cooked and milled mesocarps of palm fruits with 300 mL of n-hexane (40-60°C) in a Soxhlet extractor. Then, the solvent was gently evaporated with a rotary evaporator and extracted lipids were weighted to determine the palm oil content.

Treatment 2 (Decoction Water or DW): one hundred (100) g of cooked and milled mesocarps of palm fruits were mixed with 300 mL of distilled water and boiled at 100°C for 1h. After cooling at laboratory temperature, the mixture was transferred into a separatory funnel in order to discard the oil phase. The oil phase was then dried in oven at 40°C for 24h and weighted to determine the palm oil yield.

Treatment 3 (Soaking Water or SW): one hundred (100) g of cooked and milled mesocarps of palm fruits were mixed with 300 mL of hot distilled water (60-70°C) for 1h by using a laboratory thermostat magnetic stirrer plate. After cooling at laboratory temperature, the mixture was transferred into a separatory funnel in order to discard the oil phase. The oil phase was then dried in oven at 40°C for 24h and weighted to determine the palm oil yield.

2.3 Physicochemical Analysis of Extracted Palm Oils

2.3.1 Physical parameters determination

Specific gravity and refractive index at 20°C were carried out following the IUPAC methods [13]. Specific gravity was carried out by weighting a 25 mL pycnometer filled with palm oil sample. For refractive index, 2 drops of palm oil were placed on the prism of a refractometer and the value was digitally recorded.

Specific extinction (233 and 269 nm) and deterioration of bleachability index (DOBI) were determined according to Malaysian Palm Oil Board (MPOB) test methods [14]. For this, 0.1 g of palm oil sample was dissolved in 10 mL hexane and absorbance was read by using a UV-Vis spectrophotometer at 233, 269 and 446 nm respectively. The deterioration of the bleachability index (DOBI) was calculated using the formula:

DOBI = Absorbance at 446 nm /Absorbance at 269 nm

2.3.2 Chemical parameters determination

Palm oil samples were tested for acidity (AV), saponification value (SV), iodine value (IV) and peroxide value (PV) using the Association of Official Analytical Chemists (AOAC) methods [15]. Acid value was performed by titration of palm oil (2 g) dissolved in 10 mL ethanol-diethyl ether (v/v) with NaOH solution (0.1 N). For the saponification value determination, 2 g of the palm oil sample was mixed with 25 mL of ethanolic potassium hydroxide solution (0.5 N) and the mixture was subsequently boiled under reflux for 1 hour. The warm mixture was then titrated by HCl 0.5 N. Iodine and peroxide values were performed using Wij's reagent and potassium iodide solution (10%, w/v), respectively following by titration with sodium thiosulphate (0.1 N). The calculation of AV, PV, SV and IV parameters are given by the formulas (1), (2), (3) and (4).

$$AV = \frac{(V - V_b) \times N \times 56{,}1}{weight\ sample\ (g)} \quad (1)$$

$$PV = \frac{(V - V_b) \times 10}{weight\ sample\ (g)} \quad (2)$$

$$SV = \frac{(V_b - V) \times N \times 56{,}1}{weight\ sample\ (g)} \quad (3)$$

$$IV = \frac{(V_b - V) \times N \times 12{,}69}{weight\ sample\ (g)} \quad (4)$$

V: volume of titrant (mL); Vb: volume of blank (mL); N: normality of titrant

Unsaponifiable matter content of palm oil samples was quantified following the IUPAC method [13]. Palm oil sample (5 g) was subjected to saponification with 50 mL of 2 N KOH methanolic solution for 1 h. Afterwards, 50 mL of distilled water was added to the resulted mixture. The unsaponifiable matter was extracted three times with 50 mL of diethyl-ether. After extraction step, diethyl-ether was removed in a rotary evaporator (Heidolph, Hei-Vap, Germany) and the residue was weighed. The unsaponifiable matter was calculated in percentage of sample weight by using the formula (5).

$$Unsaponifiable\ matter = \frac{weight\ residue\ (g) \times 100}{weight\ sample\ (g)} \quad (5)$$

2.4 Nutritive Evaluation of Extracted Palm Oils

2.4.1 Carotenoids content

The total carotenoids of palm oil samples were determined as follow: 0.1 g of palm oil was dissolved in 10 mL hexane and absorbance was read by using a UV-Vis spectrophotometer at 446 nm. Total carotenoids were calculated by using the formula indicated in MPOB test methods [14]:

Carotenoids (mg/kg) = 383 x (A_{sample} – A_{blank})

Where A_{sample} and A_{blank} are absorbances of oil sample and hexane, respectively.

2.4.2 Tocopherols content

Tocopherols content of crude palm oil (CPO) samples was evaluated by using the Emmerie-Engel spectrophotometric method after pretreatment [16]. For this, 0.2 g of heated CPO samples (250°C/10 min under vacuum) was mixed with 5 mL of hexane. Then 3.5 mL of 2,2'-bipyridine (0.07% w/v in 95% ethanol) and 0.5 mL of $FeCl_3$ solution (0.2% w/v in 95% ethanol) were added. The resulting mixture was made up to 10 mL with 95% ethanol and absorbance was read at 520 nm by using a spectrophotometer (T80+, PG Instruments, England). The method was calibrated with a standard curve of α-tocopherol acetate (5 µg/mL).

2.4.3 Phosphorus content

The ammonium vanadate colorimetric method [13] was used to determine phosphorus content of palm oil samples. Test oil portion (5 g) was mixed with magnesium oxide and burned to ashes. The resulted ashes were dissolved in

nitric acid solution (65%, v/v). An aqueous ammonium vanadate solution was added in the test tube and absorbance was measured at 460 nm using a spectrophotometer (T80+, PG Instruments, England). A standard curve of phosphorus (1 mg/mL) was used as reference.

2.4.4 Fatty acids composition

Fatty acids of CPO samples were converted into fatty acid methyl esters (FAMEs) by using a micromethod [17] with modification. For this 0.1 g of oil sample was mixed with 1 mL of toluene and 4 mL of a methanolic solution of sodium hydroxide (0.5 M) in centrifuge tubes. The tubes were heated to 50°C in a water bath for 10 min and then cooled for 5 min. Five (5) mL of distilled water was added followed by 1 mL of hexane and the tubes were vortexed for 2 min. The hexane top layer containing the FAMEs was used for gas chromatography (GC) analysis. FAMEs solution (1 µL) was injected into a gas chromatograph (PerkinElmer Clarus 580, USA) equipped with a FID detector and Optima® 1701 fused silica capillary column (25 m × 0.25 mm i.d. × 0.25 µm film thickness). The carrier gas was nitrogen (N_2) and the flow rate adjusted to 2.1 mL/min. The initial column temperature was fixed to 100°C and programmed to increase to 255°C in 1°C increments. The fatty acid methyl esters peaks were identified by comparing their retention times with those of palmitic, stearic, oleic, linoleic and linolenic acids used standards. The fatty acids above were quantified and expressed as percentage (%) of total fatty acids by using their standard curve area = f (C), where C is the concentration (µg/mL) of FAMEs from standard fatty acids.

2.5 Statistical Analysis

All analyses were carried out in triplicates and data expressed as means ± standard deviation. One way analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) was carried out to assess significant differences between means ($P < 0.05$) using XLStat 2014 (Addinsoft, USA).

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties

The oil yield and physicochemical properties of CPO extracted from local and improved varieties are shown in Table 1.

There was a significant difference ($P < 0.05$) between oil contents from improved varieties (20.57 – 23.32%) and local ones (8.80 – 15.58%). This result may justify the industrial use of improved varieties for palm oil production [18]. In addition, soxhlet extraction (SH) was more efficient regarding oil content compared to decoction water (DW) and soaking water (SW). Indeed, it is well-known that lipids are more soluble in organic solvent than water. The mean values of specific gravity (0.89) and refractive index (1.44) of the different extracted CPO are were within the range of those reported for conventional edible oils [19]. The relatively low values (0.53 – 0.58) of specific extinction value at 269 nm may be related to the low contents of secondary oxidation products which are linked to the oxidative stability of CPO [20]. For the deterioration of bleachability index (DOBI) the values ranged between 2.87 and 3.78 for CPO extracted from the two varieties. The DOBI index provides an indication of carotenes contents of crude palm oils and also their fitness for refining. In our study, CPO extracted from local and improved varieties were good quality with regard the DOBI values higher than 2 [21]. The measure of acid and peroxide indexes as quality parameters of CPO samples indicated significant difference ($P < 0.05$) between values for the different extracting methods. Acid values (6.04 – 7.70 mg KOH/g) and peroxide values (11.07 – 12.72 meq O_2/kg) were higher than those (4 mg KOH/g and 10 meq O_2/kg) recommended by the Codex Alimentarius for edible oils [19]. Predominant factors such as ripening stage of palm fruits and extraction method may explain the relatively high values of acid and peroxide indexes. Indeed, free fatty acids (FFA) produced by triacylglycerols (TAGs) hydrolysis (endogenous lipases and temperature effect) are used as substrates for oxidation phenomenon leading to peroxide components in vegetable oils [20]. Nevertheless, both CPO from local and improved varieties were less liable to rancidity with regard to the peroxide values less than 20 meq O_2/kg [22]. Crude palm oil samples extracted from local varieties revealed higher iodine values (54.52 – 56.09 g I_2/100g) than those (51.06 – 51.58 g I_2/100g) extracted from improved varieties. Therefore, CPO extracted from local varieties could be nutritionally beneficial due to the positive correlation between iodine value and unsaturated fatty acids contents [23]. In addition to iodine value, CPO extracted from local varieties had appreciable unsaponifiable matter contents (0.44 – 0.48%) which were higher than that (0.33%) of peanut oil

[19]. It's important recalling that unsaponifiable matter of palm oil is a mixture of minor components of interest such as carotenes, tocopherols, tocotrienols, phytosterols and squalene [21]. Contrary to CPO extracted from local varieties, those extracted from improved varieties were characterized by high saponification values (197.93 – 202.22 mg KOH/g), making them more exploitable for soap and various cosmetics foaming products [24].

3.2 Nutritive Properties

The nutritive properties of CPO extracted from local and improved varieties are indicated in Table 2. Phosphorus, carotenoids and tocopherols were evaluated as minor components while fatty acids profile (palmitic, stearic, oleic, linoleic and linolenic acids) were determined. The contents of phosphorus, carotenoids and tocopherols in CPO were significantly different ($P < 0.05$) depending on the variety of palm fruit. Indeed, CPO extracted from local varieties may be considered as valuable sources of carotenoids (576.67 – 654.42 µg/g) and tocopherols (755.33 – 772 µg/g) for human nutrition requirements. Carotenoids of CPO mainly composed of β-carotene are considered as provitamin A which is converted into vitamin A in human body. Vitamin A is an essential nutrient for the normal functioning of the visual system, growth and development, immune function, and reproduction [25]. Based on the β-carotene bioconversion factor (1:12) defined by the Institute of Medecine (IOM), consumption of 100 g of CPO extracted from local varieties could cover 8-10 fold the recommended dietary allowance (RDA) for vitamin A estimated to 550 µg for individuals in developing countries [26]. Besides being rich in provitamin A, tocopherols contents of CPO extracted from local varieties are higher than those of sunflower oil (497 µg/g), canola oil (125 µg/g) and corn oil (122 µg/g) [27]. Thus, CPO from local varieties could play important antioxidant activity due to the protection of cell membranes from free radical damage by tocopherols during oxidative stress [28].

Chromatographic profiles of fatty acids composition and their relative amounts in CPO samples are given in Fig. 2 and in Table 2, respectively.

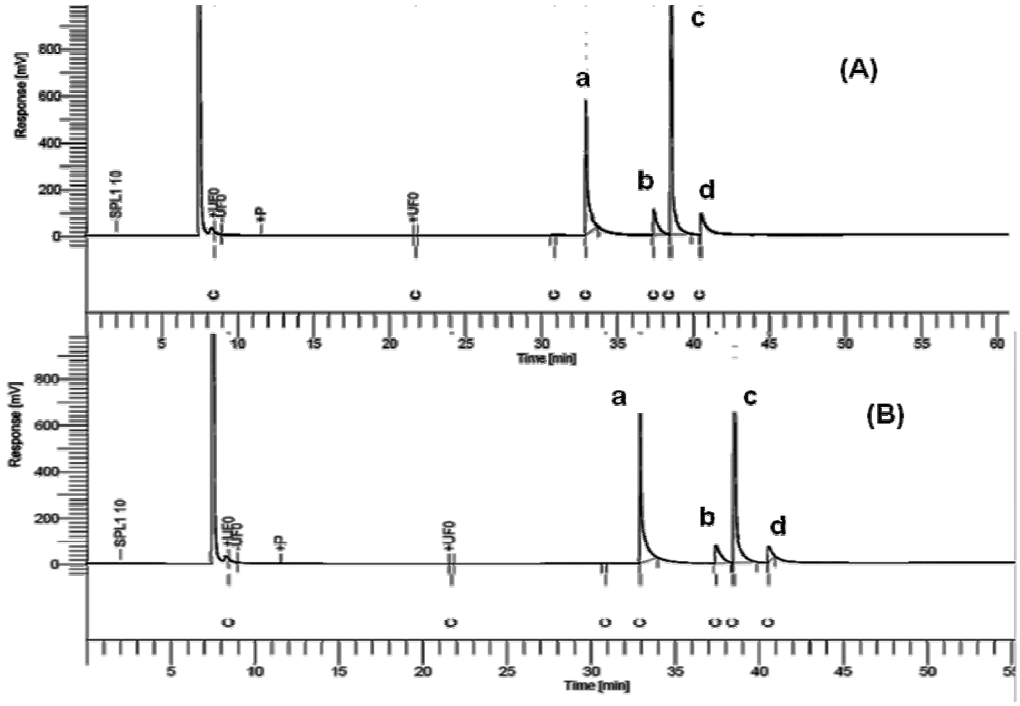

Fig. 2. Chromatogram of fatty acids of crude palm oil extracted from local (A) and improved (B) varieties

(a): palmitic acid; (b): stearic acid; (c): oleic acid; (d): linoleic acid

Table 1. Oil yield and physicochemical parameters of crude palm oil extracted from local and improved varieties

	Local			Improved		
	SH	**DW**	**SW**	**SH**	**DW**	**SW**
Oil yield (%)	15.58 ± 0.31^{d}	10.26 ± 0.29^{e}	8.80 ± 0.21^{f}	23.32 ± 0.85^{a}	21.87 ± 0.23^{b}	20.57 ± 0.31^{c}
Specific gravity	0.89 ± 0.01^{a}	0.89 ± 0.01^{a}	0.89 ± 0.01^{a}	0.88 ± 0.01^{a}	0.89 ± 0.00^{a}	0.88 ± 0.00^{a}
Refractive index	1.45 ± 0.00^{a}	1.45 ± 0.00^{a}	1.45 ± 0.00^{a}	1.44 ± 0.00^{a}	1.44 ± 0.00^{a}	1.44 ± 0.00^{a}
Extinction (269 nm)	0.54 ± 0.05^{a}	0.58 ± 0.01^{a}	0.56 ± 0.04^{a}	0.58 ± 0.01^{a}	0.54 ± 0.05^{a}	0.53 ± 0.03^{a}
DOBI	3.78 ± 0.33^{a}	3.23 ± 0.03^{c}	3.71 ± 0.24^{b}	2.87 ± 0.04^{d}	3.20 ± 0.27^{c}	3.27 ± 0.09^{c}
AV (mg KOH/g)	7.70 ± 0.00^{a}	6.77 ± 0.17^{b}	6.04 ± 0.29^{d}	6.54 ± 0.34^{c}	6.79 ± 0.22^{b}	7.43 ± 0.38^{a}
PV (meq O_2/kg)	11.59 ± 0.12^{b}	11.25 ± 0.23^{b}	11.07 ± 0.02^{b}	12.20 ± 0.76^{a}	12.68 ± 0.51^{a}	12.72 ± 0.29^{a}
SV (mg KOH/g)	192.43 ± 0.22^{b}	191.24 ± 1.66^{b}	190.26 ± 0.21^{b}	197.93 ± 3.00^{a}	201.76 ± 1.49^{a}	202.22 ± 0.28^{a}
IV (g I_2/100g)	54.05 ± 0.56^{b}	56.09 ± 0.60^{a}	54.52 ± 0.41^{b}	51.58 ± 0.35^{c}	51.42 ± 0.74^{c}	51.06 ± 0.69^{c}
Unsaponifiable matter (%)	0.48 ± 0.02^{a}	0.44 ± 0.01^{b}	0.48 ± 0.02^{a}	0.36 ± 0.01^{c}	0.35 ± 0.01^{c}	0.37 ± 0.01^{c}

Data are presented as means of triplicate analyses ± SD. Means with different superscript letter in the same raw for a single parameter are different at P < 0.05. SH: soxhlet hexane extraction; DW: decoction water extraction, SW: soaking water extraction; DOBI: deterioration of bleachability index; AV: acid value; PV: peroxide value; SV: saponification value; IV: iodine value

Table 2. Nutritive parameters of crude palm oil extracted from local and improved varieties

	Local			Improved		
	SH	**DW**	**SW**	**SH**	**DW**	**SW**
Phosphorus (µg/g)	79.21 ± 0.75^{a}	79.57 ± 0.05^{a}	76.01 ± 0.49^{b}	60.22 ± 0.25^{c}	60.31 ± 0.29^{c}	58.93 ± 0.50^{d}
Carotenoids (µg/g)	639.48 ± 4.53^{a}	576.67 ± 1.55^{b}	654.42 ± 17.09^{a}	521.77 ± 1.97^{c}	525.09 ± 7.77^{c}	530.58 ± 3.87^{c}
Tocopherols (µg/g)	763 ± 12.53^{a}	755.33 ± 5.03^{a}	772 ± 15.87^{a}	689.67 ± 11.50^{b}	683.33 ± 7.64^{b}	682 ± 22.87^{b}
Palmitic acid (%)	38.59 ± 0.62^{c}	37.56 ± 0.10^{c}	38.15 ± 0.30^{c}	37.17 ± 0.94^{c}	43.44 ± 0.11^{b}	43.26 ± 0.31^{a}
Stearic acid (%)	9.14 ± 0.01^{c}	8.06 ± 0.01^{d}	9.60 ± 0.56^{c}	13.80 ± 0.05^{a}	10.42 ± 0.14^{b}	10.90 ± 0.30^{b}
Oleic acid (%)	43.85 ± 0.17^{b}	45.72 ± 0.06^{a}	44.19 ± 0.08^{a}	42.44 ± 0.78^{b}	39.63 ± 0.56^{c}	39.29 ± 0.03^{c}
Linoleic acid (%)	8.39 ± 0.18^{b}	8.62 ± 0.08^{a}	8.02 ± 0.01^{c}	6.56 ± 0.01^{d}	5.48 ± 0.25^{f}	6.51 ± 0.02^{e}
Linolenic acid (%)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
SFA (%)	47.73 ± 0.63^{c}	45.62 ± 0.11^{d}	47.75 ± 0.36^{c}	50.97 ± 0.99^{b}	53.86 ± 0.25^{a}	54.17 ± 0.61^{a}
UFA (%)	52.24 ± 0.35^{b}	54.34 ± 0.14^{a}	52.21 ± 0.09^{b}	48.99 ± 0.79^{c}	45.16 ± 0.81^{d}	45.80 ± 0.05^{d}
Ratio UFA/SFA	1.09	1.19	1.09	0.96	0.84	0.84

Data are presented as means of triplicate analyses ± SD. Means with different superscript letter in the same raw for a single parameter are different at P < 0.05. SH: soxhlet hexane extraction; DW: decoction water extraction, SW: soaking water extraction; SFA: saturated fatty acids; UFA: unsaturated fatty acids

Fatty acids profile of the CPO highlighted the presence of four (4) main compounds namely palmitic, stearic, oleic and linoleic acids (Fig. 2). CPO extracted from local varieties were predominantly composed of unsaturated fatty acids (52.21 – 54.34%) while CPO extracted from improved varieties were saturated fatty acids rich (50.97 – 54.17%). In CPO extracted from local varieties, unsaturated fatty acids (UFA) were composed of oleic acid (43.85 – 45.72%) and a relatively low rate of linoleic acid (8.02 – 8.62%). The unsaturated fatty acids profile of CPO extracted from local varieties could be beneficial in nutritional point of view because of linoleic acid (ω6) which is known as essential fatty acid [23]. Saturated fatty acids (SFA) in CPO extracted from improved varieties were mainly composed of palmitic acid (37.17 – 43.44%) and stearic acid (10.42 – 13.80%). Ratios of UFA to SFA calculated for CPO extracted from local and improved were about 1.1 and 0.9, respectively (Table 2). Even if CPO extracted from improved varieties were palmitic and stearic acids rich, some studies have shown any deleterious effect of these saturated fatty acids on plasma cholesterol [29,30].

4. CONCLUSION

The analysis of the physicochemical and nutritive properties of crude palm oil (CPO) revealed a variation depending on the palm fruit variety and the extraction method. Crude palm oil samples extracted from local varieties were more unsaturated than the CPO extracted from improved varieties. Given that crude palm oil is a major ingredient of many dishes in Côte d'Ivoire, these results are a clear indication that the consumption of CPO extracted from local varieties may have beneficial health effect in nutritional point of view. For CPO extracted from improved varieties of palm fruit, they are suitable for the production of soaps and various cosmetics foaming products. Moreover, the impact of processing conditions on bioactive components of CPO extracted from both local and improved varieties must be conducted in order to evaluate their bioavailability.

ACKNOWLEDGEMENTS

The authors are grateful to the farmers of palm oil sector of South East Côte d'Ivoire for their collaboration and technical assistance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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