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Quality assessment of artisanal palm oil from smallholders in the department of Man, western region of Côte d'Ivoire

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Abstract

In the western region of Côte d'Ivoire, more particularly from the department of Man, artisanal crude palm oil enjoys a reputation for quality among consumers and is the subject of a developed trade. To guarantee consumers quality palm oil, it is crucial to register this product as a Geographical Indication artisanal palm oil. This study aims to evaluate the physicochemical properties of this artisanal palm oil to better understand his quality. A descriptive survey of palm oil processing was conducted among 200 smallholders in 10 localities in the department of Man, Western region of Côte d'Ivoire. Then, samples were collected from the producers and were taken to the laboratory for analysis. The physicochemical properties of CPO samples were determined using standard analytical method. The results showed that manual processing and screw hand press methods were used for palm oil extraction. About 58% of the processors have 11-20 years' experience in oil palm processing and have no formal education (48.2%). Concerning the physicochemical quality of artisanal palm oil producing, the lipid oxidation, carotenoids contents, DOBI, slip melting point, iodine and saponification indexes were relatively conformed to the standard while FFA, moisture and impurities content were different. These results demonstrate a need for monitoring of artisanal palm oil production by smallholders in the sector who should adopt good agricultural practices.

Keywords: Palm Oil; Artisanal Production; Physicochemical Properties; Western Region; Côte d'Ivoire

1. Introduction

Palm oil is widely used in the food industry because of its versatility in various food formulations and its low cost compared to other edible oils [1]. The food supplement industry has also recognized the potential health benefits associated with its carotenoid and phytosterol contents, and palm oil is the most abundant natural source of alpha-tocotrienol, an analog of vitamin E with neuroprotective properties that are independent of its antioxidant mechanism [2, 3]. The major components of palm oil are triacylglycerols, comprising various fatty acids, with approximately 50% SFA. Palmitic acid (44%) is the main SFA in palm oil, comprising approximately 39% monounsaturated oleic acid and 11% polyunsaturated linoleic acid [4, 5]. African countries produce approximately 2 Mt of palm oil per year, import approximately 8 Mt per year, and export less than 1 Mt per year, including exports to other African countries [6]. Nigeria and Côte d'Ivoire are the largest African producers. **Since 90% of Ivoirians use palm oil on a regular basis throughout the nation, it is the most widely consumed oil in Cote d'Ivoire. Production was projected to reach 650 000 tons in 2023** [7]. Palm oil processing in Côte d'Ivoire is ensured by two main sectors: industrial, which provides approximately 80% of the total palm oil, and informal (smallholders), which provides 20% of the total palm oil [8].

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In the western region of Côte d'Ivoire, artisanal crude palm oil from the sub-spontaneous palms enjoys a national and international reputation for quality among consumers and is mainly the object of highly developed local trade [9, 10]. Artisanal crude palm oil from the western region, more particularly from the department of Man, is highly sought after by the Ivorian people for its aroma and commands a price increase of approximately 25-30% compared to standard palm oil. *Man's* artisanal palm oil is distinguished by its dark red color, pleasant fragrance, smooth texture, and ability to mix well with sauces. Unlike standard crude palm oil, the production of the western region's palm oil involves processing fresh nuts and activating the fragrant element precursors contained in the nut [11]. The production methods employed by manufacturers may vary, leading to products that fail to meet standardized criteria. Despite its popularity and demand in both local and international markets, the producers of the western region palm oil do not benefit significantly from its success [9]. To improve their living conditions and ensure that consumers receive high-quality palm oil, it is crucial to register the western region palm oil as an artisanal red palm oil with geographical indications. However, before registration, it is necessary to demonstrate the uniqueness of Man's Palm Oil compared to other artisanal red palm oils produced in Côte d'Ivoire. This study aims to evaluate the physical and chemical properties of artisanal crude palm oil from the western region in order to better understand its quality.

2. Material and methods

2.1. Materials

2.1.1. Biological material

The biological material is palm oil deriving from wild oil palm trees frequently used for artisanal oil palm production.

2.1.2. Study site

The artisanal palm oil samples were collected from ten localities of Man department (West region of Côte d'Ivoire) which has an annual rainfall between 1500 and 2000 mm / year (Figure 1).

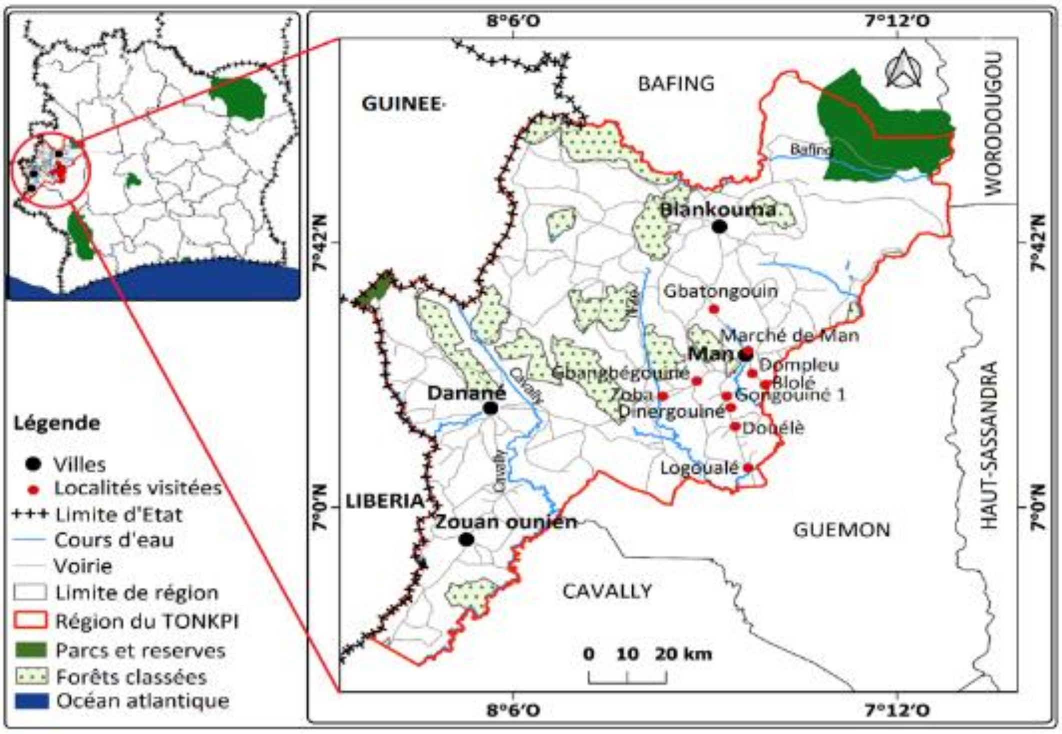


Figure 1 Collected localities of artisanal palm oil in the western region of Côte d'Ivoire

2.2. Methods

2.2.2. Sampling of artisanal palm oil

The adopted strategy consisted of two phases. The first phase consisted of identifying the localities where artisanal palm oil production constituted the main subsistence women's activities. In each locality, meetings were organized with traditional chiefdom to present the study. Questionnaires were administered to at least 200 respondents who approached producers' profiles and palm oil processing. This study was conducted with the help of the National Agency for Assistance and Rural Development (ANADER). The data were collected through individual interviews and/or grouped (structured and unstructured). Samples were then collected in 100 mL tinted bottles from the women producers and taken to the laboratory for analysis.

2.2.3. Physico-chemical analysis

Moisture (MC), impurities content (IC), free fatty acid (FFA), iodine value (IV), slip meelting point (SMP) and deterioration of bleachability index (DOBI) were carried out using a near infrared spectrometer (MPA Bruker Optics Gbmh) equipped with OPUSLAB software, 2015. Thereby, samples were analyzed in 8 mm disposable glass in transmission mode over the full Vis NIR wavelength range of 400-2500 nm. To avoid solidification, a constant temperature of 60 °C was maintained. Peroxyde (PV) and saponification values (SV) were performed by titrimetric method according to Association of Official Analytical Chemists methods [12]. Para-anisidine (*p*-AV) value was also by titrimetric method using the NF EN ISO 6885 [13]. Equation of total oxidation value (TOTOX) = 2PV + *p*-AV was used to calculate the totox value [14]. Total carotenoids content (TC) was determined using MPOB test methods p2.6 [15]. All chemicals and solvents used were of analytical grade purchased from Merck, Germany. The results are the mean values obtained from each test repeated three times.

2.2.4. Statistical Analysis

The survey and physicochemical data were recorded with Excel file and statistically treated with Statistical Program for Social Sciences (SPSS 22.0 for Windows) using Tukey post-hoc test at 5% significance level. In addition, Multivariate Statistical Analysis (MSA) was performed through Principal Components Analysis (PCA) using XLSTAT software (version 2019) for structuring correlation between the samples studied and their physicochemical traits.

3. Results

3.1. social demographics characteristics of oil palm processors

Table 1 presents the sociodemographic characteristics of the oil palm processors in the study area. Artisanal palm oil production constitutes the main subsistence activity of the producers. The dominant age groups for palm oil processing were 30–40 years (55.5%) and 40–50 years (30%). The level of education qualification was lower and primary school for most women (92.7 %). Regarding years of palm oil processing experience, 41.8 % of the respondents had 10–15 years of experience in artisanal palm oil processing, 30% had 5–10 years, 17.3% had 15–20 years, and 8.2% had over 20 years. In addition, 99% of the palm oil processes in this region are dominated by native species. Regarding marital status, 87.3% of the respondents were married and had their families actively participating in red palm oil processing. Unlike married people, single, widowed, and divorced women used hired laborers to help them in milling activities. Artisanal palm oil manufacturing activities help women take care of their families. Thus, 67.2% of the respondents had a household size of six to ten people, 25.5% of the respondents had a household size of one to five people, and 1.8% of the respondents took care of more than 15 people.

3.2. Artisanal crude palm oil processing

Table 2 presents the responses of the producers' artisanal palm oil-processing activities. Fresh fruit bunches (FFBs) are harvested from wild palm oil varieties when ripe fruits begin to detach naturally and fall to the ground. Producers use specialized climbers to do this. After harvesting, the fresh fruit bunches were transported to home and allowed to ferment for an average of 5–7 days for 87.3% of the respondents, 1–5 days for 7.3% of the respondents, and more than 7 days for 5.5% of the respondents. The FFBs underwent different operations until red palm oil was obtained. The major operating activities include splitting and shredding the FFBs, stripping FFBs to separate fruits from bunches, selecting and sieving stripped nuts using wreck and mesh wires, loading and boiling nuts, crushing boiled nuts, and clarifying red palm oil.

Table 1 Social demographics characteristics of oil palm processors

Age	Education	Years of oil palm processing experience	Ethnic group	Marital status	Size of household
11.8% 20–30 years	48.2 % None	2.7% 1-5 years	99% Native	7.3% Single	25.5% 1-5 people
55.5% 31–40 years	44.5 % Primary	30% 6-10 years	1% No native	87.3% Married	62.7 % 6-10 people
30% 41–50 years	7.3 % High school	41.8% 11-15 years		4.5 % Widowed	10% 11-15 people
2.7 % 51–60 years		17.3% 16-20 years		1% Divorced	1.8% more than 15 people
		8.2% more than 20 years			

Manual processing and screw hand press methods to obtain crude palm oil were performed by 99% of the women interviewed. Regarding the quantity of artisanal crude palm oil produced, 72.7% of respondents produced quantities of artisanal red palm oil of less than 100 kg, while 27.3% of women produced quantities of palm oil between 100 and 300 kg. Regarding the storage conditions of the artisanal palm oil produced, the survey revealed that 99% of the women interviewed stored their oils in plastic gallons with a capacity of 20 L for a shelf life of between 3 and 9 months for 49.1% of the women surveyed. However, 27.2% of the women interviewed said they could store red palm oil for more than a year while retaining their organoleptic qualities. These long storage periods allow women to sell oil at prices between 1000F and 1500F for 95% of the women interviewed and between 1500F and 2000F for 5% of the women interviewed.

Table 2 Artisanal palm oil processing of producers surveyed

Bunches storage length	Type of processing	Quantity of artisanal palm oil (in kg) per ton of FFB	Palm oil storage facilities	Palm oil storage length	Price of 1 liter of artisanal palm oil
7.3% 1–5 days	1 % Motorized processing	72.7% ≤ 100	99% Plastics gallon	6.4% 3–6 months	95% 1000-1500 F
87.3% 5–7 days	99 % Manuel processing	25.5% 100 – 200	1% Jars	42.7% 6–9 months	5% 1500 -2000 F
5.5% 7–10 days		1.8% 200–300		23.6% 9–12 months	
				27.2 % more than 12 months	

3.3. Physical properties of artisanal red palm oil

The physical characteristics of artisanal red palm oils varied significantly ($p<0.05$) in the current investigation (Table 3). The moisture content varied significantly ($p<0.05$) depending on the localities from 0.03% to 0.34%, with a high proportion observed at Gonguiné and lower proportions in Man town and Zoba. For palm oil moisture, the maximum moisture limit to ensure good quality was set at 0.25%; thus, 60% of the localities surveyed had a moisture content slightly higher than 0.25%. The impurity content of palm oil varied significantly ($p<0.05$), from 0.32% to 0.66%. The localities of Douèlè, Gbangbegouiné, Logoualé, and Gonguiné recorded the highest percentage of values, whereas Man town recorded the lowest percentage of impurities. However, the impurity content from all localities was greater than the reference, which was 0.05%. The average level of slip melting point in localities (P<0,05) also differed, with the values fluctuate between 20.90 ° C and 34.83 ° C. The statistical analysis revealed lower temperature in the locality of Zoba (20.90 ° C) as compared with Blolè (33.43 ±0.72 °C) and Dompleu (34.83 ±0.46 °C).

Table 3 Physical properties of artisanal palm oil sampled in the western region**.**

Localities	Moisture content (%)	Impurities content (%)	SMP (° C)
Blolè	0.24 ±0.01 c	0.38 ±0.07 b	33.43 ±0.72 d
Dinergouiné	0.23 ±0.01c	0.50 ±0.01 c	30.70 ±0.0 c
Dompleu	0.30 ±0.0 d	0.32 ±0.01 ab	34.83 ±0.46 d
Douèlè	0.29 ±0.0 d	0.61 ±0.02 de	25.87 ±0.12 b
Gbangbegouiné	0.29 ±0.01 d	0.59 ±0.02 cde	26.43 ±0.58 b
Gbatongouin	0.29 ±0.01 d	0.55 ±0.01 cd	28.98 ±1.90 c
Gongouiné	0.34 ±0.01 e	0.66 ±0.01 e	25.13 ±0.29 b
Logoualé	0.30 ±0.0 d	0.60 ±0.0 de	28.77 ±0.58 c
Man	0.03 ±0.0 a	0.24 ±0.06 a	29.60 ±1.13 c
Zoba	0.21 ±0.0 ab	0.56 ±0.0 cd	20.90 ±0.0 a
Recommended Standards	≤ 0.25	≤ 0.05	22.7
$F_{\text{-value}}$	48133.33	7611.49	38075.47
$P_{\text{-value}}$	<0.001	<0.001	<0.001

Means with the same letters are statistically identical.

3.4. Chemical properties of palm oil

Table 4 summarizes the chemical properties of the artisanal red palm oil sampled from the selected localities. The free fatty acid percentage (FFA) obtained varied regardless of localities from 2.54 ±0.82 % to 9.88 ±0.06 %. The statistical analysis reveals lower percentages of FFA in the localities of Blolè (2.54 ±0.82%), Dinergouiné (2.91 ±0.05%) and zoba (3.17 ±0.01 %) as compared with localities of Dompleu (8.41 ±0.29 %) and Gonguiné (9.88 ±0.06%). Average percentage of FFA less than 5% was obtained in 40% of the localities surveyed, while 60 % of the localities surveyed were above this value. Concerning iodine value, the levels are between 56.87 ± 1.68 g I2/100 g and 61.87 ± 0.06 g I2/100 g of oil and met within the recommended standards. The highest values were recorded at the Douèlè and Gbangbegouiné localities. Regarding saponification index, the values obtained vary significantly ($p<0.05$) from 162 ± 1.0 mg KOH/g to 200.69 ± 2.26 mg KOH/g of oil, with Blolè locality recorded the highest value from all other localities. For the deterioration of bleachability index (DOBI), the average levels are between 1.05 ±0.01 and 2.80 ±0.05 with a high value observed at Blolè and the lower values at Man town and Gbatongouin. Furthermore, among all the analyzed samples, 70% of artisanal red palm oil collected from small female producers fell within the recommended standards of DOBI.

Table 4 Chemical properties of artisanal palm oil sampled in the western region.

Localities	Free fatty acid (%)	Iodine value (g of I_2/100 g of oil)	Saponifaction index (mg of KOH/g of oil)	DOBI
Blolè	2.54 ±0.82 a	59.70 ± 2.04 bc	200.69 ± 2.26 g	2.80 ±0.05 h
Dinergouiné	2.91 ±0.05 ab	60.17 ± 0.06 bc	162 ± 1.0 a	2.72 ±0.01 g
Dompleu	8.41 ±0.29 f	56.87 ± 1.68 a	171.32 ± 1.55 de	2.20 ±0.02 e
Douèlè	5.40 ±0.17 d	61.87 ± 0.06 c	168 ±0.0 cd	2.57 ±0.01 f
Gbangbegouiné	5.58 ±0.11 d	61.73 ± 0.12 c	165.75 ± 2.2 e	2.57 ±0.01 f
Gbatongouin	4.37 ±0.55 c	58.93 ± 0.59 ab	187.01 ± 2.15 f	1.83 ±0.03 b
Gongouiné	9.88 ±0.06 g	61.07 ± 0.05 bc	163.82 ± 1.02 ab	1.96 ±0.01 c
Logoualé	6.80 ±0.05 e	59.50 ± 0.0 bc	172.75 ± 2.13 e	2.19 ±0.0 e
Man	6.39 ±0.10 e	59.87 ± 0.15 bc	190 ± 1.0 f	1.05 ±0.01 a

Zoba	3.17 ±0.01 b	60.47 ±0.06 bc	173.10 ± 0.79 e	2.02 ±0.0 d
Recommended Standards	0-5	50.0-55.0	190-209	≤ 1.5
$F_{\text{-value}}$	28354.81	146488.94	682668.79	378754.75
$P_{\text{-value}}$	<0.001	<0.001	<0.001	<0.001

Means with the same letters are statistically identical.

3.5. Lipid oxidation and total carotenoids content

The oxidation properties were assessed by determination of peroxide (PV), para-anisidine (p-AV), and total oxidative (totox) values; the contents varied statistically (P<.001) from palm oil samples collected from the localities of the western region. The PV are between 3.70 ± 0.10 and 8.38 ± 0.44 meq of O2/kg of oil and are under the standard value of 10 meq of O2/kg of oil. Regarding p-AV, palm oil samples also exhibited the lowest value from 0.76 ± 0.10 6.63 ± 2.0. About totox value, concentrations ranging from 8.71 ± 0.21 to 19.17 ± 1.11 with Douèlè locality recorded the lower value from all other localities (Table 5). All palm oil sampled from the smallholders' producers in the Western region recorded highest content of carotenoids with values ranging from 857.33 ± 2.52 mg/kg to 1109.3 ± 3.33 mg/kg (Figure 2).

Table 5 Lipid oxidation properties of artisanal palm oil sampled in the western region

Localities	Peroxyde index (meq of O_2/kg of oil)	Anisidin value	Totox value
Blolè	8.38 ± 0.44 f	2.41 ± 0.35 abc	19.17 ± 1.11 d
Dinergouiné	4.23 ± 0.12 ab	1.54 ± 0.11 ab	10.01 ± 0.15 ab
Dompleu	6.53 ± 0.06 de	3.19 ± 0.20 a	16.26 ± 0.25 c
Douèlè	3.70 ± 0.10 a	1.31 ± 0.14 bc	8.71 ± 0.21 a
Gbangbegouiné	6.37 ± 0.03 cde	2.42 ± 0.28 abc	15.16 ± 0.34 c
Gbatongouin	4.56 ± 1.46 ab	6.63 ± 2.0 d	15.74 ± 1.65 c
Gongouiné	5.64 ± 0.02 bcd	0.76 ± 0.10 a	12.05 ±0.08 b
Logoualé	4.70 ±0.17 ab	1.05 ± 0.1 a	10.45 ± 0.36 ab
Man	5.07 ± 0.38 abc	1.63 ± 0.22 abc	11.76 ± 0.96 b
Zoba	7.67 ± 0.03 ef	3.45 ±0.12 c	18.79 ± 0.13 d
Recommended Standards	10	10	30
$F_{\text{-value}}$	3858.35	409.52	10697.26
$P_{\text{-value}}$	<0.001	<0.001	<0.001

Means with the same letters are statistically identical.

3.6. Correlations between physico-chemical properties of palm oil regarding the different localities

The studied physicochemical properties were correlated with three factors. They accounted for 74.82% of the total variability. However, factors F1 and F2 were used to perform PCA according to the Kaiser–Meyer–Olkin rule. Factor (F1) recorded an eigenvalue of 3.51 and expresses 31.93% of the total variability (Table 6). Five parameters (SMP, peroxide, saponification, anisidine, and totox) were positively correlated with this factor. In contrast, FFA, moisture, DOBI, and iodine values were negatively correlated. With an eigenvalue of 2.57, the factor (F2) expresses 23.32% of the total variability. Moisture, DOBI, impurities, peroxide, carotenoids, iodine, and totox values are positively correlated, while FFA and SMP contribute negatively to its formation. The projection of samples in the same design highlights two groups. Group 1 consisted of Gbangbegouiné, Douèlè, Gongouiné, and Logoualé localities and stood out for their high FFA, moisture, and impurity content. Group 2 differed from group by high values of the saponification index and totox values (Figure 3).

4. Discussion

This investigation, which focused on the Western region of Côte d'Ivoire, contributed to bringing attention to the high caliber of artisanal palm oil produced by smallholders, most of whom are female. A higher proportion of the participants fell into the age brackets of 31–40 and 41–50 years old. These findings concur with those of Ohimain et al. [16], who show that responsible and mature individuals process palm oil on a limited scale. According to Nchanji et al. [17], this outcome further demonstrates that it is a business for the populace that is active.

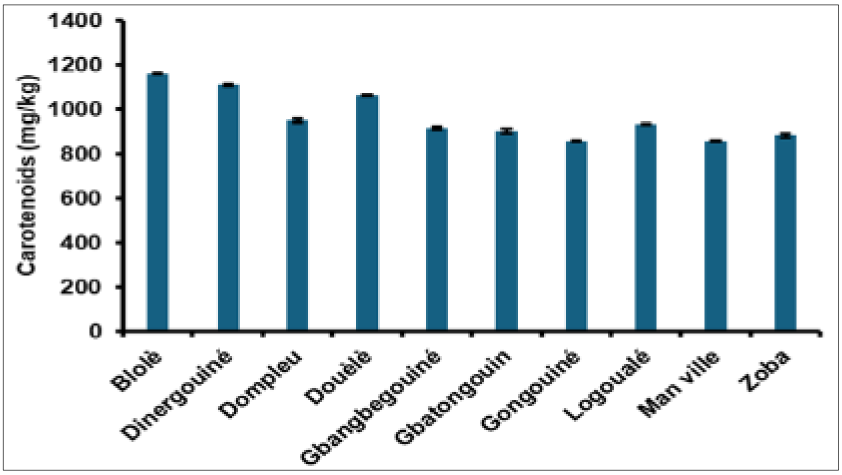
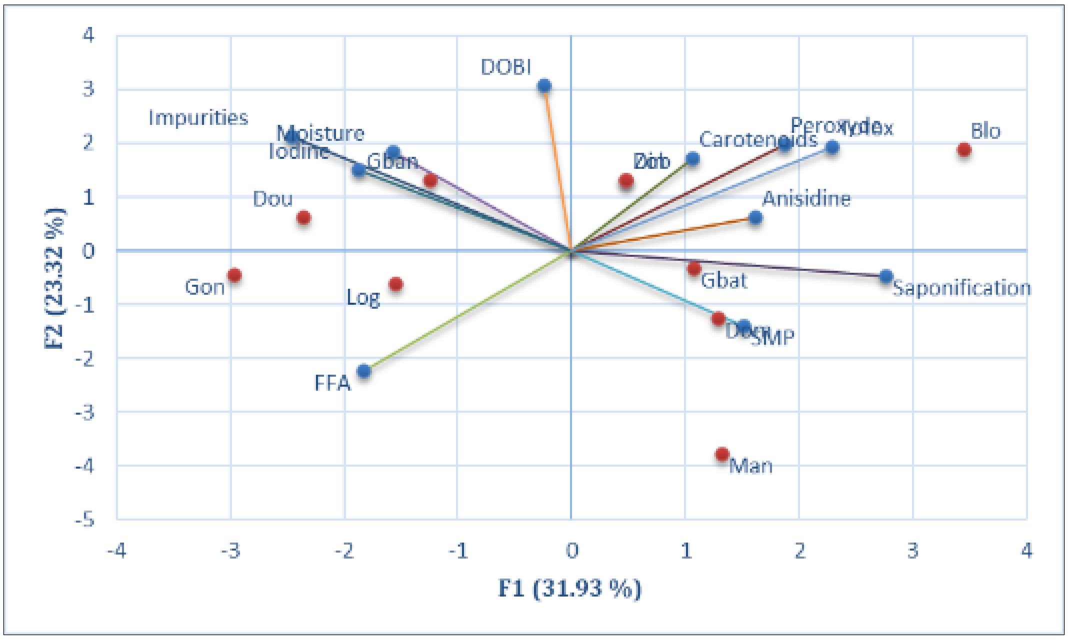


Figure 2 Carotenoids content of artisanal palm oil sampled in the western region

Table 6 Eigenvalue matrix and correlations of palm oil physicochemical properties with F1, F2 and F3 components analysis

Components	F1	F2	F3
Eigenvalues	3.51	2.57	2.15
Validity expressed (%)	31.93	23.32	19.57
Cumulative (%)	31.93	55.25	74.82
FFA	-0.30	-0.36	0.23
Moisture	-0.26	0.30	0.33
SMP	0.25	-0.23	0.53
DOBI	-0.04	0.50	0.39
Impurities	-0.40	0.34	-0.10
Peroxyde	0.30	0.32	-0.15
Carotenoids	0.17	0.28	0.49
Saponification	0.45	-0.08	0.07
Iodine	-0.30	0.24	-0.20
Anisidine	0.26	0.10	-0.21
Totox	0.37	0.31	-0.22

The educational background of palm oil processors reveals that a sizable portion (48.2%) had no formal education, compared to 44.5% with only a basic primary school education and 7.3% with a tertiary degree. This suggests that the level of education among processors is rather low. The results are consistent with those of Akangbe et al. [18], who show that 55.0% of oil palm extractors had no formal education, and only 21.3% had at least a basic primary school education, while 11.2% had post-primary education. This finding indicates that the artisanal palm oil processing in the research area may be impacted by educational attainment. Results showed that 58% of the processors have between 11 and 20 years of oil palm processing experience. The high experience level years recorded shows that palm oil processing is the major occupation of residents at the study area. this study revealed that majority of palm oil processors had households with one to ten people. Ohimain et al. [16] reported similar findings in Nigeria's Elele Rivers State. These authors revealed that 88% of palm oil processors have one to ten people living in their home. All smallholders from the western region interviewed harvest wild plants and use manual processing techniques to produce palm oil. This result was close to Olagunju [19], who reported that traditional or semi-mechanized methods are used for oil extraction from the fresh fruit bunches in Nigeria. In addition, during processing, outdated equipment was mostly used. This method of oil palm processing is arduous and time-consuming, and the oil yield is usually low. According to Ekine and Onu [20], about 25%–75% of potential palm oil is lost during processing. This observation is consistent with the results of this survey, which mentioned that 72.7% of small-scale producers interviewed produce less than 100 kg of artisanal palm oil.



Blo: Blolè; Dinergouiné: Din; Dompleu: Dom; Dou: Douèlè; Gbangbegouiné: Gban; Gbatongouin: Gbat; Gon: Gongouiné; Log: Logoualé; Man: Man

Figure 3 Projection of physicochemical properties and localities in factorial plan 1-2 of the analysis of main components

The investigation also revealed that for 50.8% of the women surveyed, the artisanal palm oil producers mostly stored their product at room temperature in discarded plastic gallons, giving it a shelf life of more than nine months. By using these strategies, the producers were able to sell their artisanal palm oil during the oil palm's low season for a higher price, which was a significant source of revenue [17].

Concerning the physicochemical properties of the artisanal palm oil sampled from the different localities of Western region, results show that the moisture content was nearly in line with the required level. The artisanal palm oils' comparatively low moisture content may be attributed to the small-scale producers' effective drying techniques and years of extensive experience of producers recorded in this investigation. Moisture content is a parameter that is used in assessing the shelf-life of a product [21]. The low moisture content of the palm oil from Blolè, Dinergouiné, Man and Zoba indicates that their storage stability was better than that of the other localities. Nevertheless, impurity content from all localities has greater values than the reference, which is 0.05% [22]. The relatively high impurity value observed may be influenced by the methods of oil palm extraction and the poor hygienic disposition of the smallholder processors [23]. Earlier studies undertaken in several countries of Africa (Nigeria, Cameroon, Ghana, Côte d'Ivoire) reported the formation high impurity levels in crude palm oil produced by smallholder processors [5, 24]. A common tool for describing the melting and solidification characteristics of oils and fats is the slip melting point (SMP). It varies according to unsaturation ratios, trans fatty acid quantity, fatty acid chain length, and where the fatty acids are located within the glycerol backbone [25]. The accepted value for the slip melting point of palm oil is 22.7 °C, according to Haizam et al. [26]. Apart from zoba locality (20 °C), the SMP of the artisanal CPO found in this study was quite similar to the accepted values. Compared to the value codex Alimentarius norms [21], the free fatty acid values found in 40% of the examined localities are lower. These findings suggest that the artisanal palm oils produced in these areas are excellent for human human consumption and are not prepared from rotten palm fruits. However, the presence of free water and suspended contaminants, which promote the hydrolysis of the TAGs, may be responsible for the high level of free fatty acid found in the other localities [27, 28]. All the palm oil samples from the ten locations that were examined came closest to the codex's suggested iodine value of 50–55 g I_2/100 g of oil, with an iodine value of 57 to 62 g I_2/100 g of oil. These results were consistent with those of Konan et al. [10], who found that traditional oil palm in the Man region had a high fluidity value, as evidenced by an average iodine index of 56 g I_2/100 g of oil. An indicator of the molecular weight of oil triglycerides is the saponification value. Since the average molecular weight or length of fatty acids is inversely proportional to the saponification value, a high number denotes a high fraction of low fatty acids.

Palm oil samples from the ten localities were found to fall within the acceptable range of 190-205 mg of KOH/g of oil for saponification, indicating that the palm oil is suitable for use in soap production [5]. The deterioration of the bleaching index (DOBI) is the ratio of the carotene content to the content of secondary oxidation products. Low DOBI values (≤ 1.5) in crude palm oil make it challenging to refine due to the presence of oxidation products that are challenging to eliminate throughout the refining process [29]. The study's DOBI values were significantly greater than the norm, except for Zoba locality, which reported a level of 1.05. The most popular tests for determining the oxidative status of oil are the peroxide value, p-anisidine value, and totox value. Since the peroxide value indicates the degree of rancidity in the oil, all palm oil sample from the different localities were within recommended value of 10 meq of O_2/kg of oil [30]. For an accurate evaluation of the oil's oxidation state, it is crucial to integrate the measurements of the para-anisidine and peroxide values. An accurate way to measure the rancidity of lipids is to calculate the Para-anisidine index [31]. Unlike the peroxide value, there is no normal value listed in the Codex Alimentarius. Previous studies recommend that oil have a para-anisidine value of less than 10 [32]. The palm oil's p-AV recorded during this investigation complied with the requirements. A measurement of the primary and secondary oxidation products is given by the Totox value. The study's findings, which show high primary and secondary oxidative stability, were lower than those of vegetable oils reported in the literature [33]. The carotenoids values ranging from 857.33 ± 2.52 mg/kg to 1109.3 ± 3.33 mg/kg. Compared to the standard, palm oil sampled had significantly higher carotenoids contents. However, this result differed from research by Ugo et al. [34], who discovered that palm oil produced and marketed in major marketplaces in the Orlu zone of Imo state, Nigeria, had a value between 2146.67 and 2516.6 mg/kg.

5. Conclusion

This study investigated the quality of artisanal palm oil producing in the western region of Côte d'Ivoire. From the analysis carried out, it could be deduced that the palm oil sample from western region had good physicochemical property that fell within the standard, except for impurities levels. It would be important to sensitize smallholders' producers on good practices and the use of suitable equipment to help improve the profitability of palm oil production and ensure food security. Therefore, it is pertinent to conclude that palm oil samples from the western region were not adulterated, hence its suitability for both domestic and industrial purposes.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared no conflict of interest

Statement of informed consent

All contributing authors read and approved the final manuscript for publication.

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