Scientific Research Publishing

Food and Nutrition Sciences, 2026, 17(2), 268-280
https://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

Physicochemical Quality of Palm Oil in Lower Casamance (Southern Senegal): Degradation Indicators and Public Health Implications

Awa Diallo[1], Omar Touré[2], Landing Ndiaye[1*], Omar Sarr[3], Boubacar Camara[1], Mohamed M. Charahabil[1], Daouda Ngom[3]

[1]Laboratory of Agroforestry and Ecology (LAFE), UASZ, Ziguinchor, Senegal
[2]Water, Energy, Environment and Industrial Processes Laboratory (LE3PI), ESP-UCAD, Dakar, Senegal
[3]Laboratory of Ecology and Eco-Hydrology, Department of Plant Biology, Cheikh Anta Diop University (UCAD), Dakar, Senegal
Email: *l.n8@zig.univ.sn

How to cite this paper: Diallo, A., Touré, O., Ndiaye, L., Sarr, O., Camara, B., Charahabil, M.M. and Ngom, D. (2026) Physicochemical Quality of Palm Oil in Lower Casamance (Southern Senegal): Degradation Indicators and Public Health Implications. *Food and Nutrition Sciences*, **17**, 268-280.
https://doi.org/10.4236/fns.2026.172019

Received: January 17, 2026
Accepted: February 23, 2026
Published: February 26, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

Palm oil, widely used in food, cosmetics and the agri-food industry, holds an important socio-economic position in Senegal, particularly in Lower Casamance. However, its physicochemical quality remains poorly documented, which raises concerns for consumer health. The aim of this study is to assess the nutritional value of six samples of palm oil produced and marketed in this region through the analysis of five parameters: acid index, peroxide index, iodine index, insoluble impurities content, and water content, in accordance with the standards of Codex Stan 210-1999. The results show that the acid index of the samples (43.06 to 47.53 mg KOH/g) far exceeds the standard (<10 mg KOH/g), indicating high acidity and degraded quality. The peroxide value is within the acceptable range (2.29 to 9.43 mEq/kg), indicating limited oxidation. The iodine index ranges from 44.5 to 75.5 g I_2/100g, with a value below the standard for Birkama oil (44.5 g), indicating a high content of saturated fatty acids. The insoluble impurities are very high (1.29% to 6.58%), well above the standard (0.05%), suggesting deficiencies in the filtration processes. Moisture and volatile content are compliant (<0.2%), with a maximum of 0.005%. The results show that, while the water content and peroxide values are generally within standards, the oils exhibit high acidity as well as insoluble impurities exceeding Codex Alimentarius standards. The authors conclude that these quality defects pose risks to public health and call for improvements in production methods and quality control.

Keywords

Palm Oil, Physicochemical Quality, Acid Value, Peroxide Value, Iodine

Value, Insoluble Impurities, Lower Casamance, Codex Standard 210-1999

1. Introduction

The oil palm is the crop that provides the highest yield of oil per hectare, with an average of 4 tons per year [1] [2]. For centuries, this tree (*Elaeis guineensis*. Jacq.) has supplied numerous products and services to local populations [3], including palm oil, palm kernel oil, sauces, soap, roofing (leaves), fertilizers (ashes), construction materials (trunks) and medicines (roots) [4].

In West Africa, palm oil is traditionally consumed in its crude form (red oil). Lower Casamance has significant production potential, and the oil it produces plays an important role in Senegal's domestic markets due to its nutritional and economic value. The region is supplied both through local production and imports from the West African sub-region, notably from Guinea-Bissau, Guinea Conakry, Sierra Leone, etc.

Despite its importance, palm oil faces serious problems. In Guinea Conakry, oil marketing is carried out mainly in an informal settings and large quantities of oil produced without regard for nutritional or sanitary standards are exported worldwide [5]. Similar quality issues are observed in oils from Lower Casamance and other countries in the sub-region. Compliance with hygiene standards during production and along the marketing chain remains insufficient, despite the presence of food quality control services. Moreover, fraudulent practices have been reported, where palm oil is mixed with other oils or foreign substances, thereby altering its quality and nutritional properties. In the markets of Lower Casamance, palm oil from Guinea is highly valued for its texture, taste and color, although its actual quality is not always guaranteed. This strong demand encourages the importation and consumption of oils whose physicochemical quality remains unverified, which is concerning. The consumption of low-quality oils can lead to serious health issues, including cancer, atherosclerosis and cardiovascular diseases [6] [7].

Against this backdrop of health risks and quality issues, the present study was undertaken. Its objective is to contribute to improving knowledge on the physicochemical and nutritional quality of palm oil produced and marketed in Lower Casamance, with the aim of assessing its implications for public health.

2. Materials and Methods

2.1. Plant Material

The plant material, consisting of two lots of palm oils, was collected between January and August 2023. The first lot, comprising two samples of palm oils, was collected from producers in Diagnon and Birkama in the Ziguinchor department (one sample per site). These samples were intense to evaluate the influence of rudimentary methods and equipment on the quality of the final product. The processes (rudimentary methods) for processing palm fruits include prolonged fermentation of the fruit bunches (7 to 10 days), sun-drying of the fruits, gentle successive cooking of about two hours each, resulting in significant evaporation, as well as rudimentary artisanal gravity clarification techniques without filtration, based on decantation and manual skimming, with no fine filtration system. After decantation, the floating oil phase is then collected by manual skimming using a ladle. The oils obtained are packaged in plastic bottles and sold on the same day. The second lot, comprising four samples, was collected from merchants. The samples originated from Sierra Leone, Nzérékoré in Guinea Conakry, Susana and Canchungo in Guinea-Bissau. The analysis of the samples from the second lot will allow us to assess the impact of marketing methods and the product's shelf life on the physicochemical properties of palm oil, in other words, on its sanitary quality. These six samples are all red palm oils and not refined oils. However, the samples of marketed palm oils underwent a traditional heat treatment (heating or cooking) to remove the residual water and facilitate filtration.

The six samples (**Figure 1**) from different sites are placed in 250 ml jars.

Figure 1. Palm oil samples from different sources.

2.2. Physico-Chemical Characterization of Palm Oil Samples

2.2.1. Acid Index

The acid value represents the number of milligrams of potassium hydroxide required to neutralize the free fatty acids (FFA) present in 1 g of oil. It provides an overall indication of the degree of deterioration of the oils. To determine the acid index of palm oils, the protocol described in standard NF T60-204 [8] was applied with certain modifications. Specifically, 2.5 g of palm oil was weighed and mixed with 100 ml of previously neutralized ethanol-alcohol solution in an Erlenmeyer flask. The mixture was heated with stirring until complete dissolution, after which 3 to 4 drops of phenolphthalein were added. The resulting solution was titrated under stirring with 1 N NaOH solution until a pink color appeared. The acid value was calculated using formula (1):

$$IA = \frac{V \times N \times 56.1}{PE}$$

IA = acid index (mg KOH/g of oil); V = Volume of NaOH added in ml; N = Normality of the NaOH solution (1 N) and PE = trial intake in g.

2.2.2. Peroxide Index

The peroxide value of a fat refers to the number of micrograms of active oxygen in the peroxide contained in 1 gram of fat, which is capable of oxidizing potassium iodide with the release of iodine [9].

This index was determined according to the NFT 60-220 standard [8] [10]. In addition, 2 g of palm oil and 10 ml of chloroform were added to a 250 ml Erlenmeyer flask. Subsequently, 15 ml of acetic acid and 1 ml of saturated potassium iodide were added. The flask was capped and shaken for 1 minute, then stored in a cupboard away from light for 5 minutes. Afterwards, 75 ml of distilled water and 1 ml of starch paste were added. Finally, the released iodine was titrated with a 0.01 N thiosulfate solution. At the same time, the blank (distilled water) was prepared under the same conditions to determine the volume of the blank (V_{blank}).

$$IP = \frac{\left(V_{\text{sample}} - V_{\text{blank}}\right) \times N \times 1000}{PE}$$

V_{sample} = volume of thiosulfate added for the sample in ml; V_{blank} = volume of thiosulfate poured for the blank in ml; PE = Mass of the test sample in g and N = Normality of the thiosulfate solution.

2.2.3. Iodine Index

The iodine (II) value was defined according to the NF T60-203 standard [11]. It corresponds to the mass of iodine (I_2) absorbed by the unsaturations of the fatty acids in 100 g of a fat. The iodine value is used to determine the degree of unsaturation of a vegetable oil and was measured using the method described below:

0.20 g of palm oil was weighed into an Erlenmeyer fask and dissolved in 15 ml of carbon tetrachloride. After dissolution, 25 ml of Wijs reagent (0.1 N) was added. The flask was sealed, gently stirred and kept in the dark at approximately 25˚C for one hour. After that, 20 ml of aqueous potassium iodide solution (100 $g \cdot L^{-1}$) and 150 ml of distilled water were added to the solution. In the presence of a few drops of starch paste (0.01 $g \cdot L^{-1}$), the titration was carried out with a sodium thiosulfate solution (0.1 N) until the color change occurred.

The iodine index, expressed in mg I_2 per 100 g, is given by the equation:

$$I_I = \frac{\left(V_B - V\right) \times N \times 12.69}{m}$$

where I_I is the iodine index (mg I_2/100g); V is the volume of the sodium thiosulfate solution titrating the sample (ml); V_B is the volume of the sodium thiosulfate solution titrating the blank (ml); N is the normality of the sodium thiosulfate solution used and m is the weighed mass of oil (g); 12.69 is a conversion factor based on the molecular weight of iodine.

2.2.4. Content of Insoluble Impurities

It is defined by the set of substances insoluble in technical n-hexane or petroleum ether or diethyl oxide or carbon disulfide that have not been measured in the determination of water and volatile matter content. To asses this parameter, two capsules containing two (2) filter papers previously soaked in n-hexane were dried in an oven for 30 minutes at 103˚C ± 2˚C, then cooled in a desiccator to room temperature. The tare of the capsule plus filter was taken. In a beaker, a mass of 20 g of oil is weighed.

- Add any amount of hexane to facilitate dissolution.
- Carry out the filtration on one of the papers, using the other as a blank.
- Rinse the filter several times with hexane until all the fat from the oil has been completely removed.
- Fold the used filter and the one for the blank and soak them in a beaker containing hexane for at least 30 minutes.
- Dry again in the oven for 3 hours.
- Cool in the desiccator to room temperature and weigh.

Presentation of results

- If the mass difference of the filter paper for the blank is positive

$$\text{Insolubilities} = \frac{\Delta m - \Delta m_0}{PE} \times 100$$

- If the mass difference of the filter paper for the blank is negative

$$\text{Insolubilities} = \frac{\Delta m + \Delta m_0}{PE} \times 100$$

Δm = mass of capsule plus filter after use − mass of capsule and filter before use; Δm_0 = mass of the capsule plus white filter − mass of the capsule and white filter after.

2.2.5. Moisture and Volatile Matter

Moisture and volatile matter were determined according to the NF T 60-201 method [8]. It is the mass loss experienced by the product after heating at 103˚C ± 2˚C for a minimum duration of 3 hours.

2.3. Data Analysis and Processing

The R software version 4.3.1 [12] (R Core Team, 2023) was used to perform the statistical analysis of the analytical data. In addition, a Principal Component Analysis (PCA) was carried out to highlight the correlation between the different palm oil samples and physicochemical parameters.

3. Results and Discussion

3.1. Results

3.1.1. Acid Index

The results of the different indices are presented in **Table 1**. Regarding the acid index ($p < 0.001$), no significant difference is detected between the samples from Canchungo, Sierra Leone and Birkama. However, significant differences were observed between the samples from Canchungo, Nzérékoré, Susana and Diagnon.

Furthermore, Table 1 shows that the acid values range from 43.06 to 66.68 mg KOH/g of oil, regardless of the sample's origin. These values do not comply with the Codex Standard 210-1999 [13] for unrefined palm oil, which stipulates that virgin palm oil must contain less than 10 mg of KOH/g of oil. Depending on the sources, palm oil from the production sites (Diagnon and Birkama) in Lower Casamance shows very high acid values (66.68 and 50.16 mg KOH/g. respectively) compared to oils from sales sites (Sierra Leone 47.53; Canchungo 47.39; Susana 45.46; and Nzérékoré 43.06 mg KOH/g).

Table 1. Variation of the physicochemical parameters of oils from production and marketing sites.

Samples	**Parameters**			
Sales sites	**% FFA**	**Acide indice**	**Peroxyde indice** (mEq O_2/kg)	**Iodine indice** (g I_2 /100g d'huile)
Canchungo	23.82 ± 1.33^{bc}	47.39 ± 2.65^{bc}	3.10 ± 0.74^{c}	53.37 ± 2.85^{bc}
Nzérékoré	21.65 ± 0.66^{d}	43.06 ± 1.32^{d}	3.29 ± 0.29^{c}	57.14 ± 6.45^{b}
Sierra Leone	23.89 ± 0.67^{bc}	47.53 ± 1.33^{bc}	3.03 ± 0.28^{c}	58.65 ± 1.47^{b}
Susana	22.85 ± 0.66^{cd}	45.46 ± 1.32^{cd}	2.29 ± 0.31^{c}	57 ± 1.73^{b}
Production sites				
Birkama	25.21 ± 0.42^{b}	50.16 ± 0.83^{b}	9.22 ± 1.78^{a}	44.5 ± 2.32^{c}
Diagnon	33.52 ± 0.097^{a}	66.68 ± 0.19^{a}	5.81 ± 0.97^{b}	75.51 ± 3.07^{a}
p-value	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Codex Standards Stand 210-1999		10	up to 15 milliequivalents of active oxygen per kilogram of oil	50 - 55

The superscripted letters represent the statistical values assigned to the variables studied by site to determine whether or not there is a statistically significant difference at the 5% level. The same applies to below table.

Regarding the fatty FFA content, oils obtained directly from production sites recorded the highest average fatty FFA content (29.37%). Whereas samples from sales sites, showed low values (23.05%). Although they are not directly toxic, fatty FFA increase the susceptibility of oils to oxidation, promoting the formation of oxidative compounds involved in oxidative stress and inflammation. Repeated consumption of such oils can therefore contribute to metabolic imbalances and a decrease in nutritional quality, highlighting an important public health issue.

The lipid profile of palm oil is mainly composed of palmitic acid and oleic acid. Myristic and lauric acids, although present in small amounts, are among the fatty acids that can influence lipid metabolism. Each saturated fatty acid (SFA) has different effects on the concentration of various cholesterol fractions in plasma lipoproteins. Lauric, myristic, and palmitic acids increase LDL cholesterol (bad cholesterol) levels, whereas stearic acid has no effect on this factor (FAO, 2012).

3.1.2. Peroxide Index

The peroxide value of palm oils from different sources ranges from 2.29 to 9.22 meq of active oxygen/kg of oil. Oils from the production sites exhibited the highest peroxide values, ranging from 5.81 mEq O_2/kg of oil for Diagnon oil to 9.22 mEq O_2/kg of oil for Birkama. Although these values remain below the Codex limit (maximum of 15 mEq of active oxygen/kg of oil as a peroxide index), they were significantly higher than those observed at sale points ($p < 0.001$). Oils collected from the sales sites displayed lower peroxide values (Nzérékoré 3.29 mEq of active oxygen/kg of oil, Canchungo 3.10 mEq of active oxygen/kg of oil and Sierra Leone 3.02 mEq of active oxygen/kg of oil). Susana showed the lowest peroxide value (2.29 mEq of active oxygen/kg of oil). Similary no significant difference were anserved among palm oil samples from the sales sites regarding the iodine value (Canchungo 53.37; Nzérékoré 57.14; Sierra Leone 58.65; and Susana 57 g I_2/100g of oil). In contrast, iodine index results of palm oil samples from retail sites (Birkama 44.5 and Diagnon 75.51 g I_2/100g of oil) differ significantly from those of samples from production sites ($p < 0.001$).

Significant differences were observed between the different palm oil samples in terms of moisture content and insoluble impurity content, with $p < 0.001$ and 0.00056, respectively. The content of insoluble impurities in the different sources of palm oil ranges from 1.29% to 6.58% (Table 2). Samples from production sites and sales sites show values above the standard (Diagnon 6.58%; Birkama 5.07%; Canchungo 3.92%; Sierra Leone 3.28%; Susana 3.12%; and Nzérékoré 1.29%). The oil from the production sites recorded the highest levels of impurities. Regarding the moisture and volatile matter content of palm oils, the recorded values (Canchungo 0.0032; Nzérékoré 0.0036; Sierra Leone 0.0026; Susana 0.0055; Birkama 0.0037; Diagnon 0.005) at the sites are below the *Codex Alimentarius standard* (0.2% m/m).

Table 2. Variation in insoluble impurity and moisture content of oils according to production and sales sites.

Samples	Insoluble impurity content (% m/m)	Moisture and volatile matter (% m/m)
	Sales sites	
Canchungo	3.92 ± 1.92^{abc}	$0.0032 \pm 1.530609e{-}04^{d}$
Nzérékoré	1.29 ± 1.29^{c}	$0.0036 \pm 4.995206e{-}05^{c}$
Sierra Leone	3.28 ± 1.39^{bc}	$0.0026 \pm 1.024600e{-}04^{e}$
Susana	3.12 ± 0.20^{bc}	$0.0055 \pm 8.260324e{-}05^{a}$
	Production sites	
Birkama	5.07 ± 0.40^{ab}	$0.0037 \pm 2.624479e{-}05^{c}$
Diagnon	6.58 ± 0.08^{a}	$0.005 \pm 2.217357e{-}05^{b}$
p-value	0.000561	$p < 0.001$
Codex Standard	0.05	0.2

3.1.3. Characterization of Palm Oils from Lower Casamance Using Principal Component Analysis (PCA)

Principal component analysis was used to establish correlation between physicochemical parameters and the origin of palm oil samples. The combination of Dim 1 and Dim 2 amounts to 81.2%. Dim 1 represents 59% of the original information, while Dim 2 contains 22.2% of the original information. The parameters (acidity, acid value and content of insoluble impurities) are positively correlated with Dim 1, whereas the water content is negatively correlated with it. The peroxide value is positively associated with Dim 2. While the iodine index showed a negative correlation with this dimension. Based on these correlations, it is concluded that Dim 1 provides information on the oils' storage stability, and Dim 2 indicates the sanitary quality and the degree of unsaturation of the oils. Palm oil samples collected from vendors (Canchungo, Nzérékoré, Sierra Leone, Susana) appear to have a higher water content compared to the samples collected from producers. Conversely, oils from production sites showed higher peroxide values (Birkama) and iodine values (Diagnon). This analysis identifies three classes of palm oil. Class (C1) represents palm oil from Birkama, characterized by a high peroxide index and a high content of insoluble impurities. Class (C2) concerns the oil harvested in Diagnon, characterized by higher iodine and acid values. Class (C3) groups four palm oils from Nzérékoré, Canchungo, Susana, and Sierra Leone.

It should be noted that the sample size (n = 6) constitutes a significant statistical constraint. In this context, the PCA conducted in this study should be interpreted as an exploratory approach aimed at identifying potential trends and relationships between physicochemical parameters, rather than as a tool for regional generalization. Nevertheless, the results obtained provide relevant preliminary indications of the main factors contributing to the degradation of palm oils in Lower Casamance and highlight the need to conduct further studies involving a larger number of samples in order to confirm and generalize these observations (**Figure 2**).

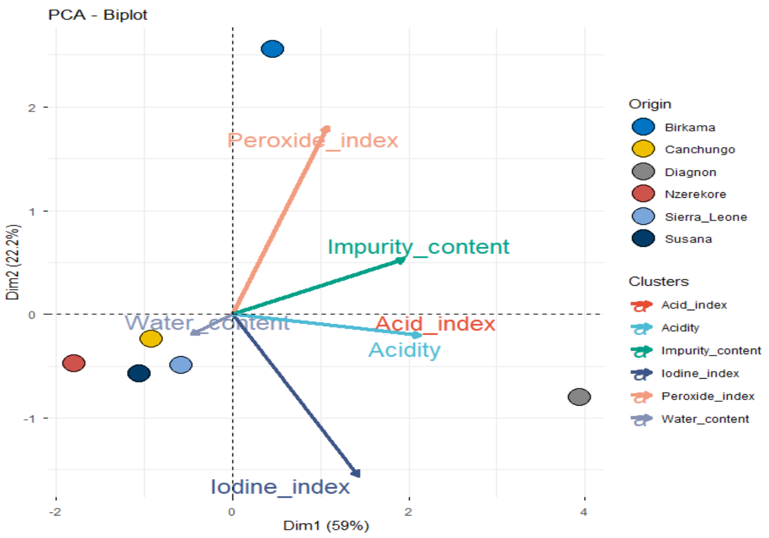

Figure 2. Characterization of palm oil sample origins from Lower Casamance according to physicochemical parameters.

3.2. Discussion

3.2.1. Acid Value and Acidity

The acid index values observed in this study range from 43.06 to 66.68 mg KOH/g of oil. These results are higher than the limit established by Codex Standard 210-1999 for virgin palm oils, which requires a value below 10 mg KOH/g of oil. Furthermore, these values far exceed those reported by [6], according to whom the acid index of artisanal palm oil consumed in Senegal ranges from 21.64 to 37.27 mg KOH/g of oil. The highest acid values come from the production sites (Birkama: 50.16 mg KOH/g and Diagnon: 66.68 mg KOH/g), where traditional extraction methods are employed. This high value could be attributed to excessive heating of the oil during production, thus contributing to its acidification. Artisanal processing methods yield a lower-quality oil, more acidic and more prone to oxidation, compared to industrial processes, which produce oils with reduced Free Fatty Acids (FFA), fewer impurities, and lower water content [14].

Another explanation for the increase in the acid index is the high hydrolytic activity of certain enzymes (lipases), triggered during picking, handling, and processing operations [15]. Fruit deterioration, particularly late harvesting (overripe fruits) or the dropping of bunches to the ground, can lead to increased hydrolysis of triglycerides into FFA.

Oil is considered unfit for consumption when it contains more than 5% FFA [16]. The results obtained for free fatty acids are 4 to 5 times higher than the standard set at 5%. They are also higher than the values of 5.3% to 8.3% of free fatty acids found by [17] in natural palm oils.

3.2.2. Peroxide Index

The Codex Alimentarius establishes a maximum peroxide value of 15 mEq of active oxygen/kg of oil for palm oil. All the oils studied comply with this standard, ranging from 2.29 mEq O_2/kg (Susana) to 9.22 mEq O_2/kg (Birkama), indicating good oxidative quality and fresh, high-quality oils.

However, the higher values observed at production sites (Birkama 9.22 mEq O_2/kg; Diagnon 5.81 mEq O_2/kg) suggest that the oil is more oxidized from the outset, potentially due to less controlled artisanal processes or poor storage conditions before being marketed. The lower index values in oils sold in markets (Canchungo 3.1; Nzérékoré 3.29; Sierra Leone 3.03; Susana 2.29 mEq O_2/kg) can be explained by refining.

The increase in peroxides is generally due to oxidation processes that occur during storage, especially at high temperatures [18]. Consuming rancid oils reduces nutritional quality (decrease in essential fatty acids and loss of fat-soluble vitamins) and has negative health effects due to the formation of toxic compounds (free radicals) that can lead to chronic diseases (cancers, cardiovascular diseases).

The study results are consistent with those of [19] (respective values of 3.99; 8.98; 9.98; 3.99 and 7.61 mEq O_2/kg). However, they are lower than those reported by [20] (44.00 ± 0.26 mEq O_2/kg) and the high indices found by [21] in refined vegetable oils (28.41 mEq O_2/kg and 31.97 mEq O_2/kg).

3.2.3. Iodine Index

The iodine values range from 44.5 to 75.5 g I_2/100g of oil for all the samples, reflecting a difference in the degree of saturation of the oils. The oils from Diagnon, Sierra Leone, Nzérékoré, Susana, and Canchungo (ranging from 53.37 to 75.51 g I_2/100g of oil) have a higher content of unsaturated fatty acids.

The palm oil from Birkama has the lowest iodine value (44.5 g I_2/100g of oil), below the standard set by the Codex Alimentarius (50 - 55 g I_2/100g of oil), indicating a higher content of saturated fatty acids. The iodine value of Canchungo (53.37 g I_2/100g of oil) meets the standard. According to [22], the more unsaturated an oil is, the higher its iodine value.

The differences between the oils from the production sites (Birkama 44.5 g I_2/100g of oil and Diagnon 75.51 g I_2/100g of oil) could be explained by a lack of consistency in the manufacturing processes, which supports the need for standardization of extraction and storage methods. The iodine value allows for the assessment of how easily oils become rancid, as the more unsaturated an oil is, the more sensitive it is to oxygen [20].

The results are consistent with the work of [23], which indicated that artisanal palm oil sold in Senegal ranges from 48.12 to 88.90 g I_2/100g of oil. Since the values obtained are below 100 g I_2/100g of oil, these oils are classified as non-drying oils [6], which confirms their liquid state at room temperature.

3.2.4. Contents of Insoluble Impurities

The recorded values for insoluble impurity content (amount of foreign matter insoluble in n-hexane) were very high (1.29% to 6.58%). These values exceed the Codex Alimentarius standard (2019) [24], which is set at 0.05% impurity.

This high level of impurities could be due to non-compliance with hygiene rules during production, distribution, storage, and warehousing. The highest rates at the production sites (Birkama 5.07% and Diagnon 6.58%) can be explained by poor filtration of the oil after extraction, often due to the use of rudimentary methods and the lack of suitable equipment to remove solid particles.

The levels are slightly lower in commercially available oils (Susana 3.12%; Canchungo 3.92%; Sierra Leone 3.28% and Nzérékoré 1.29%), a fact that could be attributed to the refining and filtration practices carried out by merchants. These results are comparable to those of [25] (0.04% to 6.97%).

The presence of impurities has a detrimental effect on the sensory (such as color) and chemical characteristics of the oil, as they can promote oxidation phenomena and serve as a medium for microbial growth [26] [27].

3.2.5. Water Content

The moisture content results of the samples (maximum of 0.005%) comply with the Codex Alimentarius standard [8], which specifies a maximum moisture content of 0.2%.

A low water content is essential for the stability of oil, as water promotes deterioration reactions [22]. These low moisture levels indicate good dehydration of the oils during the extraction process, resulting in excellent physical stability and a low presence of residual water.

These results contrast with other studies: [28] showed that the moisture content of oils produced in Benin was 3 to 11 times higher than the international standard (0.10%), and in Nigeria, artisanal crude palm oil has a water content of 0.53% to 0.73% [29]. Similarly, [30] reported a water content ranging from 0.42% to 0.70% for both artisanal and industrial red palm oil.

4. Conclusion

The results obtained reveal significant non-compliances with the Codex Alimentarius standards, raising concerns about the sanitary and nutritional quality of palm oils sold in Lower Casamance. The issue is crucial, as the consumption of low-quality palm oils is directly associated with the onset of serious health conditions, including cancer, cardiovascular diseases, and atherosclerosis. The results confirm this concern: the majority of oils on the market, whether from local production or imports from the sub-region, do not meet the fundamental standards of the Codex Alimentarius, particularly regarding acidity and purity. These failures reflect artisanal practices, insufficient compliance with hygiene standards during production and marketing, and the existence of fraudulent production (mixing with foreign substances). In the face of this high variability in quality and the presence of impurities, improving knowledge of the physicochemical and nutritional quality of palm oil should be considered an absolute priority for public health. It is imperative to implement urgent measures, ranging from the drastic strengthening of quality control to the modernization of equipment and the ongoing training of producers, in order to ensure the compliance of this essential product. Ensuring the safety and nutritional quality of palm oil is the only way to protect consumers' health and sustainably promote this vital sector in Lower Casamance.

Acknowledgements

This work was carried out within the framework of a project financed by the African Centre of Excellence in Agriculture for Food and Nutritional Security (CEA-AGRISAN). The authors thank the CEA-AGRISAN for their financial support.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Rival, A. and Levang, P. (2014) Palms of Controversies: Oil Palm and Development Challenges. CIFOR.

[2] Corley, R.H.V. and Tinker, P.B. (2016) The Oil Palm. 5th Edition, Wiley. https://doi.org/10.1002/9781118953297

[3] Carrere, R. (2013) Le palmier à huile en Afrique: le passé, le présent et le futur. Mouvement Mondial pour les Forêts Tropicales, décembre 2010, (Actualisé en août

2013).
http://wrm.org.uy/wpcontent/uploads/2013/08/Palmier_a_huile_en_Afrique_2013.pdf

[4] GRDR (2014) Projet d'appui aux femmes de la commune de Ouonck dans la production et la commercialisation de l'huile de palme. Rapport de projet.

[5] Diallo, I. (2015) Contribution à l'évaluation de la qualité des huiles végétales vendues et consommées en République de Guinée. Projet de fin d'étude en vue de l'obtention du diplôme de Master Professionnel. Technologie Alimentaire. Institut Supérieure de Biotechnologie de Sfax (ISBS). 73 p.

[6] Kandji, N.A. (2001) Etude de la composition chimique et de la qualité d'huiles végétales artisanales consommées au Sénégal. Pour obtenir le grade de docteur en pharmacie. Diplôme d'état: Faculté de Médecine, de Pharmacie et d'Odontostomatologie. Université Cheikh Anta Diop de Dakar. 99 p.

[7] Ndzouli, N.P. (2011) Sécurité alimentaire: Évaluation du taux de rancissement des huiles alimentaires (cas des huiles de fritures). Mémoire présenté et soutenu publiquement en vue de l'obtention du Diplôme de Professeur de l'Enseignement Secondaire Général deuxième grade (DI.P.E.S. II): Biochimie. Université de Yaoundé I. 80 p.

[8] AFNOR (Association Française pour la Normalisation) (1984) Recueil des normes françaises: Corps Gras, Graines oléagineuses et produits dérivés (3e eds.). AFNOR, 459 p.

[9] Bonnefis, C. (2005) Effets biologiques des peroxydes et approche de la participation des aliments composés à leur apport chez le chien et le chat. Thèse pour obtenir le grade de docteur vétérinaire, Dépôt Universitaire de Mémoires Après Soutenance.

[10] Recueil de normes françaises AFNOR (1993) Corps Gras, Graines Oléagineuses, Produits Dérivés.

[11] AFNOR (Association française de normalisation) (1981-1982) Recueil des normes françaises: Corps Gras, Graines oléagineuses, produits dérivés. 327 p.

[12] R Core Team (2023) R. A. Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

[13] Codex Stan (1999) Norme pour les huiles végétales portant un nom spécifique. 14 p.

[14] Ngando, E.G.F., Mpondo, M.E.A., Dikotto, E.E.L. and Paul, K. (2011) Assessment of the Quality of Crude Palm Oil from Smallholders in Cameroon. *Journal of Stored Products and Postharvest Research*, **2**, 52-58.

[15] Gharby, S., Harhar, H., Bouzoubaa, Z., Asdadi, A., El Yadini, A. and Charrouf, Z. (2015) Chemical Characterization and Oxidative Stability of Seeds and Oil of Sesame Grown in Morocco. *Journal of the Saudi Society of Agricultural Sciences*, **16**, 105-111.

[16] Codex Alimentarius (2015) Norme pour les graisses et les huiles comestibles non visées par des normes individuelles codex.
http://files.eacce.org.ma/pj/1438836905.pdf

[17] Fournier, S., Ay, P., Jannot, C., Okounlola-Biaou, A. and Pédé, E. (2001) La transformation artisanale de l'huile de palme au Bénin et au Nigéria. La Libraire du Cirad.

[18] Gondé, P. and Morin, O. (2012) Optimisation du choix de l'huile en friture industrielle: L'exemple Mc Cain. *Oléagineux, Corps gras, Lipides*, **19**, 96-100.
https://doi.org/10.1051/ocl.2012.0447

[19] Sankara, S., Zio, S., Cisse, H., Gueye, A., Bougma, S. and Savadogo, A. (2024) Evaluation de la qualité des huiles alimentaires utilisées en friture dans la ville de Ouagadougou, Burkina Faso. *International Journal of Biological and Chemical Sciences*, **18**, 1432-1447.

https://doi.org/10.4314/ijbcs.v18i4.18

[20] Novidzro, K.M., Wokpor, K., Fagla, B.A., Koudouvo, K., Dotse, K., Osseyi, E., *et al.* (2019) Etude de quelques paramètres physicochimiques et analyse des éléments minéraux, des pigments chlorophylliens et caroténoïdes de l'huile de graines de *Griffonia simplicifolia*. *International Journal of Biological and Chemical Sciences*, **13**, 2360. https://doi.org/10.4314/ijbcs.v13i4.38

[21] Aïssi, V.M., Soumanou, M.M., Tchobo F.P. and Kiki, D. (2009) Etude comparative de la qualité des huiles végétales alimentaires raffinées en usage au Bénin. *Bulletin d'Informations de la Société Ouest Africaine de Chimie*, **6**, 25-37.

[22] Wolff (1968) Manuel d'analyse des corps gras. Edition Azoulay.

[23] Diatta, T. (1998) Contribution à l'étude de la qualité des corps gras alimentaires commercialisés au Sénégal: les huiles végétales. Thèse pour obtenir le grade de docteur en pharmacie (diplôme d'état). Faculté de médecine, de pharmacie et d'odontostomatologie. Sénégal. Université cheikh Anta Diop de Dakar. 117 p.

[24] Codex Alimentarius (2019) Commission FAO/WHO Food Standards. Standard for Named Vegetable Oils CODEX-STAN 210. FAO/WHO.

[25] Kehaut, A.J.M. and Assa R.R. (2022) Etude de la qualité de l'huile de friture du poisson de garba vendu à Abidjan, Laboratoire de biotechnologie-Agriculture et Valorisation des Ressources Biologiques, Université Félix Houphouët Boigny de cocody (UFHB), UFR Biosciences, Abidjan, Côte d'Ivoire.

[26] Dimić, E., Premović, T. and Takači, A. (2012) Effects of the Contents of Impurities and Seed Hulls on the Quality of Cold-Pressed Sunflower Oil. *Czech Journal of Food Sciences*, **30**, 343-350. https://doi.org/10.17221/179/2011-cjfs

[27] Karleskind, A. (1992) Manuel des Corps Gras. Technique et Documentation—Lavoisier.

[28] Ahouassou, R.H., Agbobatinkpo, P.B., Sossou, C.H. and Sanya E.A. (2018) Analyse des performances techniques des clarificateurs et déshydrateurs d'huile de palme au Benin. *Tropicultra*, **36**, 773-785.

[29] Onifade, D.A. and Bolarinwa, O.O. (2016) Microbiological and Physiochemical Analysis of Palm Oil Sold in Ibadan, Nigeria. *Science and Engineering Perspectives*, **1**, 33-41.

[30] Niaba, K.P.V., Combo, A.M.M., Ekissi, A.C., ESSE, D. and Beugre, G.A.M. (2020) Influence of Storage Type on the Quality Parameters of Industrial and Artisanal Red Palm Oils Produced in Côte d'Ivoire. *International Journal of Food Science and Nutrition*, **5**, 87-91.