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## Some quality parameters of crude palm oil from major markets of Douala, Cameroon

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Palm oil is the major cooking oil in Cameroon, and crude palm oil (CPO) is an essential ingredient of many local recipes. However, the quality of this foodstuff is subject to doubt, considering the very often inadequate conditions of its extraction and storage in the fast growing small holder sector. In order to assess the quality of (CPO) available to Cameroonian consumers, 40 samples of this product were randomly collected in 10 major markets of the city of Douala and assayed through three physico-chemical parameters, namely oil acidity, peroxide value (PV) and moisture content. Results of this study showed that the quality of CPO samples was good regarding PV, as all values were below the 15 meqO<sub>2</sub>/kg maximal limit. However, data from oil acidity determination were cause for concern, as 50% of the samples had values above the 5% acidity maximal limit for CPO. The worst was for moisture content which had all values above the 0.2% maximal limit. Considering that high moisture content inevitably enhances deterioration reactions involved in food spoilage, one can easily conclude that the quality of the CPO samples assessed was quite poor but above all could rapidly undergo further deterioration upon storage.

**Key words:** Oil palm, crude palm oil, food safety, quality, food deterioration.

### INTRODUCTION

With an annual global production equating to about 39% of world production of vegetable oils (oil world, 2011), palm oil has outclassed soybean during the last decade to become the most important oil crop in the world. In Cameroon, palm oil accounts for about 90% of edible oil needs (Hirsch, 1999). Due to long term local eating habits, cheaper cost, and the presence of an important none industrial sector representing about 30% of total local production, palm oil is extensively used in its crude form (crude palm oil or CPO) for food purposes in Cameroon and also throughout Central and West African regions. This can be nutritionally beneficial, as CPO is a rich source of some essential nutrients such as carotenes, tocopherols and tocotrienols. Carotenes

(mainly  $\beta$ -carotenes) are the most important vitamin A precursors in human nutrition, and deficiency of the latter can cause visual disorders. The  $\beta$ -carotene content in CPO is 15 fold higher than in carrot and 300 fold higher than in tomato, making CPO the richest source of this nutrient (Choo, 1994).

Tocopherols and tocotrienols are both precursors of vitamin E which plays important roles in the human reproductive system. The content of these two vitamins in palm oil is partially lost as a result of refining process. It has been reported that refined palm oil (RBD) retain approximately only 70% of the level of vitamin E in CPO, whereas vitamin A is almost entirely destroyed by the refining process (Sambanthamurthi et al., 2000). As a

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result, CPO has been widely used in many developing countries in supplementary feeding programmes (Latham, 1979; Tan et al., 1991; Qureshi et al., 1991; Gopalan et al., 1992; Seshadri, 1996). Many studies have also outlined the potential effect of tocotrienols on the resorption of tumour cells (Carrol et al., 1995; Guthrie et al., 1997a, b).

However, the consumption of CPO can also be detrimental to human beings, as CPO contains some components which are likely to enhance numerous reactions (hydrolysis, oxidation, etc.) involved in the degradation of this product. Moreover, these degradation reactions can also be initiated and/or accentuated by poor transportation and storage conditions of the product as it is generally the case among small holders. The most effective degradation process of CPO is acidification which was already mentioned by Desassis in 1957. Generally, fatty acids are present in oils as part of triacylglycerol molecules. The presence of free fatty acid molecules is an indication of the impairment of the quality of oils, as FFA are liberated from the triacylglycerol molecules under the action of enzymes from the acylglycerol hydrolase family, notably lipases and esterases. Acidification is generally assessed through determination of oil acidity or FFA content which is one of the most important criterion for determining the quality of virgin cooking oils.

Another degradation reaction of CPO regarding food safety is lipid peroxydation. This process involves unsaturated fatty acids moieties which undergo a chain reaction mechanism involving free radicals as intermediates and generating lipid peroxides as end products. The latter undergo additional chain cleavage at the level of the hydroperoxide group to form secondary oxidation products such as short chain aldehydes and products bearing ketone, epoxy or alcohol groups responsible for the rancid smell and taste of the oil. The determination of peroxide value (PV) gives an indication of the level of lipid peroxidation of cooking oils.

Alongside oil acidity and PV, moisture content is also one of the most important criterion for determining the quality of cooking oils and fats regarding food safety, as the presence of residual water is not a concern per se, but water is a catalyst of almost all chemical degradation reactions.

Based on the determination of these physicochemical parameters, previous studies by Ngando et al. (2011) showed that CPO from small holders' extraction sites was of lesser quality as compared to that from industrial oil mills regarding food safety. Considering the fact that about 30% of Cameroon's national production of CPO is provided by small holders, one can assume that the quality of this product which is freely available in local markets is subject to doubt.

The present study aimed to assess the quality (regarding food safety) of CPO available in the major markets of the city of Douala in the Republic of

Cameroon. For this purpose, the three above-mentioned physicochemical parameters were chosen, namely acidity, moisture content and peroxide value. We decided to use them for our study as they were routinely used worldwide for the assessment of the quality of cooking oils.

## MATERIALS AND METHODS

### Collection of palm oil samples

CPO samples were collected in ten major markets of the city of Douala. Markets were chosen so as to provide equitable representation of all the geographical areas of the city. Market 10 is the main market of the city, whereas all the other could be ranged in the same category and be considered as of lesser importance. For each market, four samples were collected at seven days interval among vendors randomly chosen. The samples were collected in 200 ml screw capped glass flasks filled to the maximum, transported at room temperature and processed prior to laboratory analyses according to standard norms applicable in Cameroon (AFNOR, 1988). All samples were analyzed within 24 h after sampling. Additional information was also collected from the vendors regarding the origin of the CPO samples (industrial oil mill or from small holders). One industrial CPO sample collected at the oil mill was also used in this study as control.

### Physicochemical analyses

For each sample, PV, free fatty acids (FFA) and moisture contents were assayed. Peroxide value was determined by titrating a chloroform/acetic acid/saturated KI solution of the oil with an aqueous solution of sodium thiosulfate using starch as colour indicator and expressed in MeqO<sub>2</sub>/kg. For the FFA content, determination was performed by titrating the alcoholic solution of the oil with a 0.1 N solution of sodium hydroxide using phenolphthalein and alkaline blue as colour indicators. The FFA content was expressed as a percent of palmitic acid. Moisture content was determined through the gravimetric method by oven drying oil samples at 105°C to constant weight. All physicochemical analyses were performed according to AFNOR (1988) methods.

### Statistical analysis

Each parameter was determined in triplicate for each sample, and average values for each market were expressed as mean ± SD. Kruskal-Wallis ANOVA were used for multiple comparisons. The Beauvais-Pearson test was used to assess the degree of linear dependence amongst the various parameters assessed.

## RESULTS AND DISCUSSION

Result from Tables 1, 2 and 3 show an important variability for each of the three parameters assessed, with variation coefficients of 49, 59 and 72% for oil acidity, PV and moisture content, respectively. This variability was observed on samples collected within and amongst markets. Broadly, values ranged from 0.64 to 10.28% for oil acidity, 0.4 to 10.89 meq O<sub>2</sub>/kg for PV and 0.2 to 3.6% for moisture content, respectively. No significant correlation was found amongst the three parameters assessed.

**Table 1.** Oil acidity measurements for the 41 samples of the study.

Market	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	Control (oil mill)
Sample 1	10.28	<i>5.14</i>	<i>3.22</i>	6.16	6.6	<i>6.85</i>	<i>6.51</i>	<i>0.64</i>	1.19	<i>1.45</i>	<i>0.55</i>
Sample 2	6.44	<i>3.58</i>	<i>7.35</i>	5.42	5.09	<i>7.27</i>	<i>6.27</i>	<i>5.00</i>	5.46	<i>6.54</i>	
Sample 3	<i>2.08</i>	<i>2.21</i>	<i>1.28</i>	<i>2.38</i>	<i>4.06</i>	<i>2.76</i>	<i>1.83</i>	<i>1.06</i>	<i>4.65</i>	<i>4.98</i>	
Sample 4	4.65	<i>5.36</i>	<i>5.8</i>	<i>4.53</i>	<i>6.52</i>	<i>5.59</i>	<i>1.37</i>	<i>6.01</i>	<i>4.91</i>	<i>2.63</i>	
Mean ± SD	<i>5.86 ± 3.45</i>	<i>4.07 ± 1.47</i>	<i>4.41 ± 2.69</i>	<i>4.62 ± 1.64</i>	<i>5.57 ± 1.22</i>	<i>5.62 ± 2.03</i>	<i>4 ± 2.77</i>	<i>3.18 ± 2.72</i>	<i>4.05 ± 1.94</i>	<i>3.90 ± 2.29</i>	<i>0.55</i>

Acidity was determined by titration with 0.1 N NaOH solution and expressed as percentage palmitic acid. Samples from industrial oil mills (according to information from vendors) are in italics. The control sample was collected directly at the mill.

**Table 2.** Peroxide value (PV) measurements for the 41 samples of the study.

Markets	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	Control (oil mill)
Sample 1	0.4	<i>1.31</i>	<i>3.18</i>	2.88	3.56	<i>2.63</i>	<i>9.57</i>	<i>2.99</i>	<i>2.22</i>	<i>9.76</i>	<i>1.11</i>
Sample 2	4.79	<i>4.20</i>	<i>5.61</i>	2.74	5.11	<i>4.47</i>	<i>5.71</i>	<i>0.92</i>	<i>1.25</i>	<i>1.57</i>	
Sample 3	<i>2.77</i>	<i>6.5</i>	<i>5.99</i>	<i>7.7</i>	<i>5.84</i>	<i>3.42</i>	<i>5.42</i>	<i>3.37</i>	<i>3.28</i>	<i>6.31</i>	
Sample 4	1.31	<i>5.22</i>	<i>5.26</i>	<i>8.87</i>	<i>4.61</i>	<i>5.75</i>	<i>1.3</i>	<i>3.45</i>	<i>1.13</i>	<i>10.89</i>	
Mean ± SD	<i>2.32 ± 1.92</i>	<i>4.31 ± 2.21</i>	<i>5.01 ± 1.26</i>	<i>5.55 ± 3.2</i>	<i>4.78 ± 0.96</i>	<i>4.07 ± 1.35</i>	<i>5.50 ± 3.38</i>	<i>2.68 ± 1.19</i>	<i>1.97 ± 1</i>	<i>7.13 ± 4.19</i>	<i>1.11</i>

PV was determined by titration with 0.002 N sodium thiosulfate solution and expressed in Meq O<sub>2</sub>/kg. Samples from industrial oil mills (according to information from vendors) are in italics. The control sample was collected directly at the mill.

**Table 3.** Moisture content determination for the 41 samples of the study.

Markets	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	Control (Oil mill)
Sample 1	0.26	<i>0.33</i>	<i>0.27</i>	0.40	0.86	<i>0.60</i>	0.20	<i>0.20</i>	1.46	<i>0.53</i>	<i>0.067</i>
Sample 2	0.80	<i>0.60</i>	<i>0.47</i>	0.73	0.20	<i>1.07</i>	<i>0.27</i>	<i>0.20</i>	0.33	<i>1.27</i>	
Sample 3	<i>0.73</i>	1.40	0.93	<i>1.27</i>	<i>0.73</i>	1.47	<i>1.53</i>	<i>0.53</i>	<i>1.33</i>	<i>1.47</i>	
Sample 4	0.27	<i>1.06</i>	<i>1.26</i>	1.40	0.73	<i>1.33</i>	0.20	<i>0.73</i>	0.20	<i>3.06</i>	
Mean ± SD	<i>0.52 ± 0.29</i>	<i>0.85 ± 0.48</i>	<i>0.73 ± 0.45</i>	<i>0.95 ± 0.47</i>	<i>0.63 ± 0.29</i>	<i>1.12 ± 0.38</i>	<i>0.55 ± 0.65</i>	<i>0.42 ± 0.26</i>	<i>0.83 ± 0.66</i>	<i>1.58 ± 1.06</i>	<i>0.067</i>

Moisture content was determined through the gravimetric method by oven drying oil samples at 105°C to constant weight and expressed as percentage. Samples from industrial oil mills (according to information from vendors) are in italics. The control sample was collected directly at the mill.

**Oil acidity**

Regarding oil acidity (Table 1), the highest single value (10.28%) was recorded on a sample from the market 1, as well as the highest average value (5.86%). On the other hand, the lowest single

value (0.64%) was noticed in a sample from market 8 as well as the lowest average value (3.18%). From the 40 samples assessed, 20 had oil acidity values above the 5% maximal limit allowed for crude palm oil samples (Codex Alimentarius/FAO/WHO norms, 2011), but only 3

of the 10 markets assessed had mean values above that maximal limit. Markets 5 and 6 recorded the highest percent of poor quality samples (3 out of 4), thus appearing as the most unsafe regarding oil acidity. Meanwhile markets 8, 9 and 10 also appeared as the ones with the

lowest percentage of poor quality samples (1 out of 4).

These results also show that values above the 5% norm were recorded in all the 10 markets assessed, and ANOVA tests showed no significant difference among mean values from different markets, thus confirming the overall poor quality of CPO sold in Douala markets regarding this parameter. FFAs are liberated from the triacylglycerol molecules under the action of enzymes from the acylglycerol hydrolase family, notably lipases and esterases.

Many studies have pointed out the presence of a very active endogenous lipase in the mesocarp of the fruit of the oil palm (Desassis, 1957; Abigor et al., 1985; Henderson and Osborne, 1990; Sambanthamurthi et al., 1995; Ngando et al., 2006). This lipase is activated in the fruit at maturity upon wounding and/or bruising and is responsible for the hydrolysis of triglycerides and the liberation of FFA. In order to limit the action of the lipase, fresh fruit bunches (FFB) must be processed rapidly after harvest. This is the case in industrial oil mills where the harvested FFB are generally steam sterilized rapidly or at the very worst less than two days after harvest so as to inactivate the lipase, thus limiting subsequent FFA accumulation in the resultant CPO. These facts are confirmed in our study by data of the control sample from industrial oil mill (SOCAPALM) whose FFA content is 0.55%, that is, far below the overall mean value of all the samples assessed (4.53%). These results are in accordance with those of Ngando et al. (2011) who already pointed out the poor quality of CPO produced by smallholders in Cameroon regarding oil acidity. Though CPO from industrial oil mills is of better quality, it is mostly dedicated to oil refineries and soap factories. As a result, most of the CPO sold in markets and dedicated to local consumption is produced by smallholders, as recent estimates consider the latter to provide about 30% of Cameroon national CPO production (Hoyle and Levang, 2012). Even in case CPO from industrial oil mills is destined to markets in Douala, poor packaging, transport and storage conditions of the product in force among smallholders negatively impact the quality and contribute to enhance acidity.

### Peroxide value

As for PV (Table 2), the highest value (10.89 meq/kg) was recorded in a sample from market 10, whereas the lowest (0.4 meq/kg) belong to market 1. The highest average value was also for the market 10 (7.13 meq/kg), and the lowest for market 9 (1.97 meq/kg). The overall quality of the CPO samples assessed within this study was quite good regarding this parameter, as all the forty samples had PV below the 15 meq/kg maximal limit for cold pressed and virgin oils (Codex Alimentarius/FAO/WHO, 2011). The average mean value for the 40 samples of the study (4.34 meq/kg) was also below this 15 meq/kg maximal limit. ANOVA tests showed

no significant difference among mean values from different markets. PV is used to assess the quality of cooking oils and fats through the measurement of the amount of lipid peroxides and hydroperoxides formed during the initial stages of oxidative degradation and thus, estimate to which extent spoilage of the oil has advanced. This parameter was chosen for our study as it is routinely used during food security controls to assess the quality of cooking oils. However, these peroxides are very unstable transitory products, and the determination of PV might not necessarily provide a correct estimate of the level of peroxidation, as it gives accurate information on the amount of peroxides and hydroperoxides but not on the secondary oxidation products.

Moreover, as all chemical processes involving chain reaction, peroxidation is a very dynamic process, and the amount of peroxides might change considerably within a short period of time in favourable conditions such as the presence of oxygen, sunlight, metallic ions or high moisture content. In this regard, the absence of samples with high PV in our study must be interpreted with care, as all the samples had high moisture content which is an enhancing factor for peroxidation. From another point of view, the overall low PV of CPO samples in our study is in the nature of things, as this oil is known to have a high oxidative stability. Thanks to its fatty acid composition with a balanced ratio of polyunsaturated/saturated fatty acids (51:49 w/w), CPO is less susceptible to oxidation and is widely used for frying of food (Matthaüs, 2007). Beside these visible harmful effects on the sensory quality of the oil, peroxidation also makes the oil dangerous for human health, as the free radicals generated by this process are proven to be carcinogenic (Rossel, 1999).

### Moisture content

The highest value for moisture content (Table 3) was recorded in a sample from market 10 (3.06%), as well as the highest group average (1.58%). All the samples in our study had values above the 0.2% maximal limit for volatile matters at 105°C in oils and fats (Codex Alimentarius/FAO/WHO, 2011), and the overall average mean was up to 0.82%. ANOVA tests showed no significant difference among mean values from different markets. Water is an unusual component of oils and fats, as the two are non-miscible and the presence of water can be compatible only at very low proportions. However, even very low moisture contents can prove to be harmful to oils and fats products, as the presence of residual water is not a concern per se, but water is a catalyst of almost all chemical degradation reactions. In this regard, assaying the moisture content generally provides a good indication of the level of the other quality parameters and can also prove very helpful to forecast subsequent variation upon storage. As said earlier, the presence of high moisture content enhances oxidative degradation

and thus PV. However, the harmful effect of high moisture content on CPO is more effective regarding oil acidity.

Though FFA accumulation in CPO is principally due to the action of the endogenous lipase of the mesocarp of the fruit of the oil palm, oil acidity can still be enhanced by other factors well after the lipase have been inactivated by the sterilization step during the extraction process. Thus, FFA can be formed in CPO through the action of contaminating lipases from microorganisms (Hiol et al., 1999; Houria et al., 2002; Tagoe et al., 2012). Moreover, in the presence of moisture content above the critical limit of 0.2%, FFA are also formed by a chemical process called autocatalytic hydrolysis where the FFA moieties initially present act as catalysts and highly enhance subsequent formation of other FFA (Loncin, 1952; 1956; 1965; Loncin and Jacobsberg, 1965; Chooi et al., 2006). Therefore, it is very important for CPO samples to maintain moisture content below this 0.2% critical limit, as the action of contaminating microbial lipases and autocatalytic hydrolysis is then very unlikely. In this regard, data from our study raised a real concern for CPO available in Douala markets regarding food safety, as all the samples assayed were above the 0.2% moisture content maximal limit. In such conditions, it is likely that these CPO samples already improper for consumption rapidly undergo additional degradation during storage.

Previous studies have demonstrated that oil acidification and peroxidation processes are significantly enhanced by high moisture content of CPO samples at the outset (Ngando et al., 2011). Analyses showed there were no differences amongst samples for the three parameters assessed regarding the size of the market or information provided by the vendor on the origin, thus strongly suggesting that the CPO (randomly) sampled in our study were probably all processed by smallholders, as the control sample from an industrial oil mill had moisture content far below the 0.2% maximal limit.

Data from our study were generally in accordance with those obtained by Aletor et al. (1990), Onwuka and Akaerue (2006) and Orji and Mbata (2008) in similar studies on Nigerian crude palm oil from small holders. For all the three parameters assessed, the overall important variability observed on data within and between markets is a clear indication of the volatility of quality indicators of CPO from small holders. This could be explained by the fact that the small holding sector is very fragmented, and CPO stockists generally have to collect from numerous suppliers in order to build up substantial stock.

## Conclusion

Results from this study provided clear indication of the quality of CPO available in the markets of the city of Douala regarding food safety. It appeared that oil acidity

was a real concern, as almost 50% of the samples assayed did not comply with recognized norms. On the other hand, all the samples assayed were in compliance with norms regarding PV, thus confirming the good oxidative stability of CPO. However, the most serious concern was raised by the assessment of moisture content, as all samples had values above the maximal limit and both oil acidity and PV are enhanced by high moisture content. These results clearly point out the overall poor quality of CPO available in Douala markets and the need to raise public awareness on the existence of norms related to food products as well as the necessity of CPO to comply with them. As CPO is a major component of local diets in Cameroon, and considering the increasing proportion of national production allocated to non-industrial oil extraction, it is obvious that despite its beneficial nutritional properties, this poor quality CPO may rapidly become a real concern regarding food safety.

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