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Full Length Research Paper

Assessment of the quality of crude palm oil from smallholders in Cameroon

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Oil palm is the highest oil producing plant, with an average yield of 3.5 tons of oil/ha/year. In 2006, palm oil became the world's most important edible oil with 37 million tons produced, accounting for 25% of the total oils and fats production. In Cameroon, palm oil meets 80% of total edible oil needs and it is estimated that 30% of crude palm oil (CPO) production is provided by none industrial oil mills. However, previous studies tend to demonstrate that, there was a problem with the consumption of CPO with respect to food safety. In the present study, the effect of processing methods and storage time on some physico-chemical parameters of Cameroonian CPO was assayed. Results showed that, lipid peroxidation and oil acidity significantly increased in palm oil samples from none industrial oil mills during the first four weeks of storage; thus making them unfit for human consumption. Both processes were enhanced by moisture and impurity levels of the oil at the outset above 0.1 and 0.01% respectively. Despite its many other benefic properties, this is a clear indication that, CPO from inappropriate extraction processes is becoming a real problem in sub-Saharan African countries regarding food safety.

Key words: Food safety, oil acidity, peroxide value, crude palm oil, FFA, oil palm.

INTRODUCTION

Oil palm is by far the highest oil producing plant, with an average of 3.5 tons of oil/ha/year. Extracted from the mesocarp of the fruit, crude palm oil (usually referred to as CPO) represents 95% of the total oil production of the oil palm which also provides palm kernel oil. Since 2006, palm oil has become the world's most important edible oil with about 37 million tons produced that year, representing 25% of the total oils and fats production (Oil world Ista GmbH Mielke, 2007). Unlike palm kernel oil which has wide applications in the oleochemical industry, palm oil is used mainly for edible purposes. It is reported to be the richest natural source of carotenoids in terms of retinol (provitamin A) equivalent (Vaughan, 1990; May, 1994). In some tropical countries, such as Cameroon, it contributes up to 80% of the total edible oil needs (Hirsch, 1999). Following the drop in the early nineties of the prices of cocoa and coffee which were then the major commercial farming crops in Cameroon, many smallholders turned out planting oil palm. This fact is clearly illustrated by the amount of germinated oil palm seeds purchased by small and medium size farmers at the Centre for oil palm research of La Dibamba (Cameroon) which rose from 20% of the total production in 1996 to an average of 60% during the past ten years. From these data, it is estimated that about 5, 000 ha of oil palm were planted by small and medium size farmers each year during the last decade, making a total of about 90, 000 ha for the none industrial palm grove in Cameroon (Bakoume and Mahbob, 2006).

However, this rush to oil palm growing also raised difficulties, mainly with regard to the quality of palm oil produced by these smallholders. For those who are located in the neighbourhood of industrial oil mills, fresh fruit bunches (FFB) are delivered to the latter for processing. But in many cases, palm plantations are very

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far from the industrial oil mills, small and medium scale farmers have to process the FFB themselves. In industrial oil palm estates, FFB are harvested when the fruits are at optimum ripeness and handled with care to avoid bruising. The FFB are quickly sterilized, threshed and digested. CPO is extracted from the digested fruits hydraulically or using a screw press, clarified and dried. There are some subtle differences between oil extraction methods used by smallholders and the process in force in industrial oil mills. Once harvested, FFB are allowed to ferment for a time (1 to 6 days) at ambient temperature, so as to allow easy separation of fruits from the bunch. The fruits are then boiled for some hours. In the traditional method, the boiled fruits are pounded into a pulp using a mortar and pestle or trampled underfoot, and the oil is separated by adding water and skimming it off. In many modern methods, manual or motorized screw presses are used to squeeze out the oil from boiled fruits. The oil is finally heated to remove the residual water. It is estimated that none industrial oil mills contributes 30% to Cameroon's national crude palm oil production.

In this regard, and owing to the fact that it is a perishable food item, none industrial crude palm oil must fulfill the requirements of quality applicable to all oils and fats dedicated to human consumption. CPO from the traditional oil extraction method is highly sought after in local markets, due to its better sensory qualities (red color, taste, smell) which make it an irreplaceable ingredient of many local recipes. However, when some physico-chemical parameters generally used as indicators of the quality of dietary oils and fats regarding food safety were assayed, it was demonstrated by some authors that CPO samples from the traditional oil extraction methods were of lesser quality compared to the CPO from industrial oil mills (Coursey, 1966; Broadbent and Kuku, 1977; Aletor et al., 1990). In the present study, we are intending to assay through chemical analyses the quality of CPO produced by smallholders in the main oil palm growing areas of Cameroon. The effect of processing methods and storage on these chemical parameters will also be discussed.

MATERIALS AND METHODS

Collection of oil samples

Palm oil samples were collected in four oil palm growing areas of the South-west and Littoral Regions of Cameroon. This sampling was performed between January and April, what corresponds to the peak season for FFB production. For samples from group I, palm oil was extracted by the traditional method, with the boiled fruits being trampled underfoot. For samples from groups II, III and IV, palm oil was extracted by improved processes using manual or motorized screw presses. Samples from the control (C) were obtained from an industrial oil mill (SOCAPALM). The three oil extraction processes involved are summarized in the flow charts in Figure 1. All samples were collected in 0.5 L PVC screw capped bottles filled to the maximum and closed hermetically. The samples were kept at ambient temperature, and transported to the laboratory for analyses within 1 to 3 days after collection.

Chemical analyses

For each sample, moisture and FFA content were assayed, alongside peroxide value and impurity level. The FFA content was determined by titrating the alcoholic solution of the oils with a 0.1 N solution of sodium hydroxide using phenolphthalein and alkaline blue as indicators. The FFA content was then expressed as a percent of palmitic acid, the major fatty acid in palm oil. The peroxide value was determined by titrating chloroform/glacial acetic acid/saturated KI solution of the oil with an aqueous solution of sodium thiosulphate using starch as indicator. Moisture content was determined by the gravimetric method of air-oven drying to constant weight at 105°C. For the assessment of the impurity level, oil samples were mixed with an excess of hexane then filtrated. The residue on the filter was then washed with hexane and oven dried to constant weight at 105°C. All chemical analyses were determined by methods of the Association Française de Normalisation (AFNOR, 1988).

Effect of storage on the chemical parameters of palm oil

For this purpose, two chemical parameters were chosen, namely oil acidity and peroxide value. Oil samples were assessed every two weeks, carefully locked again and stored at room temperature.

RESULTS

The FFA content, peroxide value, moisture and impurity level of palm oil samples from different areas and/or extraction processes are illustrated in Table 1. There is an important variability between samples from different groups and within groups for all parameters assessed. The highest values for FFA content and peroxide value were recorded for samples from group III. For moisture content, the highest values were recorded for samples from groups II and III, whereas group IV samples had the highest values regarding the impurity level. Except for the peroxide value, the industrial palm oil sample used as control showed the lowest value for all the parameters assessed.

The effect of storage time on FFA content is shown by Figure 2. A continuous increase of the FFA content was recorded for all groups of samples during the first 4 weeks of storage. The highest rate was attributed to samples from group I which increased by 110% within this period, moving from 6.4 to 13.4% FFA content. On the other hand, the control sample increased by only 15% within the same period. The FFA content subsequently decreased significantly between the fourth and the sixth week of storage for all groups of samples, and for group I samples the decrease even continued during the sixth and eighth weeks. No significant variations were noticed during the sixth and the tenth weeks of storage (eighth and tenth weeks respectively for samples from group I).

The effect of storage time on the peroxide value of

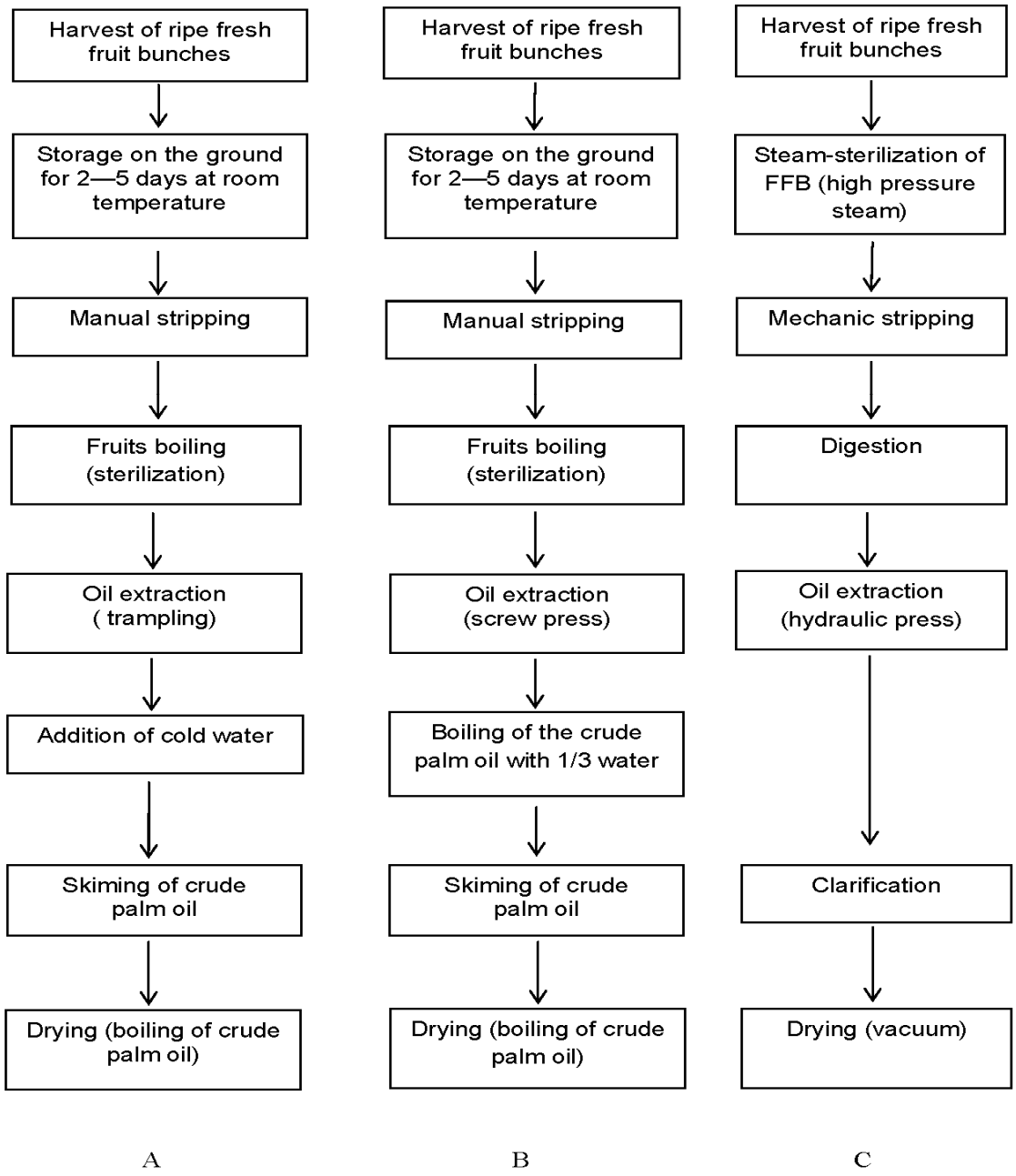

Figure 1. Flow charts of the traditional (A), semi-mechanized (B) and industrial (C) crude palm oil extraction processes from which samples of this study were obtained.

Table 1. Effects of extraction processes on chemical parameters of crude palm oil samples.

	Extraction process	Number of samples	FFA (%)	Peroxide value (Meq O_2/kg)	Moisture (%)	Impurity level (%)
Group I	Traditional	7	6.39 ± 3.20	2.07 ± 0.91	0.22 ± 0.04	0.11 ± 0.09
Group II	Semi-mechanic	4	7.72 ± 2.35	2.87 ± 0.91	0.32 ± 0.15	0.05 ± 0.03
Group III	Semi-mechanic	9	10.26 ± 4.56	5.71 ± 4.45	0.30 ± 0.05	0.08 ± 0.07
Group IV	Semi-mechanic	7	5.00 ± 1.91	1.48 ± 0.55	0.23 ± 0.05	0.31 ± 0.02
Control (C)	Industrial	1	4.71 ± 0.60	2.67 ± 0.60	0.08 ± 0.02	0.01 ± 0.00

Values are expressed as mean of a triplicate ± standard deviation.

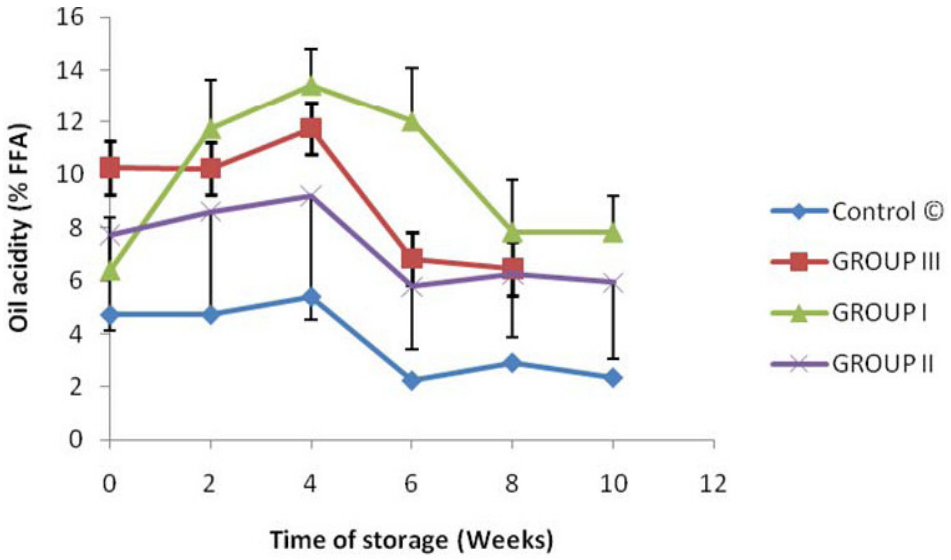

Figure 2. Changes in oil acidity during storage of crude palm oil samples from the traditional (group I), semi-mechanized (groups II and III) and industrial (Control C) oil extraction processes.

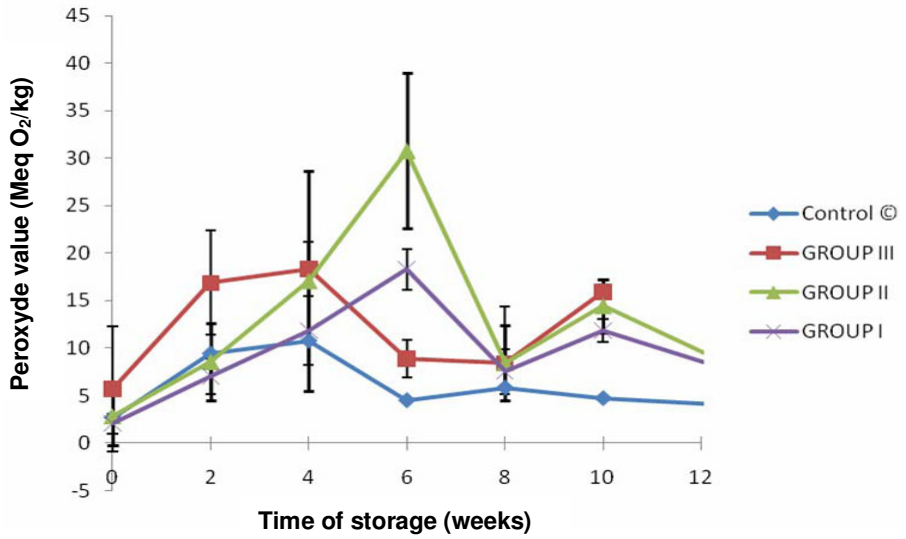

Figure 3. Changes in peroxide value during storage of crude palm oil samples from the traditional (group I), semi-mechanized (groups II and III) and industrial (Control C) oil extraction processes.

palm oil samples from different groups is shown by Figure 3. As it was the case for FFA content, a continuous increase was observed for all groups of samples during the first four weeks of storage. But unlike the FFA content where the increase was only two fold for the highest value, peroxide values increased by three to six folds within the same period for all groups of samples. For samples from groups II and III, peroxide value continued to increase between the fourth and sixth week, and final ten and eight folds increases respectively were recorded within the first six weeks of storage. A significant decrease was subsequently recorded between the fourth and the sixth weeks (sixth and eighth weeks respectively) for the control and group I samples (group II and III samples respectively). Thereafter, no significant variations were observed during the last weeks of storage.

DISCUSSION

FFA content is the most used criterion for determining the

quality of palm oil, as it must not exceed 5% (expressed as palmitic acid) according to Codex Alimentarius/ FAO/WHO norms (2005). Fatty acids are generally present in oils as part of triacylglycerol molecules. The presence of free fatty acids moieties in palm oil is an indication of the impairment of oil quality. This process is essentially attributed to an active lipase present in the mesocarp of the oil palm fruit and which is responsible for the hydrolysis of triacylglycerols (Henderson and Osborne, 1991; Sambanthamurthi et al., 1995; Ngando et al., 2006). The lipase is activated at maturity upon bruising and/or wounding of the fruit. According to Desassis (1957), 15 min are enough to hydrolyze 40% of the triacylglycerols of a bruised ripe fruit. However, this endogenous lipase activity was found to be very variable, and some lines with very low lipase activity were identified. The crude palm oil extracted from the fruits of these low lipase activity lines also showed a low FFA/oil acidity content (Ngando et al., 2008).

FFA can also be generated to some extent by contaminating lipases from microorganisms (Hiol et al., 1999; Houria et al., 2002). In order to limit lipase activity, fresh fruit bunches must be handled gently and above all, processed rapidly after harvest. For all the groups of samples, values were above the 5% limit, regarding the FFA content except for the control sample from industrial oil mill. This is not surprising, as only industrial oil mills generally process FFB shortly after harvest. The steam-sterilization of FFB at high temperature rapidly inactivates the lipase, thus limiting subsequent FFA accumulation in palm oil from industrial oil mills. For the traditional and semi-mechanized processes (Figure 1), a prior fermentation of FFB is usually carried out, in order to enable fruits easily detach from the bunch. In some cases, the harvested FFB can be kept at room temperature for one week or more before they are processed. The harmful effect of fermentation is the continuous build up of FFA in the mesocarp of the fruit under the action of the lipase. Once the fruits are processed, the lipase is no more active, but the FFA content of the resulting palm oil may also increase during storage as a result of autocatalytic hydrolysis. In that case, FFA acts as catalysts for the reaction between triacylglycerols and water to generate more FFA. Results from Figure 2 clearly illustrates this process, as the sharp increase of the FFA content of palm oil samples during the first four weeks of storage can be attributed to autocatalytic hydrolysis. Figure 2 also clearly showed that, the FFA content of the control sample from the industrial oil mill recorded the lowest increase during the first four weeks of storage, as this sample also had the lowest FFA and moisture contents at the outset. A positive correlation (0.76) was found between FFA and moisture content data from Table 1. Therefore, it is imperative to limit FFA and moisture contents of CPO prior to long term storage, as autocatalytic hydrolysis is unlikely to occur or is very limited below the 0.1% moisture content limit recommended by Codex Alimentarius/FAO/WHO norms. Data from Figure 2 also indicate a sharp decrease of FFA content between the fourth and eighth weeks of storage. This does not necessarily express a real decrease, as unsaturated FFA may undergo subsequent chemical reactions such as peroxidation and generate secondary products which could not be detected while assaying oil acidity. FFA are more likely to undergo peroxidation reaction than fatty acids within the triacylglycerol molecule, and an increase of the FFA content may also enhance the peroxidation process.

Another important parameter used to assess the quality of palm oil is the peroxide value which is an indicator of the level of lipid peroxidation or oxidative degradation. In this process involving unsaturated fatty acids, specially reactive hydrogen atoms from methylene ($-CH_2-$) groups adjacent to double bonds undergo a chain reaction mechanism involving free radicals as intermediates and generating lipid peroxides as end products. These lipid peroxides later 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. Peroxide value is used to assess the stability or rancidity of fats by measuring the amount of lipid peroxides and hydroperoxides formed during the initial stages of oxidation and thus, estimate to which extent spoilage of a dietary oil (expressed by the level of rancidity) has advanced. 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). All the groups of samples in Table 1 met with the Codex Alimentarius/FAO/WHO norms which recommend a maximum peroxide value of 10 meq O_2/kg palm oil.

However, this was no longer the case after the first four weeks of storage, as sharp increases were recorded for almost all groups of samples except for the control from industrial oil mill. The means recorded at this stage for the 3 groups of samples (11.84, 17.08 and 18.35 meq O_2/kg for group I, II and III respectively) were above the Codex Alimentarius/ FAO/WHO 10 meq O_2/kg limit. Peak values obtained after 6 weeks of storage for samples from group II were even 3 fold higher than this recommended norm. Oxidation may be significantly enhanced by the impurity level, as components such as resins, hydroxyl-fatty acids, carbohydrates and oxidized fatty acids are quantified among impurities (AFNOR, 1988). In this regard, the maximum value recommended by FAO/WHO norms for insoluble impurities is 0.01% (w/w). Thus, although samples from groups I and II had almost the same peroxide value as the control (Table 1), they suffered higher increases during the first four weeks of storage, probably because of their higher impurity

levels. The decrease of peroxide value observed between the fourth and eighth weeks of storage may not necessarily reflect a decrease of the amount of hydroperoxides formed, as the latter are transitory intermediates which undergo additional chain cleavage to generate secondary oxidation products as stated earlier. DeRouchey et al. (2000) showed that, primary and secondary oxidation products appeared during fat oxidation following Gaussian curves overlapping each other. In fact, rancidity is a qualitative state that is not chemically defined and is difficult to quantify. As a result, numerous methods have been developed to assess the amount of various intermediates or products of oxidation, of which the Peroxide Value assay.

However, these products are most of the time unstable, making it difficult to estimate the correct level of fat oxidation at a given period of time. Peroxide Value can only measure the amount of hydroperoxides formed but is not appropriate to quantify the amount of secondary oxidative products such as short chain aldehydes, ketones and epoxydes. It can therefore measure only current or recent oxidation. A second chemical parameter named Anisidine Value is used to provide information on oxidative history of a fat, as it is appropriate to quantify secondary oxidative products essentially made up of high molecular weight saturated and unsaturated carbonyl compounds. The correct estimate of the oxidative process of dietary oils within a long period of storage can be given by a parameter known as Total Oxidation or TOTOX value which can be calculated based on Peroxide Value (PV) and Anisidine Value (AV) using the equation:

$$TOTOX = 2PV + AV.$$

Thus, TOTOX value is a quantification of the precursor non volatile hydroperoxides present in the oil plus any further secondary oxidation compound formed during storage. However, the use of the sole peroxide value in this study is fully justified, as it was proven sufficient to monitor the significant increases above authorized limits in peroxydation levels of CPO samples, after only four weeks of storage. Data from Table 1 were generally in accordance with those obtained by Aletor et al. (1990) and Onwuka and Akaerue (2006) in similar studies on the influence of extraction processes on Nigerian crude palm oil.

Conclusion

Our results showed that, peroxide value and FFA content may significantly increase in none industrially processed crude palm oil samples from smallholders in Cameroon, during the first weeks of storage. Both processes are enhanced by high moisture and impurity levels of the oil at the outset, as it was demonstrated that oils with low moisture and impurity levels suffered very slight changes. Considering that this non-industrial palm oil may take at least one week or in some cases several months to move from the extraction site to the market and finally to the consumer, it is likely that, a significant increase of peroxide value and FFA content may occur during this period, thus making the oil unsuitable for human consumption.

In this regard, peroxide value and oil acidity are very useful indices to control dietary oils safety and quality. Given that crude palm oil is a major ingredient of many recipes in sub-Saharan Africa, this is a clear indication that palm oil from smallholders may become a real problem in these countries regarding food safety if nothing is done, despite its many other benefic properties.

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