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Changes occurring in quality indices during storage of adulterated red palm oil

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Abstract
Changes occurring in free fatty acid (FFA), peroxide value (PV), iodine value (IV) and carotene content (CC) during storage of adulterated crude palm oil (ACPO) under environmental conditions were studied for six months, at one month intervals. Unadulterated crude palm oil was also subjected to storage under identical conditions, and served as control. Increases in FFA and PV ranged from 0.66-1.07% and 0.46-1.65%; and 3.6-15.0 meq/kg and 2.0-8.6 meq/kg for the control and ACPO respectively, while decreases in IV and CC ranged from 55.6-49.3 gI_2/100g and 55.2-51.0 gI_2/100g; and 548-450 µg/g and 693-550 µg/g for the control and ACPO respectively. PV and IV of control showed faster rates of change than those of ACPO, suggesting there was faster oxidative breakdown in this sample than in ACPO during storage; while greater rate of change in FFA was observed for ACPO, indicating that hydrolytic breakdown was faster in ACPO. However, sensory evaluation revealed that ACPO lost its colour stability within 2 months of storage, and its aroma stability within 1 month; while the control maintained its colour and aroma stability and was preferred to ACPO by the panelists throughout the storage period studied.

Keywords: Red palm oil; Quality indices; Adulteration; Red dye; Storage stability; Sensory attributes

1. Introduction
The oil Palm (*Elaeis guinensis*) is West Africa's most important oil producing plant. The fruit produces two distinct types of oil: orange-red crude palm oil which is extracted from the mesocarp and brownish yellow crude palm kernel oil extracted from the seeds (kernel). The former consists of mainly palmitic and oleic acids and the latter of mainly lauric acid. Both oils are important in the world trade. The high level of saturated fatty acid palmitic, renders palm oil a viscous semi-solid consistency at tropical ambient and a solid fat in temperate climates. Palm oil and its fractions (stearin and olein) are widely used for direct blending with other oils for improved oxidative stability and functionality [1] or are interesterified with other oils to meet the *trans*-free fat requirements of the food industry [2]. Crude palm oil (CPO) is the richest natural source of carotenoids and tocotrienols. Carotenes, which impart the distinctive orange-red color to palm oil, together with tocopherols contribute to the stability and nutritional value of the oil. To a great extent these and other minor constituents determine the quality characteristics of palm oil [3]. The main carotenes present in CPO are β-carotene (56%) and α-carotene (35%), both of which are provitamin A [2]. the compound acts as an important substance that is needed by the body to further convert into vitamin A. Besides their provitamin A activity, carotene is a good singlet oxygen quencher and minimizes or prevents photosensitized oxidation Type II [4].
Palm oil is an important vegetable oil which has an increasing consumer interest in tropical West Africa. In Nigeria, there is a widening gap between consumption (demand) and production (supply) with demand increasing at a faster rate than supply. This trend has also witnessed a rise in adulteration of crude palm oil, with the primary aim of increasing the quantity of the oil for maximum profit. The adulterants reportedly used include extracts from carrot and papaya, natural potash and red dye from leaf sheath of *Sorghum bicolor*; with potash and red dye being the most common adulterants due to their abundance and low cost.
In a previous study [5] it was reported that CPO can be adulterated with red dye from the leaf sheath of *Sorghum bicolor* and that the adulterated oil can remain unnoticed by unsuspecting consumers for a period of up to 30 days. In the present study, changes in some quality and sensory parameters of CPO adulterated with red dye from the leaf sheath of S*orghum bicolor* were studied over a 6-month storage period under environmental conditions.

2. Materials and Methods
2.1 Sample Preparation
To assure the absence of adulterant, the crude palm oil used in this study was extracted in the Lab from freshly harvested ripe palm fruits of Dura variety. The fruits as well as the red dye used as adulterant were purchased from an open market in Abakaliki. CPO was extracted using the traditional technique describe by Okogeri and Otika [6]. Fresh palm fruits were parboiled in a cooking pot (to prevent enzymatic spoilage and to soften fruits mesocarp for easy pounding) and then pounded using wooden pestle and mortar until pulp and nuts were obtained. The nuts (palm kernels) were removed and the pulp manually squeezed to obtain a red viscous fluid (oil, fiber, water, impurities),which was heated for about 30 minutes for traces of water to evaporate, and finally sieved using metal basket to obtain a clear red palm oil.

2.2 Adulteration of Crude Palm Oil
Exactly 40g of the freshly processed CPO was weighed into 100ml transparent plastic bottles and warmed in a water bath set at 45ºC to decrease oil's viscosity. Then to each of the bottles, an equal amount (40g) of 0.25% dye solution was added [5]. Samples without adulterant served as control. Both the adulterated samples and control were agitated, capped and stored on the shelves of the laboratory, exposing them to direct

sunlight. At 1-month intervals, samples were withdrawn from storage and evaluated for quality (FFA, PV, IV and CC) and sensory (appearance and aroma) characteristics. Enough samples were used and no sample was subjected to further storage once withdrawn for analyses.

2.3 Analysis of Samples

Free fatty acid, Peroxide value and Iodine value, were determined according to AOCS Official Methods Ca 5a-40, Cd 8b-90, and Cd 1d-92 respectively [7]. Carotene content was determined spectrophotometrically, according to the method described by Prasanth and Gopala [8]. Exactly 1g of adulterated and unadulterated crude palm oil samples were mixed with 10mL acetone, after which 1mL aliquot was further diluted using 10mL acetone. Absorbance was measured at 446nm using a UV/vis spectrophotometer (Spectronic 2D, USA). All reagents were of analytical grade and purchased from Merck (Darmstadt, Germany).

2.4 Sensory Evaluation

Fifteen semi-trained panelists were selected from students of the Department of Food Science and Technology, Ebonyi State University, Abakaliki. Adulterated and unadulterated crude palm oils were evaluated by rating on a 9-point hedonic scale, where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely, according to acceptability of appearance and aroma. Evaluation of sensory attributes of samples was carried out based on the recommendations described by Malcolmson [9].

2.5 Statistical Analysis

Regression analysis was carried out using Microsoft Excel 2007 to compare the rates of changes occurring in quality parameters of the unadulterated (control) and adulterated samples during storage.

3. Result and Discussion

3.1 Initial Oil Quality

The initial quality characteristics of the fresh palm oil sample used in this study (control) alongside sample adulterated with 25% red dye solution are shown in table 1. FFA which is an important trading quality parameter, as it indicates the level of deterioration, recorded values of 0.66 and 0.46% for the control and ACPO respectively, suggesting that the fruits from which the samples were obtained, were harvested at their right ripening stage, thus avoiding lipase activity which leads to increase in FFA.

Table 1: Initial characteristics of unadulterated and adulterated samples[a]

Parameter	Control	ACPO
FFA (%)	0.66	0.46
PV (meq/kg)	3.60	2.0
IV (gI_2/100g)	55.60	55.10
Carotene (µg/g)	548	693
Colour[b]	Orange-red	Bright orange-red

[a] Values are means of duplicate analysis
[b] Colour was evaluated by visual inspection.

Although the acidity of commercial crude palm oil is 3.5% on average, acidity of as low as 0.02% can be obtained for crude palm oil from fresh ripe fruits [10]. The lower FFA value recorded for ACPO may be attributed to dilution effect arising from the addition of dye solution. Similar trend was observed for PV which was 3.6 and 2.0 meq/kg for the control and ACPO respectively. The iodine values were within the reported range for crude palm oil [2], while carotene content of the adulterated sample was about 26% higher (693µg/g) than that of the control (548µg/g), indicating that the red dye may contain substantial amount of carotenoids. Colour is usually the first and most obvious characteristic evaluated by any consumer of crude palm oil and change in this parameter is usually perceived as indicating poor quality oil. In terms of colour, evaluated visually, the control had the characteristic orange-red colour of freshly processed crude palm oil while ACPO had a brighter (and attractive) orange-red colour. This difference in appearance can be attributed to the 26% increase observed in the carotene content of ACPO.

3.2 Changes during Storage

During storage of the control and adulterated sample, increment in FFA and PV; and decrement in IV and CC were observed (fig. 1). Good linear relationships were also observed between storage time and changes in these parameters, with correlation coefficients (R^2) ranging from 0.9172-0.9754 and 0.9106-0.9727 for the control and ACPO respectively (table 2). FFA of both samples gradually increased during the first 4 months of storage, after which ACPO showed a greater trend of increase than the control (fig. 1a). For the entire 6-month storage, FFA increased from 0.66-1.07% and 0.46-1.65% for the control and ACPO respectively. The rate of formation of FFA, expressed as slope (table 2) was higher in ACPO than the control, indicating that hydrolytic breakdown was higher in ACPO and could be attributed to the high amount of water (section 2.2) present in the sample. However, throughout the 6-month storage FFA values of both the control and ACPO remained well below 3.5% which has been reported as the average acidity for commercial crude palm oil [10].

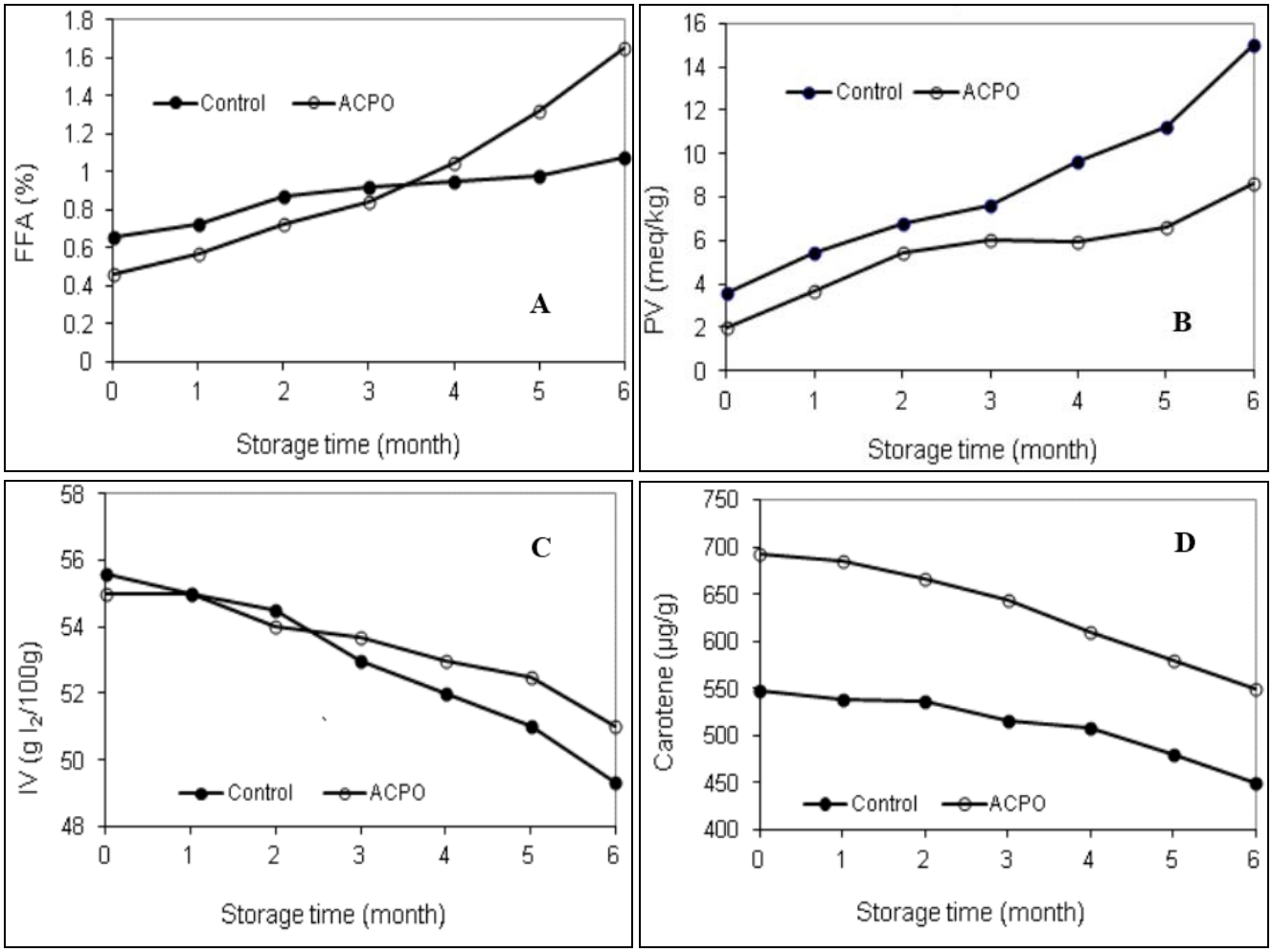

Fig 1: Changes in PV (a), FFA (b), IV (c) and Carotene (d) during storage of unadulterated (control) and adulterated (ACPO) crude palm oil.

Peroxide values progressively increased from 3.6-15.0 meq/kg and 2.0-8.6 meq/kg for the control and ACPO respectively during the 6-month storage (fig. 1b), indicating that formation of hydroperoxides, the most important primary oxidation products, took place in both samples during storage. Regression analysis (table 2) indicates that there was faster rate of formation of peroxides in the control (1.74meq/kg per month) than in the adulterated sample (0.93meq/kg per month). The slower rate of peroxide formation observed for ACPO may be attributed in part to the increased concentration of carotene in this sample (table 1), and to glycosides and polyphenols which have been reported to be present in the leaf sheath of *Sorghum bicolor* [11, 12]. These compounds are known to have antioxidant characteristics [13, 14] and to inhibit the formation of hydroperoxides during lipid oxidation [4].

Table 2: Regression model and correlation between storage time and quality parameters

Quality parameter	Regression: y = a*x* + b (y = quality parameter; *x* = storage time; a = slope; b = intercept)				Correlation coefficient (R^2)	
	Slope (a)		Intercept (b)			
	Control	ACPO	Control	ACPO	Control	ACPO
FFA (%)	0.06	0.19	0.62	0.37	0.9447	0.9588
PV (meq/kg)	1.74	0.93	1.51	1.73	0.9580	0.9106
IV (gI_2/100g)	-1.05	-0.64	57.11	56.02	0.9754	0.9557
Carotene (µg/g)	-15.65	-24.85	573.60	732.10	0.9172	0.9727

Iodine value which is a measure of the degree of unsaturation, decreased from 55.6-49.3 gI_2/100g and 55.2-51.0 gI_2/100g for the control and ACPO respectively, with the control recording a higher rate of increase, expressed as slope (table 2). However, throughout the entire storage period, the iodine values of both the control and ACPO remained within the range expected for crude palm oil [2].

Carotene, which is responsible for the distinctive orange-red colour of CPO and also an important quality control parameter for crude palm oil, decreased in both samples as storage time increased (fig. 1d) with ACPO undergoing greater rate of decrease and decreasing at the rate of 24.85 µg/g per month versus 15.65 µg/g per month (table2) for the control. This finding is in agreement with the slower rate of formation of hydroperoxides (measured as peroxide value) observed for ACPO (fig.1b and table 2), and also an indication of the inhibitory action of carotene during oxidation of ACPO.

3.3 Appearance and Aroma

Considering the untested toxicity of the red dye used in this study, sensory evaluation was limited to acceptability of appearance (colour) and aroma only, which are also among the most obvious attributes evaluated by consumers of crude palm oil. Changes in these attributes are usually associated with poor quality crude palm oil. Table 3 shows that the mean scores for acceptability of colour were similar for both the control and ACPO during the first 2 months of storage, after which ratings for ACPO progressively decreased with increasing storage time until a final score of 5.23 (neither like nor dislike) at the end of the storage period; suggesting that the attractive bright red colour brought about by the addition of red dye (table 1) is stable for a period not exceeding two months, under environmental conditions. This progressive decrease in the mean scores of colour acceptability is also in line with the greater loss in carotene, observed for ACPO (fig. 1d and table 2). Colour acceptability scores for the control remained almost unchanged throughout the 6-month storage period (table 3).

Table 3: Changes in some sensory attributes of control and adulterated sample during storage[a]

Storage Time (month)	Colour		Aroma	
	Control	ACPO	Control	ACPO
0	8.45 ± 0.50	8.53 ± 0.63	7.88 ± 0.92	7.62 ± 1.08
1	8.11 ± 0.75	7.94 ± 1.07	7.50 ± 0.98	7.30 ± 0.88
2	8.32 ± 0.68	7.61 ± 1.05	7.60 ± 1.03	6.00 ± 0.90
3	8.10 ± 0.93	6.72 ± 0.95	7.00 ± 1.10	4.80 ± 1.15
4	8.00 ± 0.80	6.40 ± 1.05	7.50 ± 0.95	5.00 ± 0.85
5	8.13 ± 0.77	5.90 ± 0.90	7.10 ± 1.06	4.88 ± 1.20
6	8.03 ± 0.59	5.23 ± 1.10	6.98 ± 0.86	4.73 ± 1.11

[a]Values are mean scores (n=15) ±SD

In terms of aroma acceptability, similar ratings were observed for both samples during the first one month, after which the mean scores for aroma acceptability decreased markedly for ACPO throughout the remaining storage period (table 3), indicating that the addition of red dye reduced the pleasantness of aroma of crude palm oil within a period of one month. The control on the other hand maintained the distinctive "nutty" aroma of freshly produced crude palm oil, throughout the storage period. Generally the pattern of variations of colour and aroma scores clearly indicates that the panelists preferred the control to ACPO throughout the entire storage period.

4. Conclusions

The quality parameters of the control and ACPO changed progressively with storage time. As storage time increased, FFA and PV increased while IV and CC decreased. The rate of increments of FFA was faster in ACPO suggesting that hydrolytic breakdown occurred at a faster rate in this sample than in the control. Faster rate of increase in PV and faster rate of decrease in IV were observed for the control, indicating that oxidative breakdown occurred at a faster rate in this sample than in ACPO. Carotene content on the other hand decreased at a faster rate in ACPO and is in line with the changes in PV and IV of this sample. Higher mean scores of acceptability of colour and aroma were recorded for the control, which appeared to retain these two attributes throughout the entire storage period. In contrast, ACPO lost its colour stability within the first 2 months of storage and its aroma stability within the first 1 month, suggesting that the attractive bright orange-red colour brought about by the addition of red dye is stable for a period not exceeding 2 months; and that the effect of red dye on the aroma of crude palm oil becomes noticeable after 1 month of storage. The above findings therefore indicate that while ACPO appeared to have higher oxidative stability as evidenced by PV and IV, the sample was generally unappealing to the panelists.

5. References

1. De Marco E, Savarese M, Parisini C, Battimo I, Falco S, Sacchi R. Frying performance of a sunflower/palm oil blend in comparison with pure palm oil. European Journal of Lipid Science and Technology. 2007; 109: 237-246.
2. Gee PT. Analytical characteristics of crude and refined palm oil and fractions. European Journal of Lipid Science and Technology. 2007; 109:373-379.
3. Goh SH, Choo YM, Ong SH. Minor constituents of palm oil. Journal of the American Oil Chemists' Society. 1985; 62(2):237-240.
4. Frankel EN. Lipid oxidation. 2nd ed. The Oily Press, Bridgwater, England, 2005, 51-66.
5. Okogeri O. Adulteration of Crude Palm Oil with Red Dye from the Leaf Sheath of Sorghum Bicolor. Food Science and Quality Management, 2013; 17:1-6.
6. Okogeri O, Otika FN. Quality parameters of crude palm oil obtained by traditional processing techniques. 9th Euro Fed Lipid Congress, Rotterdam 2011: Poster abstracts. European Journal of Lipid Science and Technology. 2011; 113(S1):117.
7. AOCS. Official Methods and Recommended Practices of the American Oil Chemists' Society 5th ed., AOCS Press, Champaign, Ca 5a-40, Cd 8b-90, and Cd 1d-92, 2004.
8. Prasanth Kumar PK, Gopala Krishna AG. Physico-chemical characteristics and nutraceutical distribution of crude palm oil and its fractions. Grasas y Aceites, 2014; 65(2):1-12.
9. Malcolmson LJ. Flavor and sensory aspect. In F. Shahidi (Ed.). Bailey's Idustrial Oil and Fat Products. 6th ed., John Wiley & Sons, Inc, 2005; 1:413-429.
10. Gibon V, De Greyt W, Kellens M. Palm oil refining. European Journal of Lipid Scence and Technoogy. 2007; 109:315-335.
11. Rey J-P, Pousset J-L, Levesque J, Wanty P. Composition and isolation of a natural dye from the stems of Sorghum

bicolor (L.) moench subsp. Americanum caudatum. Cereal Chemistry, 1993; 70(6):759-760.
12. Akande IS, Oseni AA, Biobaku OA. Effects of aqueous extracts of sorghum bicolor on hepatic, histological and haematological indices in rats. Journal of Cell and Animal Biology. 2010; 4:137-142.
13. Ryan D, Robards K. Phenolic compounds in olives. Critical review. Analyst, 1998; 123:31R-44R.
14. Okogeri O, Tasioula-Margari M. Changes occurring in phenolic compounds and α-tocopherol of virgin olive oil during Storage. Journal of Agricultural and Food Chemistry. 2002; 50:1077-1080.