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STORAGE STABILITY AND SENSORY ATTRIBUTES OF CRUDE PALM OIL ADULTERATED WITH RED DYE

Otu Okogeri* and Blessing Okoro.

Department of Food Science and Technology, Ebonyi State University, PMB 053, Abakaliki, Nigeria.

ABSTRACT: *In the present study, crude palm oil was adulterated with red dye from the leaf sheath of sorghum bicolor and stored for six months under conditions which mimic those prevailing in retail stores; in order to evaluate the storage stability and changes in sensory attributes of the adulterated crude palm oil (ACPO) during storage. FFA contents ranged between 2.28-2.80% and 1.32-1.9% for UCPO and ACPO respectively while PV ranged between 3.35-16.00 meq/kg and 2.07-6.80 meq/kg for UCPO and ACPO respectively. The above variations suggest that measurement of FFA and PV may not be reliable method for monitoring storage stability of adulterated crude palm oil. In terms of acceptability of colour, odour, taste and overall acceptability, UCPO recorded higher mean scores than ACPO. The colour and odour of ACPO were relatively stable for 5 months and 3 months respectively while the taste (measured as mean scores of taste acceptability) and general acceptability were readily unstable from the beginning of storage and progressively recorded lower scores until the end of the storage study*.

KEYWORDS: Crude palm oil; Adulteration; Red dye; Storage Stability; Sorghum bicolor; Sensory evaluation.

INTRODUCTION

The oil Palm (*Elaeis guinensis*) is West Africa's most important oil producing plant. The oil palm 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). Crude palm oil is the richest natural source of carotenoids and tocotrienols. The carotenoids (500–700 ppm) are responsible for the characteristic deep orange-red color of crude palm oil (CPO) (Gunstone, 2005), while its semi-solid consistency at tropical room temperature is mainly due to the presence of triacylglycerols of palmitic and oleic acids (Gee, 2007).

Oil palm is one of the most important economic oil crops in Nigeria. In recent years there has been rising production (supply) and consumption (demand) of palm oil, with demand growing faster than the supply. As a result, the trend has been that of increasing domestic consumption not matched by a rather slow growth in production. This widening gap between demand and production has also been accompanied by increasing reports of adulteration. Adulteration of fats and oils is an old problem and has been the subject of many studies (Imai et at., 1974; Rossell et al., 1984; Aparicio and Aparicio-Ruiz, 2000). Often cheaper oils have been sold in place of, or mixed with, more expressive oils.

There is a wide spread speculation in Nigeria that crude palm oil is being adulterated. The adulteration is believed to be deliberate and practiced by producers in order to increase the quantity of CPO, for the sole purpose of profit maximization and without considering the possible effect on the quality of palm oil and the health of consumers. One major problem associated with the use of adulterants is that these compounds have not undergone stringent studies and the level of threat they may pose to human health when consumed is not well established. For crude palm oil, adulteration could lead to loss of quality and nutritive properties, loss of organoleptic attributes and overall degradation of the oil.

In an earlier study (Okogeri, 2013) it was reported that CPO can be adulterated with red dye from the leaf sheath of *sorghum bicolor* at 0.25% level and at maximum oil/dye ratio of 1:1; and that the adulterated oil can remain unnoticed by unsuspecting consumers for a period of up to 30 days. In the present study, storage stability of the adulterated crude palm oil (ACPO) was evaluated by storing the oil under conditions which mimic typical storage conditions in local retail stores and by periodically monitory some chemical and sensory attributes of the adulterated oil, for six months.

MATERIALS AND METHODS

Sample preparation

To assure the absence of adulterant of any type, the crude palm oil used in this study was extracted in the Lab from freshly harvested ripe palm fruits of Tenera variety. The fruits were provided by a local processor. The red dye used as adulterants was purchased from a local grocery store. CPO was extracted in the Lab using traditional technique (Okogeri and Otika, 2011): 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.

Sample adulteration

Exactly 40g of the freshly processed CPO (section 2.1) 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. The dye solution was prepared by dissolving 1g of red dye in 100ml distilled water, and then diluting with distilled water to obtain the required concentration (Okogeri, 2013). Samples with no added adulterant served as control. Both the adulterated samples and control were agitated, capped and stored on the shelves of the laboratory and exposed to direct sunlight. The stored samples and control were then withdrawn at 1-month intervals (for 6 months) and evaluated for chemical and sensory characteristics. Enough samples were used and no sample had to be placed back on the laboratory shelves once withdrawn for analyses.

Physicochemical evaluation
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 (AOCS, 2004).

Fatty acid profile
The fatty acid profiles of the fresh and adulterated palm oil samples were evaluated by GC analysis of methylated samples according to AOCS Official Method Ce 1h-05 (AOCS, 2004). FAMEs were analyzed on a HP 6890 GC system from Hewlett Packard, using a DB-23 capillary column (60m x 0.32 mm x 0.25 μm film thickness).
All reagents were of analytical grade and purchased from Merck (Darmstadt, Germany)

Sensory Evaluation
Sensory analysis was used to assess the organoleptic quality of adulterated samples. Fifteen experienced panelists were selected from final year students of the Department of Food Science and Technology, Ebonyi State University, Abakaliki. The panelists were screened using the triangle test (Nobel, 2006) and selected based on their ability to consistently discriminate between fresh CPO and CPO with added red dye. Adulterated CPO 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 colour, taste, odour, and general acceptability. Sample preparation and evaluation of sensory attributes of samples were carried out based on the recommendations reported by Malcolmson (2005).

Statistical analysis
Analytical data were processed using Microsoft Excel 2007.

RESULTS AND DISCUSSION

Quality indices
The quality indices of the fresh CPO alongside those of sample adulterated with 0.25% red dye at oil/dye ratio of 1:1 are shown in Table 2. FFA which is one of the most important quality parameters in palm oil industry as it indicates the level of deterioration of the oil, recorded values less than 3.5% which has been reported as the average acidity for commercial crude palm oil (Gibon et at., 2007). This indicates that the CPO used in this study was obtained from freshly harvested fruits with restricted activity of the endogenous lipase (triacylglycerol acylhydrolase) in oil palm fruits (Henderson and Osborne, 1991). Lower peroxide and FFA values (2.07 meq/kg and 1.32 respectively) were recorded for ACPO and could be attributed to dilution effect from the addition of dye solution. The iodine values were 51.88 and 52.56 for fresh CPO and ACPO respectively and were within the ranges expected for palm oil (Gee, 2007). The fatty acid compositions in table 1 show the predominance of palmitic (C16:0) and oleic (C18:1) acids for both the adulterated and unadulterated samples. This is in line with results reported on Nigerian palm oils (Rossell et al., 1983). Table 1 also suggests that adulteration with red dye did not impact fatty acid composition.

Table 1: Quality indices of unadulterated and adulterated crude palm oil.

Parameters[a]	Fresh CPO	Adulterated CPO[b]
Free fatty acid (%)	2.28	1.32
Peroxide value (meq/kg)	3.53	2.07
Iodine value	51.88	52.56
Fatty acid (% peak area)		
C12:0	0.28	0.30
C14:0	1.11	1.18
C16:0	42.78	42.35
C18:0	4.18	4.24
C18:1	39.18	39.66
C18:2	10.36	10.18
C18:3	0.40	0.43
C20:0	0.35	0.34

[a] Values are mean of duplicate analysis
[b] Fresh CPO was adulterated with 0.25% dye solution at 1:1 ratio.

Storage stability
Both the adulterated (ACPO) and unadulterated (UCPO) oils were stored on the Lab shelved under diffused light, in transparent plastic bottles and evaluated for possible changes in chemical and organoleptic characteristics every one month for 6 months. The storage condition (transparent vial and direct sunlight) was chosen to mimic a typical storage conditions in retail stores; while the storage time (6 months) was estimated by the authors to well represent the interval between adulteration, retailing, and consumption. Changes in FFA content and PV of the adulterated (ACPO) and unadulterated (UCPO) crude palm oils during storage are represented in figures 1a and 1b respectively.

The FFA contents of UCPO and ACPO did not increase substantially during the 6-month storage compared with their initial FFA values (fig. 1a). The initial free fatty acid value of ACPO was 1.32%, which increased slowly and steadily to 1.9% after a storage period of 6 months. The corresponding values for ACPO were 2.28-2.8% for the same period. However the rate of formation of FFA, expressed as slope (not shown) was higher for ACPO. The calculated slope for ACPO was 0.065, while that of UCPO was 0.044; indicating that hydrolytic alteration was higher in ACPO during the 6-month storage and could be attributed to the higher amount of water (see section 2.2) present in this sample. FFA is one of the most important quality parameters in palm oil industry as it indicates the level of deterioration of the oil. Throughout the 6 months storage FFA values of both UCPO and ACPO remained well below 3.5% which has been reported as the average acidity for commercial crude palm oil (Gibon et al., 2007).

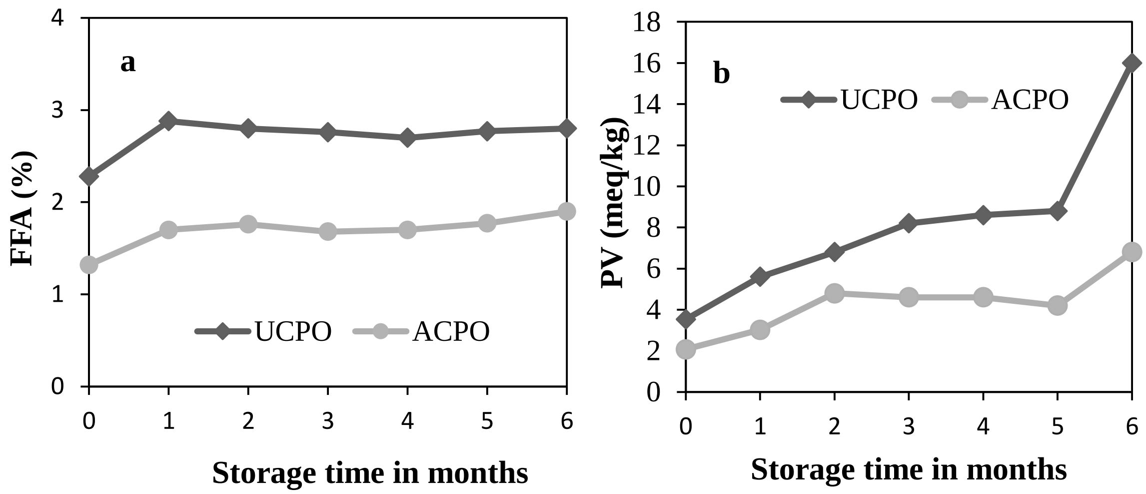

Fig. 1. Changes in free fatty acids (FFA) and peroxide values (PV) of unadulterated (UCPO) and adulterated (ACPO) crude palm oil during storage.

Increase in PV ranged between 3.53-16.0 meq/kg and 2.07- 6.80 meq/kg for UCPO and ACPO respectively during the 6-month storage (figures 1b), indicating a slower rate of formation of hydroperoxides, the most important primary oxidation products, in ACPO. This slower rate of formation is contrary to expectation and could be attributed to the presence of glycosides, flavonoids and polyphenols in the leaf sheath of *sorghum bicolor* (Rey et al., 1993; Akande et al., 2010). These compounds have been reported to have antioxidant characteristics (Ryan and Robards, 1998; Okogeri and Tasioula-Margari, 2002) and can inhibit the formation of hydroperoxides by donating hydrogen atoms to lipid alkyl, alcoxyl and peroxyl radicals (Frankel, 2005). However, as expected, the PV of both samples recorded progressive increase with increasing storage time.

Sensory attributes

Samples UCPO and ACPO were further subjected to sensory evaluation and the results are shown in Figures 1a-1d. Colour and appearance are usually the first and most obvious characteristics evaluated by any consumer of crude palm oil and changes in these characteristics are usually perceived as indicating poor quality product, irrespective of the reason or effect on overall performance. That colour plays a role in the acceptability of many foods cannot be denied. The mean scores for acceptability of colour were similar for both adulterated and unadulterated samples (fig. 1a) during the first 2 months of storage. After the second month, colour acceptability scores for UCPO remained almost unchanged, indicating that the oil maintained high colour stability over 6 months of storage; while the corresponding scores for ACPO progressively decreased with storage time until the end of storage time. The scores of pleasant odour were similar for both samples during the first one month, after which the odour acceptability for ACPO decreased markedly throughout the remaining storage period (fig. 1b), indicating that the addition of red dye can mask the characteristic "nutty" odour of crude palm oil but not for a period exceeding one month.

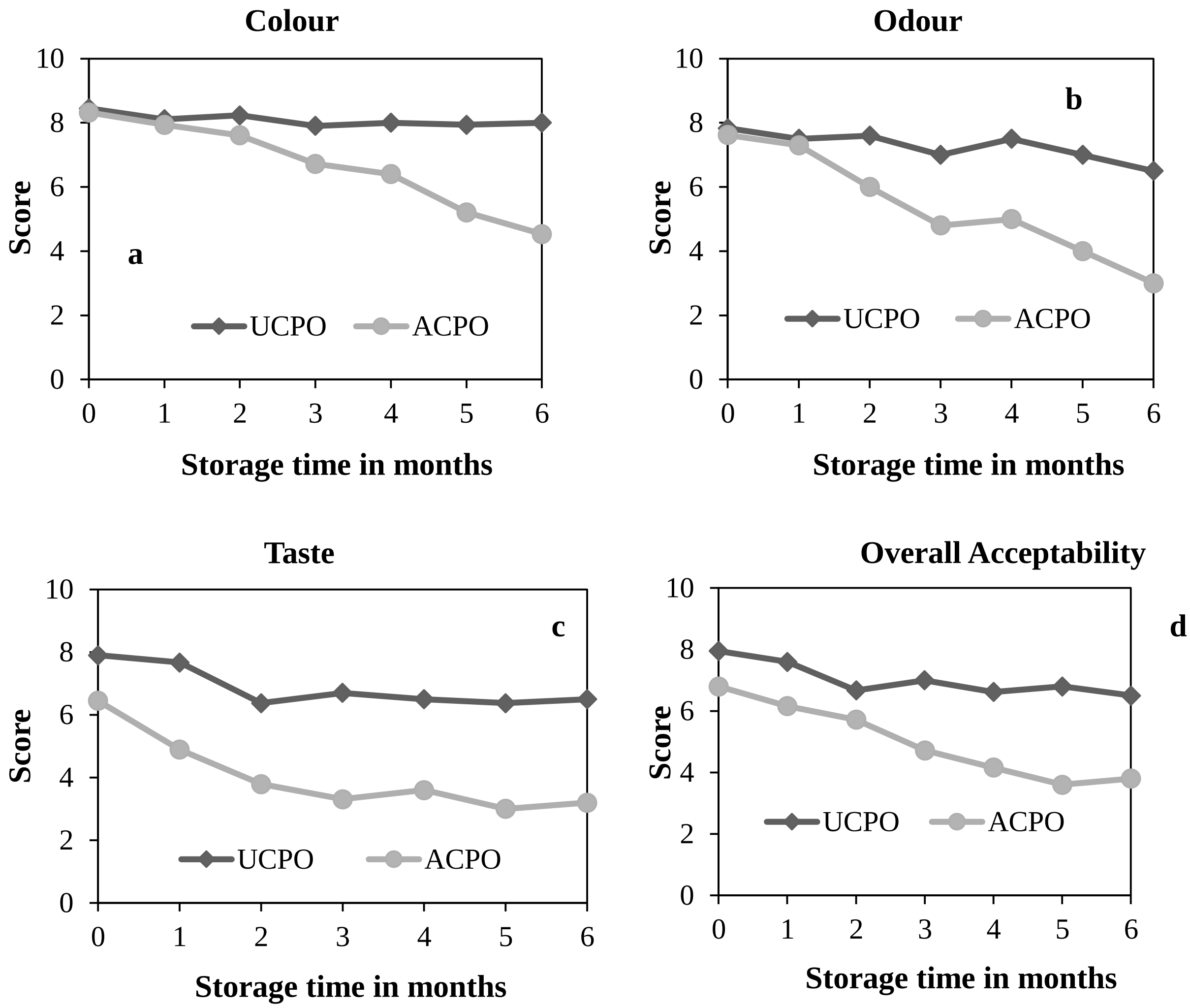

Fig. 2. Changes in sensory attributes of unadulterated (UCPO) and adulterated (ACPO) crude palm oil during storage.

The mean scores for acceptability of taste (fig. 2c) were clearly lower for the ACPO from the beginning of storage and throughout the 6-month storage period, indicating that the addition of red dye instantly reduced the pleasantness of taste of crude palm oil. Overall acceptability varied in a similar manner. Overall acceptability was more closely related to taste than to colour and odour acceptability, suggesting that colour and odour cannot substitute for taste in the detection of crude palm oil adulteration. The pattern of variation of overall acceptability clearly indicates that UCPO was clearly preferred more than ACPO by the panelists throughout the entire storage period.

CONCLUSIONS

Adulterate and unadulterated crude palm of samples were stored for a period of six months without any major changes in FFA contents. Changes in PV suggest that the formation of peroxides in UCPO occurred in a faster rate compared to ACPO, and may be attributed to presence of naturally occurring antioxidants in red dye from the leaf sheath of *sorghum bicolor*. Results from FFA and PV further suggest that measurement of common quality indices may not be a reliable method for monitoring the storage stability of adulterated crude palm oil. Higher mean scores for acceptability of colour, odour, taste and overall acceptability were recorded by UCPO compared to ACPO. Sensory results indicate that the colour and odour of ACPO were relatively stable for 5 months and 3 months respectively while the taste (measured as mean scores of taste acceptability) and general acceptability were readily unstable from the start of the storage study. Sensory evaluation, particularly acceptability of taste, was found to be a more reliable approach for monitoring the storage stability of adulterated crude palm oil.

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