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VARIETAL DIFFERENCES AND POLYMORPHISM IN PALM OIL: A CASE STUDY OF PALM OILS BLENDED WITH COCONUT OIL

O. D. EKPA, M. I. AKPANABIATU, MAURO AMELIO and RENZO RIZZO

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ABSTRACT

Palm oils from two varieties (*Dura* and *Tenera)* of the African Oil Palm (*Elaeis guineensis*), were individually blended with coconut oil in order to study some of their characteristic properties. Blending the oils with coconut oil enabled the observation of the relevant properties or parameters over a wide range of palm oil concentrations. One set of the samples was exposed to fluorescent light while the order set was exposed to normal room conditions. For both varieties, the free fatty acids (FFA) and melting points (MP) were found to increase with palm oil concentrations. The *Dura* variety, in general, exhibited higher values of FFA than the *Tenera* variety. The Fluorescent light also had a considerable effect on the oil samples as the FFA and melting points of the light-exposed samples were much higher than those of the unexposed ones. Graphical presentations of free fatty acid and melting point versus percent oil blends exhibited steps at five percent palm oil incremental intervals for both the *Dura* and *Tenera* oil samples.

In addition to these steps, *Dura* samples also showed a eutectic at 70% palm oil and 30% coconut oil which was not detected in the *Tenera*. The differences in the FFA and MP profiles of the two oils are explained in terms of differences in the level of chain packing of the constituent fatty acids of the individual oils. The presence of steps in the FFA and MP of the oil samples appear to be a new phenomenon in palm oil chemistry, which could provide the basis for distinguishing between oil from the *Tenera* and *Dura* varieties of the oil palm.

Key words: Varietal differences, Polymorphism, Blends, Palm and Coconut oils, free fatty acids and melting points.

INTRODUCTION:

Elaeis guineensis is the major species of oil palm cultivated in Nigeria. There are three main varieties of *Elaeis guineensis* each distinguishable by its mesocarp and shell thickness. The *Dura* variety has a characteristic thin mesocarp and thick hard shell enclosing large kernel while the Pisifera has thick mesocarp with little or no shell. The *Tenera*, which is a highbred of *Dura* and Pisifera, has thick mesocarp and thin shell with small kernel. The oil palm is, on the average,the most oil producing crop as both the mesocarp and the kernel provide palm and kernel oils respectively.

The major triglyceride components of palm oil are palmitodiolein and dipalmitolein, with the latter having the higher melting point (Swern, 1979). Palmitic and oleic acids constitute the main constituent fatty acids in palm oil with linoleic, linolenic and stearic acids as the minor components (Ekpa et al, 1999). Palm kernel oil on the other hand, resembles coconut oil in its glyceride and fatty acid constituents and is therefore interchangeable with coconut oil in most applications.

Studies have been carried out on the fatty acid composition of palm oil from the Tenera and Dura varieties of the oil palm (Ekpa et al, 1994a) and on the storage and processing conditions on the quality of palm oil (Ekpa et al, 1994b). Metallic soaps of palm kernel oils have been used as plasticizer and drier in the formulation of soyabean-oil based paints (Ekpa, 1995b) while the bioinorganic constituents and possible uses of the female inflorescence of the oil palm fruit have been determined (Ekpa, 1995a). Effect of light exposure on the characteristic parameters and deterioration properties of *Tenera* and *Dura*

palm oils has also been reported (Ekpa and Ekpe, 1996a).

Binary systems of palm and coconut oils have recently been used to study the effect of coconut oil concentration and air exposure on the total acidity of palm oil (Ekpa and Ekpe, 1995), and on the melting point and free fatty acid profiles of palm oil (Ekpa and Ekpe, 1996b) and could therefore prove to be a

O. D. EKPA, Department of Pure and Applied Chemistry, University of Calabar, Calabar, Nigeria
M. I. AKPANABIATU, Department of Biochem. College of Med. Sciences University of Calabar, Calabar, Nigeria
MAURO AMELIO, Fratelli Carli SpA Via Caressio 11-13, 18100 Imperia, Italy.
RENZO RIZZO, Fratelli Carli SpA Via Caressio 11-13, 18100 Imperia, Italy.

suitable system for studying other characteristic properties of palm oil. Such a system should permit the study of the physico-chemical and /or oleochemical properties of palm oil over a wide range of concentrations. Coconut oil is particularly preferable due to its oxidative stability and contains mostly saturated short-chain fatty acids in marked contrast to palm oil which is made up of long-chain fatty acids with a high degree of unsaturation (Chung and Ng, 1991).

The palm oil-coconut oil system will therefore be used in the preset study to examine the differences, if any, in the physico-chemical properties of palm oils from the *Tenera* and *Dura* varieties of the oil palm. The data expected from this study could provide useful information for the selection of proper blends of oils from the two varieties of the oil palm for domestic and industrial consumption based on individual characteristic of the oil concerned. Most of the available information on palm oil have been based on bulk oils, without distinguishing among the individual varieties. This study is therefore a continuation of our series on the varietal characterisation of palm oils from the African oil palm, *Elaeis guineensis.*

MATERIALS AND METHODS

The palm oil was obtained from four bunches of each variety of the oil palm fruit obtained from the Nigerian Institute for Oil Palm Research (NIFOR) in Abak Local Government Area of Akwa Ibom State of Nigeria. The palm oil was extracted from ripe, fresh, unbrushed fruits by the method described by Ekpa et al (1994b), purified and treated for analysis according to Ekpa and Ekpe (1995). The fruits of each sample (1kg) were boiled for 30 minutes in an aluminium pan and then digested in a wooden mortar while still hot. The palm oil was extracted by squeezing the mashed mesocarp between the fingers. The crude palm oil was purified by heating with one third its volume of water after which the oil on the surface was drawn off. The oil (100ml) was extracted with a solution of methanol-chloroform-water mixture (10:5:3, v/v). The Chloroform layer which contained the oil was dried with anhydrous sodium sulphate and the chloroform removed on a rotary evaporator.

Coconut oil was obtained from the nuts of *Cocos nucifera* bought from Watt market in Calabar, Cross River State, Nigeria. Grated coconut mesh (1kg) was taken in four litres of distilled water and the oil globules which floated on the surface separated. The resulting milk was heated over a bunsen flame until all the water had evaporated. The pale yellow oil was then decanted from the fat. The coconut oil was similarly purified by the method already described. Both the coconut and palm oils were stored in stoppered plastic containers in the refrigerator (-4°C).

The oil samples were each melted on steam bath and then mixed together to obtain the required percentage composition (w/w) of 100% palm oil (PO),100% coconut oil (CO), 90g palm oil/10g coconut oil etc., at 10% incremental levels. One set of samples was placed in a fluorescent light box (Ekpa and Ekpe, 1995) for a period, of fourteen days while the other set was also placed in a box but without fluorescent light for the same period of fourteen days. At the end of the exposure period, each sample was thoroughly mixed using a glass rod before aliquots were taken for the various determinations, which were carried out in triplicates.

Determination of Free Fatty Acid

The IUPAC method (1987) was used for the determination of the free fatty acid contents. The oil samples (2.0g) in 50ml of 95% ethanol-diethyl ether mixture (1:1,v/v) was titrated with 0.1M ethanolic KOH to phenolphthalein end point. The volume of KOH required to reach the end point was used in calculating the free fatty acid (FFA) content expressed as palmitic for palm oil and lauric for coconut oil.

Determination of Melting Point

The oil samples were each placed in small transparent plastic bottles with the quantity of the oil enough to cover the bulb of the thermometer (BS–5°C to 105°C x 0.5°C). The samples were stoppered and placed in a freezer for four days, after which period, the solidified oil samples were removed one at a time, and the thermometer inserted into the solid fat. The fat was placed in hot paraffin oil bath and the temperature and time at which it started to melt were recorded. The steady temperature at which the solid fat became liquid and there was no further rise in temperature was taken as the final melting point of the oil sample. The melting point and time were recorded as average of the initial and final readings for each of the samples. The oil bath was cooled with ice to about 10°C after each determination to ensure gradual melting of the next sample.

RESULTS AND DISCUSSION

The characteristic properties of various blends of palm and coconut oils were studied. Blending the palm oil with coconut oil enabled the observation of the relevant parameters over a wide range of palm oil concentrations. The study has revealed a marked difference in the melting point and free fatty acid

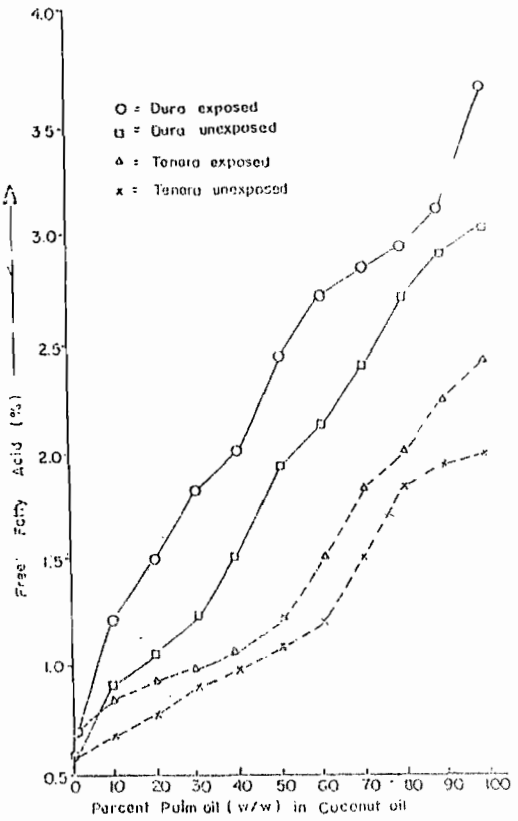

Fig 1 Effect of Coconut oil concentration and Light exposure on Free Fatty Acid, Coconut oil increases from right to left

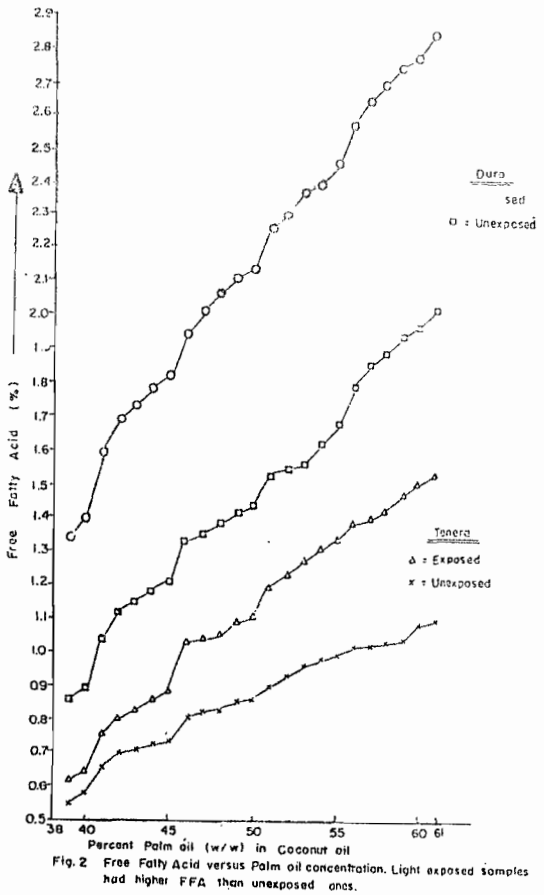

Fig. 2 Free Fatty Acid versus Palm oil concentration. Light exposed samples had higher FFA than unexposed ones.

formation pattern between the *Tenera* and *Dura* varieties of the African oil palm.

For both varieties, the free fatty acids were found to increase with palm oil concentration (Fig.1), with the *Dura* generally exhibiting higher values than the *Tenera*. The fluorescent light also has a significant effect on the samples as free fatty acid contents of the exposed samples were much higher than those of the unexposed ones. Fig.1 shows that the pattern of free fatty acid (FFA) formation in the *Dura* is markly different from that of the *Tenera*, as the rate of formation of FFA increases in opposite direction for the exposed and unexposed *Dura* samples. This indicates that the pathway for the formation of FFA in the exposed *Dura* samples may be different from that of the unexposed samples, the nature of which is the subject of an ongoing investigation.

The narrow regions between 30–50% in the *Tenera* oil and 40–50% in the *Dura* samples were further investigated with the hope of better understanding the causes of the observed constrictions.

Fig. 2. Shows a plot of free fatty acid (FFA) versus palm oil concentration at 1% incremental levels. Due to the large number of samples involved, only

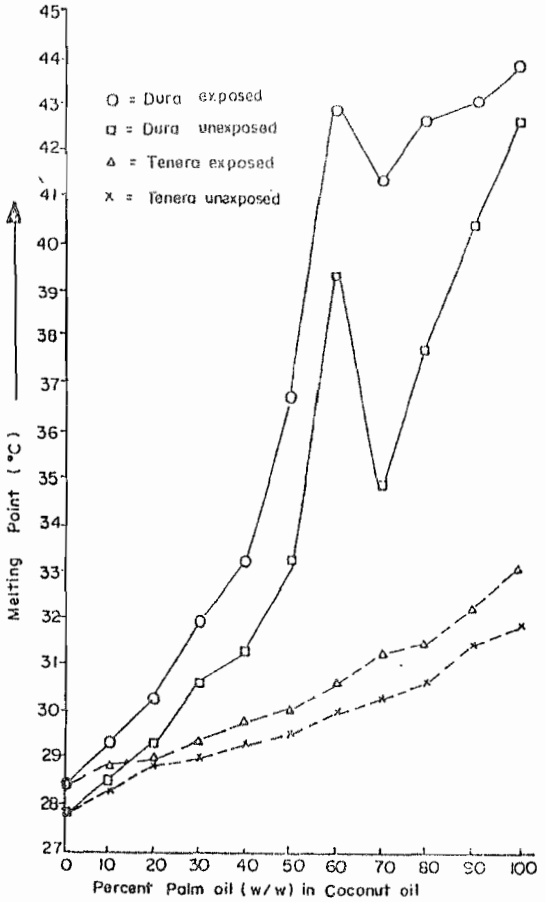

Fig. 3 Effect of Coconut oil concentration and Light exposure on melting point. Coconut oil concentration increases from right to left. Dura had eutictic at 70% Palm oil (top)

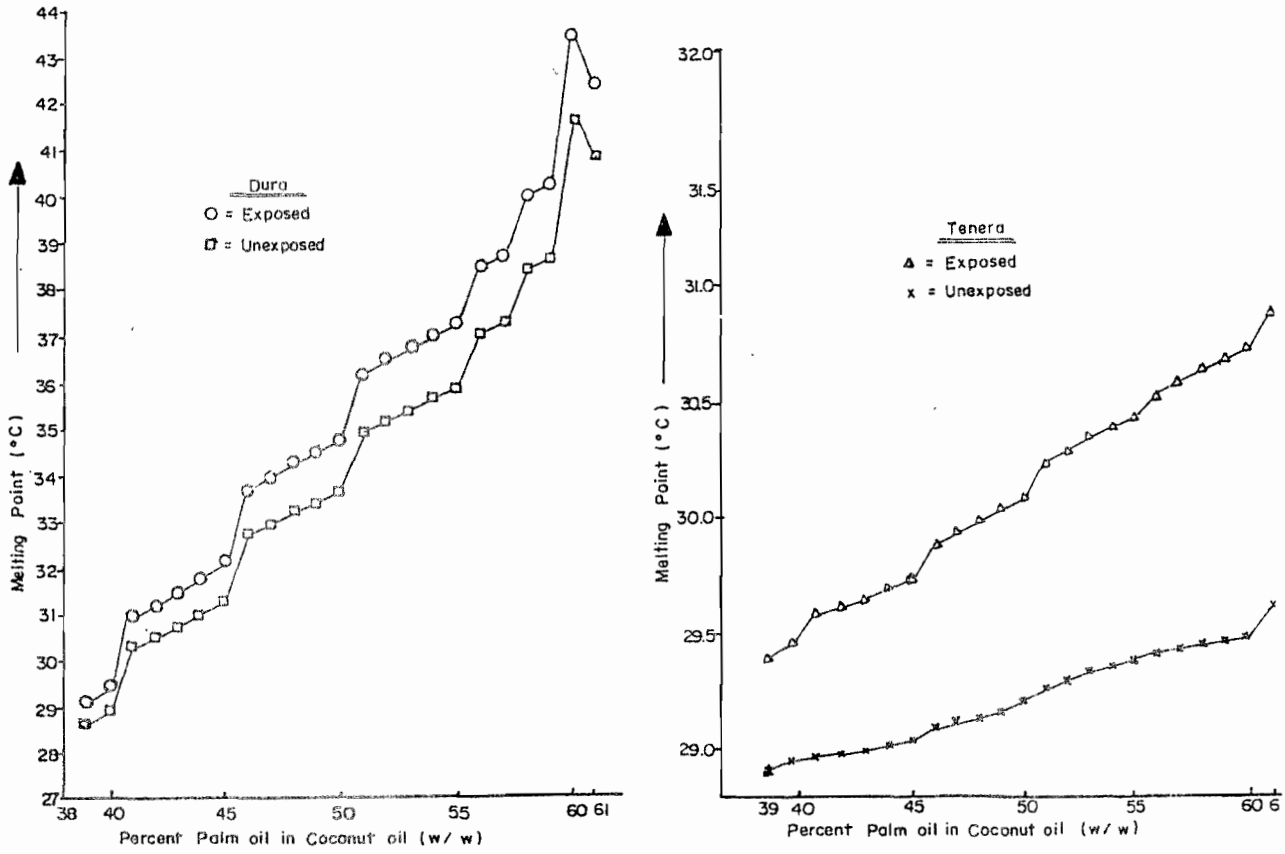

Fig. 4 Differences in melting point between Dura (left) and Tenera (right) palm oils (compare 55-61%). Sample exposed to light had higher melting points

the 40–60% region was investigated. The plot revealed an interesting feature in the graph of both the *Dura* and *Tenera* oil samples. Both graphs exhibited steps at five percent intervals with the gap between the exposed and unexposed oil samples increasing with increasing palm oil concentration. The reasons for these steps are not immediately clear, but it would appear that more free fatty acids are released at each five percent incremental level while being masked at the others. Such a demasking effect could be due to adoption of favourable molecular arrangements resulting from interaction of the side-chain of constituent fatty acids of the count oli-palm oil system, at these points.

The melting points of the two oils are represented graphically in Fig. 3. In contrast to the free fatty acid in which a gradual rise in the FFA was observed, the melting point curves showed sharp rise at 60% palm oil with a eutectic at 70% for the *Dura* oil. As with the case of free fatty acid, a closer examination also revealed the presence of steps in the melting point curves (Fig. 4) for both the *Tenera* and *Dura* oil samples. The absence of eutectics in the *Tenera* palm oil suggests a fundamental difference in the molecular orientations of fatty acids of palm oils from the two oil palm varieties. Morgan (1963) studied the melting point behaviour of some binary systems of synthetic palmito-oleo triglycerides, and attributed the presence of eutectics in some of the binary systems to chain packing, involving two fatty acids of different chain lengths, and those with continuous solid solutions, to components with isomorphous crystal structures. The interactions between the long-chain fatty acids of palm oil with the short-chain fatty acids of coconut oil could therefore be responsible for the eutectic observed. The monotectic system observed for the *Tenera* palm oil would therefore preclude the interaction between fatty acids of coconut oil and those of palm oil, thus suggesting individual interactions of fatty acids with the same chain lengths. The individual differences observed in the melting point profiles of the *Dura* and *Terera* palm oils suggest a fundamental difference, probably in configuration, of one of more of the constituent fatty acids of either of the two oils.

The presence of steps were also observed in the melting point of the oil blends. Such steps are known features that are characteristic of the melting points of hydrocarbons and fatty acids (Noller, 1966). This is because normal hydrocarbons and straight chain fatty acids with even number of carbon atoms are normally associated with higher melting points because they have the end carbon on the opposite side of the chain, making them more closely packed than the odd

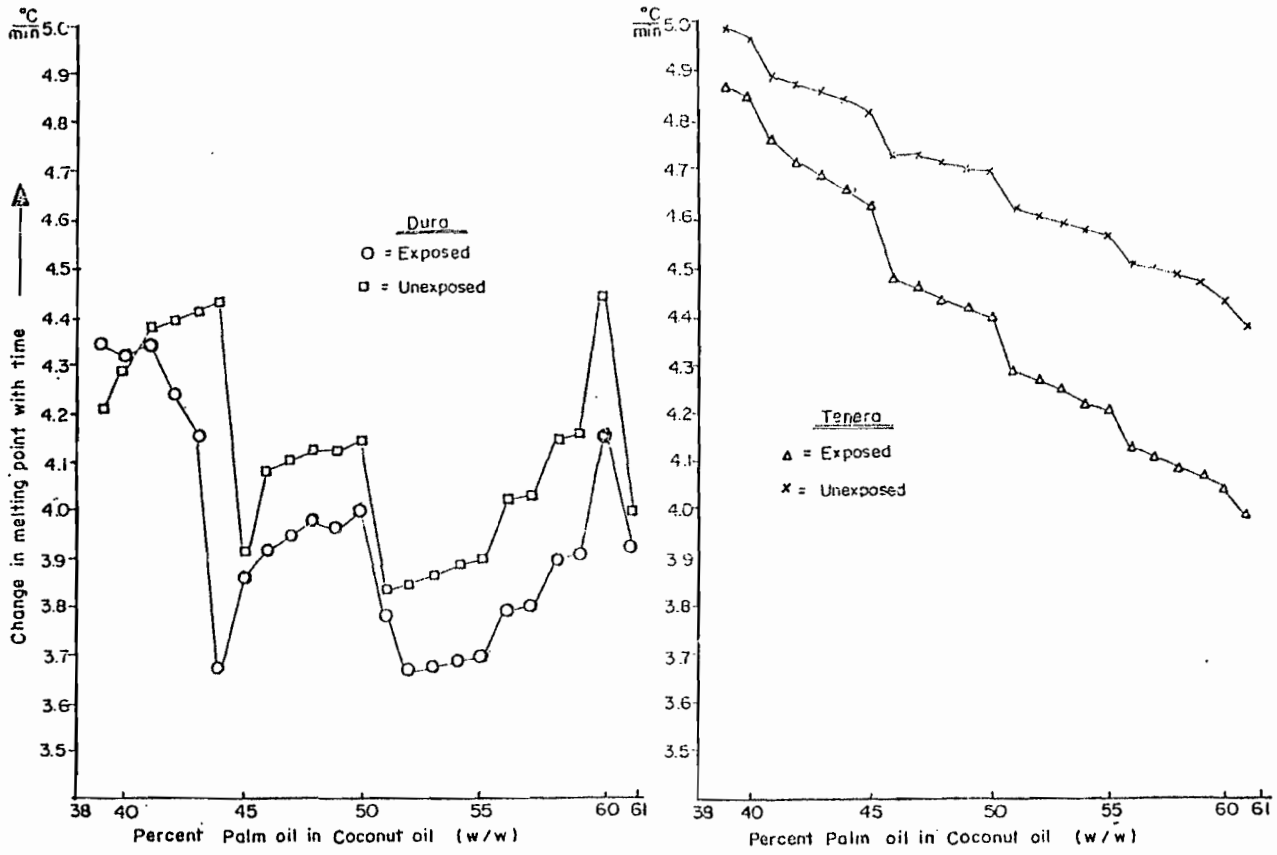

Fig. 5 Rate $(\frac{°C}{min})$ of melting of the oil samples Tenera (right) exhibited descending steps while Dura (left) showed alternating

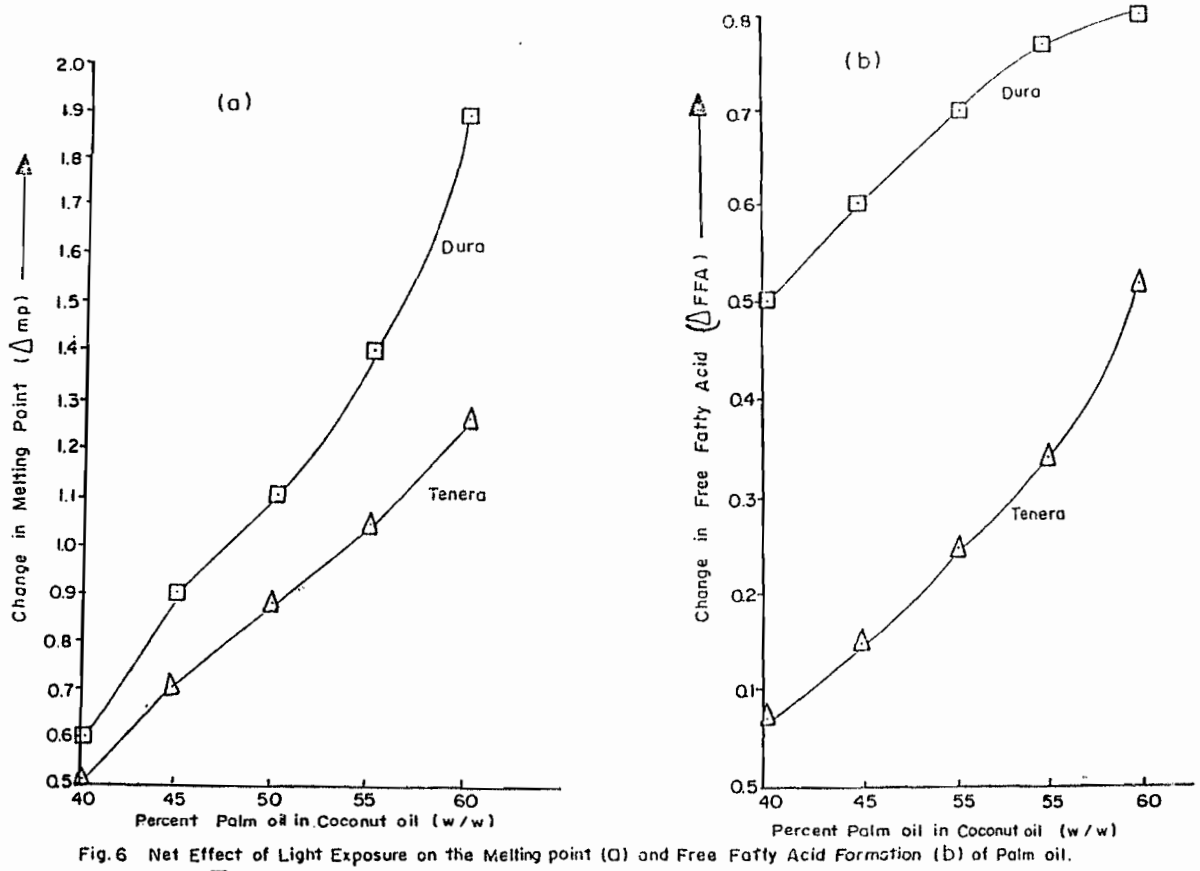

Fig. 6 Net Effect of Light Exposure on the Melting point (a) and Free Fatty Acid Formation (b) of Palm oil. Dura (□), Tenera (Δ)

number carbon chains, with the end carbon on the same side. The steps observed for the oil blends, at regular intervals,could therefore be attributed to individual fatty acids in the oils. However, it should be noted that the oils do not contain odd number-carbon fatty acids in their structures. According to Larson (1986), all lipids form crystal structure with the hydrocarbon chains extended in all-trans configuration, so that planar zig-zag carbon chain is formed to allow the chain to be closely-packed with parallel chain axis. In the case of the system under investigation, the major constituent fatty acids are palmitic and oleic in palm oil, lauric in coconut oil. The extended all-trans zig-zag structure for these fatty acids places the end groups on the opposite sides, in the case of palmitic and lauric acids, and for oleic acid the end groups are placed on the same side. Therefore, a condition which allows for interaction between the saturated fatty acids of the oil chains (possibly of the same chain lengths) should lead to better close packed structures which result in higher melting points than interactions involving oleic acid. It is therefore probable that favourable conditions exist, at the indicated intervals, which permit better crystal packing between the constituent fatty acids resulting in higher melting points.

Differences were also observed in the rate of melting, expressed as melting point/melting point time (°C/min), of the two oils (Fig.5). The graph of the *Tenera* palm oil showed a gradual stepwise descent compared to that of the *Dura* which exhibited alternating steps between 44 and 55 percent palm oil concentrations, with a maximum at 60%. The net effect of fluorescent light exposure on the sample was determined by taking the difference between the exposed and unexposed values of melting points and free fatty acids respectively. The data, also represented graphically, (Fig. 6) indicated that light had a clearly defined effect on the melting point of *Dura* palm oil, which exhibited rapid increase, when compared to that of *Tenera*. The reverse was however observed for free fatty acids in which a slow increase was exhibited by *Dura* palm oil, with the *Tenera* increasing rapidly between 55 and 60% palm oil. These differences in the rate of melting and in the response of the oil samples to light exposure appear to support the idea of differences in the structural orientation of the constituent fatty acids of the individual oils. Although the *Dura* palm oil is higher in total unsaturation than the *Tenera* (Ekpa et al, 1994a), the differences observed here cannot be attributed to unsaturation alone, since the two parameters (melting point and free fatty acid) are not a function of unsaturation, which involves the carbon-carbon double bonds of the constituent fatty acids.

CONCLUSION

Palm oils from the *Dura* and *Tenera* varieties of the African oil palm have been shown to exhibit differences in their melting point and free fatty acid profiles. The observed differences in these parameters could be attributed to differences in structural orientation of one or more constituent fatty acids of the oils. The presence of a eutectic in the melting point curve of *Dura* palm oil, a phenomenon not observed in the corresponding *Tenera* oil, could be a useful feature in distinguishing between the two oils.

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