COMPARISON OF THE CHARACTERISTIC PARAMETERS AND DETERIORATION PROPERTIES OF OILS FROM THE TENERA AND DURA VARIETIES OF THE OIL PALM

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ABSTRACT

Palm and kernel oils from the Tenera and Dura varieties of the oil palm (Elaeis guineensis) were analysed for their characteristic parameters to determine their susceptibility to oxidative deterioration. Palm oils from the two varieties exhibited substantial differences in their free fatty acid (FFA)contents, peroxide value (PV) and saponification value (SV), with oil from the red fruits of the Dura generally being higher in PV and FFA values than the Tenera. Higher peroxide values were also recorded for palm kernel oils from the red and yellow fruits of the Dura, while FFA contents were higher in Tenera palm kernel oils. FFA content, AV, and PV increased with period of light exposure for the two oil samples, with higher values generally being recorded for Dura palm oil.

INTRODUCTION

Elaeis guineensis is the main specie of the oil palm cultivated in Nigeria and provides a substantial proportion of the edible and non-edible vegetable oils required for domestic and industrial consumption in the country. There are three major varieties of the oil palm each distinguishable from the other by the mesocarp and endocarp (shell) thickness. These are the *Dura* (thin mesocarp, thick endocarp), *Tenera* (thick mesocarp and thin endocarp) and the *Pisifera* with thick mesocarp but with little or no endocarp (shell-less).

Recent studies[1] have revealed substantial variations in the fatty acid contents and degree of unsaturation of the oils of the *Dura* and *Tenera* varieties while factors affecting the quality of Nigerian palm oil have also been discussed[2]. Much of the information found in the literature on Nigerian palm oil have been based on bulk samples without specific reference to the varietal sources of the palm oil.

Oil palm products such as palm and kernel oils and palm kernel cakes are important raw materials for the vegetable oil, confectionery, soap and feed industries. The reported[1] variations in the fatty acid composition of palm oils from the *Dura* and *Tenera* varieties of the oil palm have necessitated further work to determine the differences, if any, in the characteristic properties of these oils. The availability of such data could lead to improved handling of palm oil for longer shelf life and to ease of selecting the oil or other oil palm products for domestic or industrial uses, based on properties specific to the varietal source of the oil. This in turn would lead to a more specific utilisation of palm oil and enhanced earnings for its producers.

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EXPERIMENTAL

The reaction apparatus

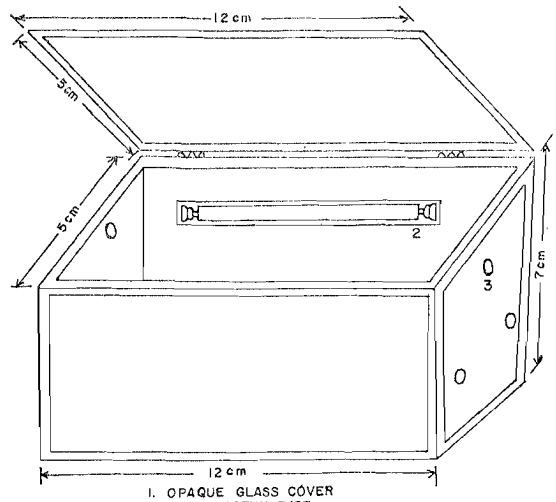

Fig I The Reaction Apparatus.

The equipment used in the study is shown in Fig. 1. The system is made of wood with opaque glass cover (A) and three holes (B), 1.5cm in diameter each, drilled at both ends of the box. The light source is a

60cm (40w) fluorescent tube (C) placed inside the back of the box 4cm from the bottom of the box. The fluorescent lamp holder carries a 130cm flexible cable fitted with a plug for connection to electricity source.

Sourcing and processing for oil samples

The palm fruits used in the extraction of palm oil samples were collected from the Nigeria Institute for Oil Palm Research (NIFOR) at Abak, Akwa Ibom State of Nigeria. The palm fruit bunches were harvested and processed the same day to minimise the degradation of the oil. The palm oil samples were extracted and treated as described by Ekpa et al[1]. The palm fruits of each variety were isolated and boiled for 30min, then mashed by pounding in a wooden mortar and pestle while still hot and the oil extracted by hand-squeezing the mashed mesocarp. The oil was clarified by heating with one-third its volume of water after which the oil on the surface was drawn and dried by heating in an air-circulating oven at 105°C for 5minutes. The clarified oil was used in the fluorescent light study immediately after the extraction.

For the determination of the characteristic parameters, the above procedure was repeated but this time with the fruits of each variety separated and classified as red and yellow fruits depending on the visual appearance of the fruits[1].

The nuts left over from the palm oil extractions were separated from the fibre and sun-dried for 7days. The kernels obtained by manually cracking the nuts were crushed by pounding in a wooden mortar and then finely ground with an electric grinding mill. The resulting cake was extracted with two successive portions of n-hexane by soaking in the hexane for 30 minutes, filtering and evaporating off the hexane over a steam bath. The oil was dried in an air-circulating oven at 102°C for 30 minutes.

Sample codes

The samples were described as *Tenera* red palm oil (TRPO), *Dura* red palm oil (DRPO), *Tenera* red kernel oil (TRKO) and *Dura* red kernel oil (DRKO). Oils from the yellow fruits were similarly classified as TYPO, DYPO, TYKO and DYKO to represent yellow palm and kernel oils.

Determination of characteristic parameters of samples

The methods used in the determination of the characteristic parameters were those approved by the IUPAC[3] for the analysis of fats and oils. The parameters determined were saponification value (SV), free fatty acid (FFA), moisture content and peroxide value (PV).

Saponification value

The saponification value was determined by refluxing 2.0g of the oil sample in 25cm^3 of 0.5M ethanolic potassium hydroxide on a heating mantle for 60 minutes followed by titration with 0.5M HCl to the phenolphthalein endpoint. A blank determination was carried out also and the difference in volume of the HCl between blank and sample titrations was used in the calculation of SV.

Free fatty acid

To obtain the free fatty acid content, 5.0g of sample in 50cm^3 of 95% ethanol-diethyl ether solvent mixture (1:1, v/v) was titrated with 0.1M ethanolic KOH to the phenolphthalein endpoint. The volume of KOH required to reach the endpoint was used in calculating the FFA expressed as palmitic acid, after correcting for the blank.

Peroxide value

The peroxide value was obtained by dissolving 5.0g of the oil sample in 10cm^3 of chloroform and adding 1.0cm^3 saturated KI and 15cm^3 concentrated acetic acid. The mixture was gently shaken and then stored in a dark cupboard for 5 minutes. 75cm^3 of distilled water was added to the mixture and titrated with 0.01M sodium thiosulphate with starch as indicator.

Moisture content

5.0g of the sample was heated to a constant weight in an air-circulating oven at 105°C. The difference in weight before and after the heating gave the moisture content of the sample. Results for all parameter determinations are presented in Table 1.

Table 1: Characteristic Parameters of Palm and Kernel Oils.

Parameters	Triplicate mean ± Standard deviation							
	TRPO	DRPO	TYPO	DYPO	TRKO	DRKO	TYKO	DYKO
Peroxide value (meq/kg)	0.70 ±0.05	1.50 ±0.04	0.80 ±0.09	1.32 ±0.04	0.30 ±0.02	0.60 ±0.03	0.40 ±0.04	0.62 ±0.04
Free fatty acid (%)	2.20	2.90 ±0.17	1.38 ±0.10	1.30 ±0.15	1.0 ±0.10	0.70 ±0.26	0.98 ±0.05	0.80 ±0.02
Saponification value (mg/100g)	197 ±0.32	206 ±1.0	209 ±1.0	200.4 ±0.53	251 ±0.44	246.7 ±0.96	242.8 ±1.06	248.1 ±0.36
Moisture content (%)	0.30 ±0.0	0.32 ±0.0	0.29 ±0.01	0.14 ±0.0	0.10 ±0.03	0.06 ±0.01	0.10 ±0.02	0.07 ±0.01

Effect of fluorescent light on the deterioration properties of palm oil samples

The oil samples obtained from fresh fruits of the *Tenera* and *Dura* varieties were each divided into four equal portions (total of eight) and each portion placed in a previously labelled plastic plate. The oil in each plate was stirred until completely homogenous after which aliquots of each were withdrawn for the determination of peroxide values, acid values (AV) and free fatty acid contents. These determinations were carried out the same day the oil samples were extracted which was designated as day 0. Four portions of the oil samples, two each of *Tenera* and *Dura*, were placed inside the box constructed specifically for this purpose while the remaining four were left open on the laboratory desk as controls. The box was closed and the fluorescent light turned on. Aliquots of the samples was taken for analysis after the first day of exposure (designated as day 1) and, thereafter, every three days for 13 days. Samples were thoroughly mixed each time before aliquots were taken for the determinations. Triplicate determinations were carried out for each sample, and the readings are reported as mean of two separate determinations per variety.

RESULTS AND DISCUSSION

Peroxide value

Peroxides are sensitive indicators of the oxidative status of lipids. In this study, all the oils used were relatively fresh and had not undergone marked oxidative deterioration as indicated by their peroxide values in Table 1. However, both the palm and kernel oils exhibited significant differences ($P<0.05$) in their peroxide value contents. Palm oil samples obtained from the red and yellow fruits of the *Dura* variety (DRPO and DYPO) had higher peroxide values (1.51 and 1.32 respectively) than the values for palm oils from the corresponding *Tenera* variety (0.70 for TRPO and 0.80 for TYPO). Similar trends in peroxide values were observed for the kernel oils with the DRKO and DYPO having the highest but almost the same peroxide values (DRKO 0.60; DYKO 0.62). The higher susceptibility of the *Dura* palm oil to autoxidation than the corresponding *Tenera* variety could be due to the differences in their fatty acid contents. According to Ekpa et al.[1], palm oil from the *Dura* variety of the oil palm has higher unsaturated fatty acid content than that obtained from the Tenera. The rate of autoxidation of fats and oils increases with increasing level of unsaturation[4].

Free fatty acid contents

Significant differences in free fatty acid contents were observed for palm oils from the red and yellow *Dura* and *Tenera* fruits, ($P<0.05$). The free fatty acid content was higher in the DRPO (2.90%) than the corresponding TRPO (2.20%) while essentially equal amounts were recorded for the yellow fruits of the two varieties (TYPO, 1.38% and DYPO, 1.30%) (Table 1). The kernel oil samples had free fatty acid percentages that fall within the range of 0.70 - 1.0. The observed percentage free fatty acids for the kernel oils did not differ significantly. Generally, the average percentage free fatty acids of the palm oil samples are within the 2 - 5% range reported for Malaysian palm oil[5] and lower than the 3.5% maximum recommended for Nigerian palm oil[6]. However, since the refining loss is twice the percentage free fatty acid of any vegetable oil[7], palm oil from red fruits of *Dura* (DRPO) would suffer a higher refining loss of 5.8% during the refining processes in view of its high percentage free fatty acid of 2.90.

Saponification values

The saponification values of the oil samples ranged from 197 for TRPO to 209 for TYPO. A saponification value of 200.4 was recorded for DYPO compared to 206 for DRPO. The SV for the kernel oil samples were within the range of 242.8 - 251.0 which is comparable to that of 243 - 249 reported[8] for Malaysian palm kernel oil. Also, the value of 242.8 obtained for TYKO is the same as that reported[9] for palm kernel oil liquid fraction. Saponification value is a measure of the average molecular weight of a fat or oil[10]. The higher the SV the lower the average molecular weight and chain-length of the constituent fatty acids making up the triglyceride molecule. The low SV for *Tenera* palm oil (197) suggests that this oil is slightly richer in short-chain fatty acids, such as lauric and myristic, than the other palm and kernel oils.

Deterioration properties of the palm oil samples

This study was carried out to determine the effect of the observed differences in the characteristic parameters between oils from the two varieties of the oil palm on their tendency to undergo oxidative degradation reactions. The deterioration of the oil samples was followed by the measurement of three characteristic parameters namely; peroxide value, free fatty acid contents and acid value for each of the samples for 14 days at three day intervals. The deterioration of an oil can take place by hydrolytic cleavage of the ester bonds of the glyceride molecule or by oxidative cleavage of the carbon-carbon double bonds of the constituent unsaturated fatty acids, or both. The former reaction was followed by the measurement of the free fatty acid content and the latter by determining the peroxide contents of the oil samples. The oils used for this study were free of primary oxidation products and free fatty acids, which were determined immediately after their extractions (Day 0), as these were not detected in the samples.

The results of the fluorescent light studies are indicated in Figs. 2-4. The free fatty acid content was found to increase progressively with period of exposure to light, with DRPO having higher FFA values than TRPO for both the control and the exposed samples. The FFA for TRPO increased from 0.75 on the first day of exposure to 3.41 on the 13th day, compared to 0.92 for DRPO which increased to 3.7% on the 13th day. Similar trends were also observed for the acid value (AV), which is a measure of the total acidity of the oils, with the DRPO generally recording higher values than the TRPO. The net effect of the fluorescent light on FFA and AV formation was determined by subtracting the values for the controls from those of the exposed samples for each of the determinations. These are recorded as ΔFFA and ΔAV to represent the differences in free fatty acid and acid values between the exposed samples and the respective controls.

The FFA, AV, ΔFFA and ΔAV are represented graphically in Fig. 2. Compared with the controls the light had significant effect on the FFA formation of the oil samples, with the effect being greater on the TRPO than on the corresponding DRPO (Fig. 2 A) especially after the 7th day when the change is indicated by a rapid increase in FFA. Although there is a significant rise in FFA of both samples on the 4th day with the DRPO higher than the TRPO, subsequent increase in DRPO is slower than that of the TRPO, as indicated in Fig. 2B.

The effect is more pronounced when considering the total acidity of the system as represented by the acid value (Fig. 2 D-E), where the acidity of DRPO is much lower than that of TRPO (Fig. 2E) by the 12th day of exposure.

The effect of light on the peroxide values of the palm oils is shown on Fig. 3. A linear relationship existed between the peroxide value and period of light exposure, with the TRPO passing through the origin. A significant increase in PV was observed for DRPO on the first day of exposure (Fig. 3 A & B), with the increase becoming gradual in subsequent days of exposure. A plot of ΔPV against time of exposure gave Fig. 3A which showed a sharp but steady rise in the PV of TRPO.

These results indicate the tendency of the DRPO to deteriorate more rapidly than the TRPO. One of the factors that could be responsible for this may be the higher degree of unsaturation of DRPO[1] than the TRPO, which makes the former more susceptible to peroxide oxidation than the latter.

It should be noted that the reaction box is not air-tight and the deterioration of samples placed in it could

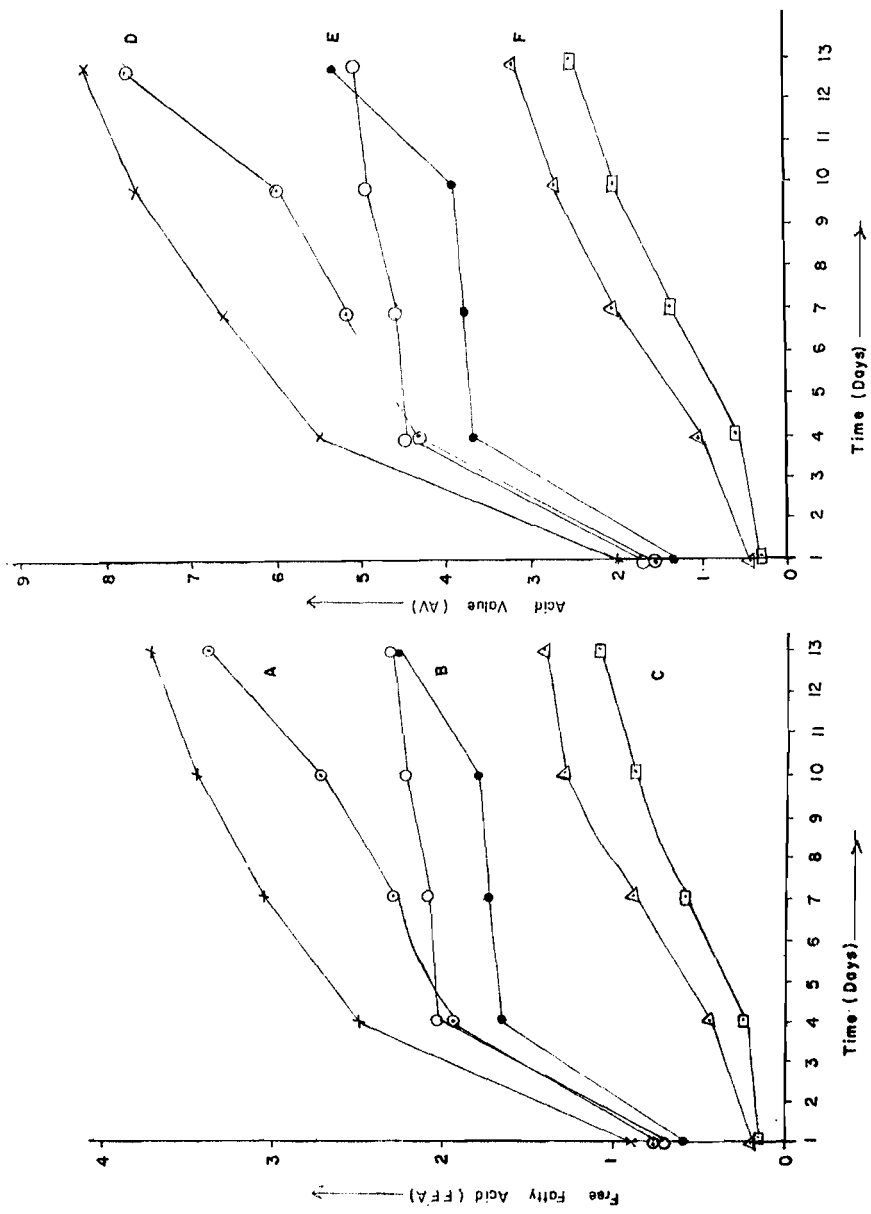

Fig. 2 Effect of exposure of palm oil to fluorescent light on the formation of free fatty acid (A, B & C) and acid value (D, E & F). (X) Dura sample, (O) Tenera sample (O) Dura Δ FFA (ΔAV in the acid value (E)), (●) Tenera Δ FFA (ΔAV for acid value (E)), (Δ) Dura control, (□) Tenera control. Sample = palm oil exposed to fluorescent light

also be influenced by factors such as oxygen and moisture in the air. However, the fluorescent light is the major contributor to the higher values of FFA, AV and PV observed for these samples, otherwise the value of these parameters would have been lower than those observed for samples exposed to normal room conditions where airflow, among other variables, was not restricted.

Contributions of individual parameters to the spoilage of the oil samples were determined from plots of FFA and AV against PV (Fig. 4A & B). Similar plots of PV versus FFA and AV versus FFA are also shown in Fig. 4 (C & D). These graphs indicated that, when compared with peroxide values of the individual oil samples, there is a higher ratio of FFA in TRPO at any specified time than in DRPO. These results show that there is a proportionate increase in free fatty acid with peroxide value. This increase is linear for the control samples but non-linear for those samples exposed to light. A linear relationship also exists between AV and PV (controls) as well as between AV and FFA. The results also indicate that the contribution of free fatty acid to the spoilage of the palm oil samples is higher

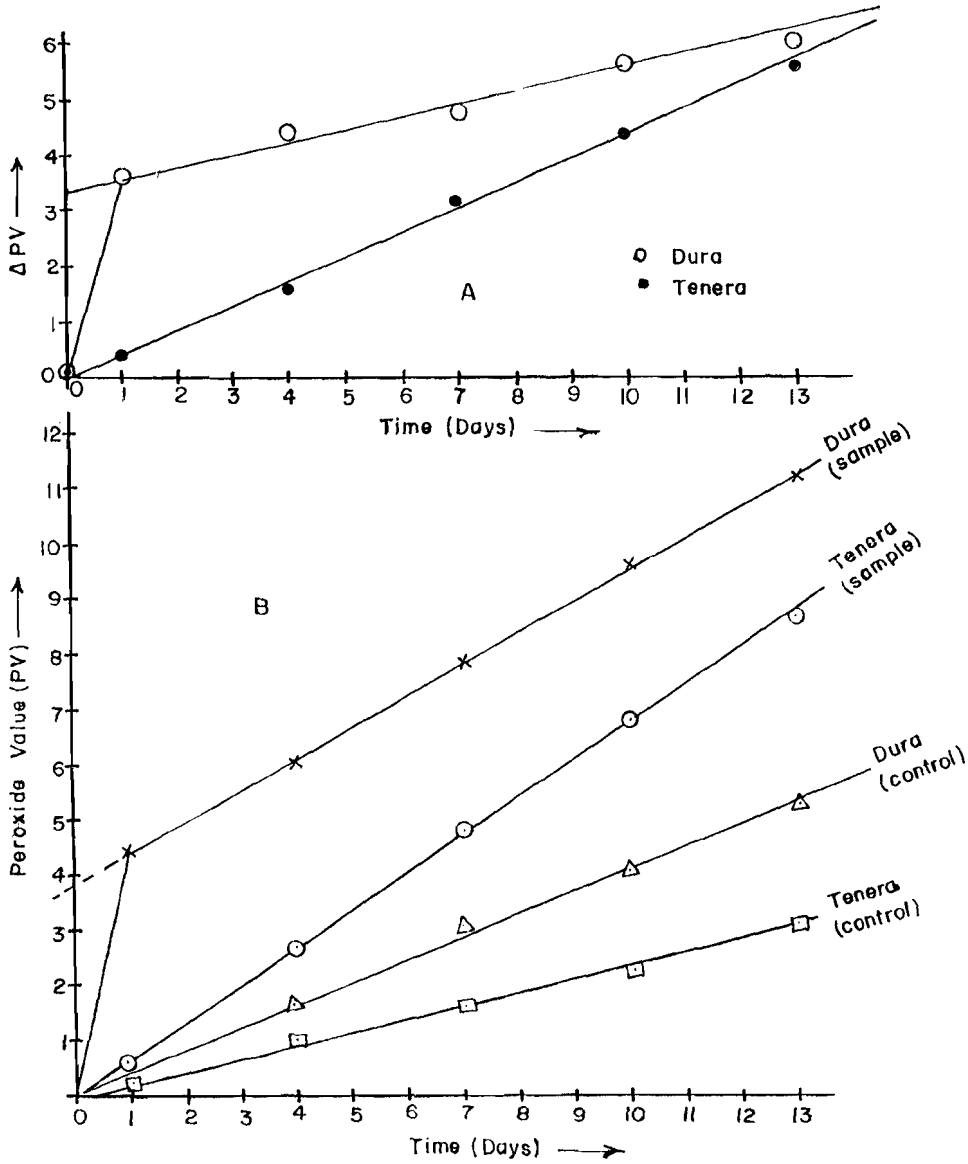

Fig. 3 Effect of exposure of palm oil to fluorescent light on the peroxide value (PV) (B); ΔPV = PV (sample) – PV (control) (3A), is the net contribution of the fluorescent light to the change in peroxide value Sample = oils exposed to fluorescent light.

for TRPO, while DRPO is affected more by peroxide oxidation. This was indeed manifested in the oil samples when DRPO started developing offensive odour towards the end of the observation period. The odour was absent in TRPO even though both had become semi-solid by the end of this period. The formation of free fatty acid is generally responsible for the soapy taste associated with some oils while the pervading off-odours are due to peroxide oxidation products[4] that include aldehydes, ketones and lower molecular weight carboxylic acids.

CONCLUSION

The results of this study have revealed that palm oil from the red fruits of the *Dura* has greater tendency to undergo rapid autoxidation reactions than the corresponding *Tenera* variety. Oils extracted from the kernels of the red and yellow fruits of the *Dura* would also be more susceptible to peroxide oxidation as indicated by their higher peroxide values. *Tenera* kernel oil, on the other hand, would be expected to experience more refining losses during refining into edible vegetable oil because of their higher free fatty

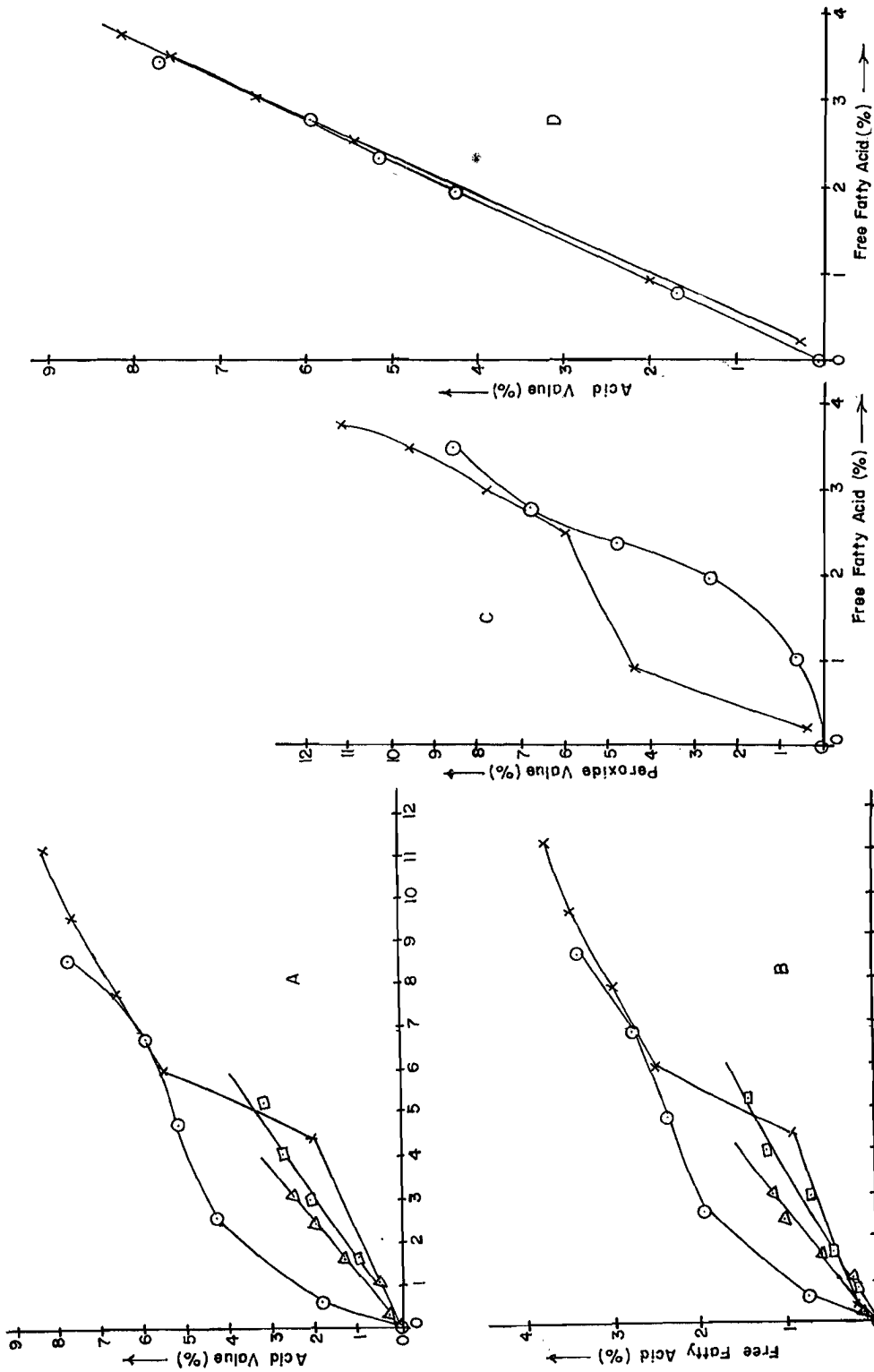

Fig.4 Relationship between (A) acid value and peroxide value;(B) Free fatty acid and peroxide value;(C) Peroxide value and free fatty acid and (D) Acid value and free fatty acid (○) Tenera sample, (X) Dura sample, (△) Tenera control, (□) Dura control. Sample = palm oils exposed to fluorescent light.

acid contents. *Tenera* palm oil would have a longer shelf life which is desirable for those applications that require bulk storage of the oil.

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