EFFECT OF COCONUT OIL CONCENTRATION ON THE MELTING POINT PROFILE AND FREE FATTY ACID FORMATION OF PALM OIL

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ABSTRACT

Various blends of palm and coconut oils were used to study the characteristic properties of the two oils. Free fatty acids and melting points were determined for samples exposed and unexposed to normal room conditions (28°C). The free fatty acids were found to increase with increase in palm oil concentration for the two sets of samples. Rate constants based on palm oil concentration, however, revealed an inverse relationship between the rate of formation of free fatty acid for the exposed and unexposed oil samples. The results on the changes in free fatty acid contents and melting points of the oil blends are explained in terms of the structural interactions accompanying addition of coconut oil to palm oil. The information obtained from this study could be useful for extending the present uses of the two oils

INTRODUCTION

Palm oil is one of the major commercial products of the oil palm (*Elaeis guineensis*). It is an important part of the diet in Nigeria in addition to being used in the manufacture of soaps, margarines, shortenings, and lubricants. The oil contains both saturated and unsaturated fatty acids which differ from one another in their chain length and degree of saturation. The major saturated fatty acids in palm oil are palmitic acid and stearic acid with lauric and myristic acids being minor constituents. Oleic and linoleic acids constitute the bulk of the unsaturated fatty acids in the oil[1]. Coconut oil, on the other hand, has lauric acid as its major constituent fatty acid[2]. The high proportion of both saturated and unsaturated acids in palm oil accounts for the variety of its industrial applications. Fractionation of the fatty acids gives two fractions, the solid (stearin) and liquid (olein) fractions[3,4]. The latter finds applications in the areas of shortening, edible vegetable oil and frying while the former is used in the manufacture of soaps, candles, greases and cosmetics.

The nature of constituent fatty acids in palm oil may have determined the edible and non-edible industrial applications of the oil. This is evident in the area of soap production where palm oil, having long-chain fatty [illegible] soaps with poor [illegible] properties [illegible] soaps with greater [illegible] creaminess are obtained by blending palm [illegible] coconut or palm kernel oil[2]. Oil blends have also been used in the vegetable oil and paint industries to obtain products with better consistency and greater acceptability, to reduce production cost, or modify the structural properties of the individual oils through trans-esterification or interesterification[2].

Studies have been carried out on the effect of processing conditions on the quality of palm oil[5] and on constituent fatty acids of palm oil[1,6] but not much is known about the physico-chemical properties of palm oil blended with other economically important oils. This study is therefore intended to examine the effect of coconut oil concentration on the characteristic properties of palm oil. Coconut oil was chosen because of its marked differences in constituent fatty acids, melting point and stability from palm oil[7] to enable noticeable changes to be observed over a wide range of palm oil concentration. The information expected from this study could be useful to the vegetable oil and toiletries industries in selecting proper blends of the two oils to meet specified needs and applications. It could also serve as a reference point for further works on other oil blends which would invariably extend the end uses of the individual oils concerned.

EXPERIMENTAL

[illegible] samples

[illegible] market [illegible] [illegible] Nigeria. [illegible] 1-litre plastic [illegible] [illegible] [illegible] in

* [illegible] for correspondence

the market and then blended together to give the oil that was used in the study. The coconut oil was extractedd from coconut bought from the same market. Five coconuts were cut open and the fleshy mesocarp (meat) removed and ground. Four litres of water was added to the resulting mixture and filtered. The filtrate was left overnight and the oil globules which floated on top of the mixture was separated and heated to obtain the oil from the fat. The pale yellow oil was stored in a plastic container until required.

Purification of palm oil

The palm oil was purified by partitioning 100g of the crude oil in methanol-trichloromethane-water mixture (10:5:3, v/v). After separation of layers, the trichloromethane layer was removed and dried with 10g of anhydrous sodium sulphate The oil was then passed over silica gel G (10g) in a Hirsh funnel and the trichloromethane evaporated off in vacuo

Selection of samples and exposure conditions

Blends of the two oils were prepared by mixing proportionate amounts (w/w) of the oils. Replicate sets of mixtures were prepared for samples used for the determination of free fatty acids (FFA) and melting points with one set acting as control. For these determinations, the individual oils and their blends were each placed in a 250ml Erlenmeyer flask and one set left without stoppers, on top of the laboratory desk for seven days while stoppered analogues of samples were placed inside the laboratory lockers for the same period Each set consisted of eleven blended samples (2 pure + 9 mixtures) with the amount of coconut oil gradually increased at 10% incremental intervals.

The precision of the means for the various data were tested using the Student t-test[8] at 95% confidence level. All the determinations were carried out in triplicates.

Determination of free fatty acid of the oil blends

Free fatty acid content was determined by the IUPAC methods[9]. 10g samples were dissolved in 50cm^3 of diethyl ether-ethanol solvent mixture (1:1, v/v) and then titrated with 0.1M ethanolic potassium hydroxide to the phenolphthalein end-point. The average volume of base required for each triplicate titrations was used in the calculation of the free fatty acid as palmitic for palm oil and as lauric for coconut oil using the relationship,

$$\% \text{ FFA} = \frac{NxMxV}{w}$$

where M = molarity of KOH, V = volume of KOH, w = weight (g) of sample and N = equivalent weight of plamitic or lauric acid. The results of the free fatty acid determinations are indicated in Fig. 1 while the rate constants calculated from the free fatty acid composition are shown in Table 1.

Table 1: Rate constants (k) of free fatty acid formation for exposed and unexposed oil blends.

Oil Blends %		Average k x 10^3 (g^{-1})	
PO	CO	Unexposed	Exposed
100-90	0-10	3.2	2.1
89-80	11-20	7.8	2.4
79-70	21.30-	6.5	2.6
69-60	31-40	5.9	3.1
59-50	41-50	5.3	3.7
49-40	51-60	5.1	4.1
39-30	61-70	4.7	4.6
29-20	71-80	4.2	5.3
19-10	81-90	3.9	6.0
9-0	91-100	2.6	10.4

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 to 105 x 0.5°C Gallenkamp, Loughborough (UK)].

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 temperature and time at which the oil started and finished melting were recorded. The steady temperature at which the solid fat became liquid was taken as the final melting point of the oil sample. The melting point and time were recorded as the average of the initial and final readings for each of the samples. The results of the melting point determinations are indicated in Fig. 3.

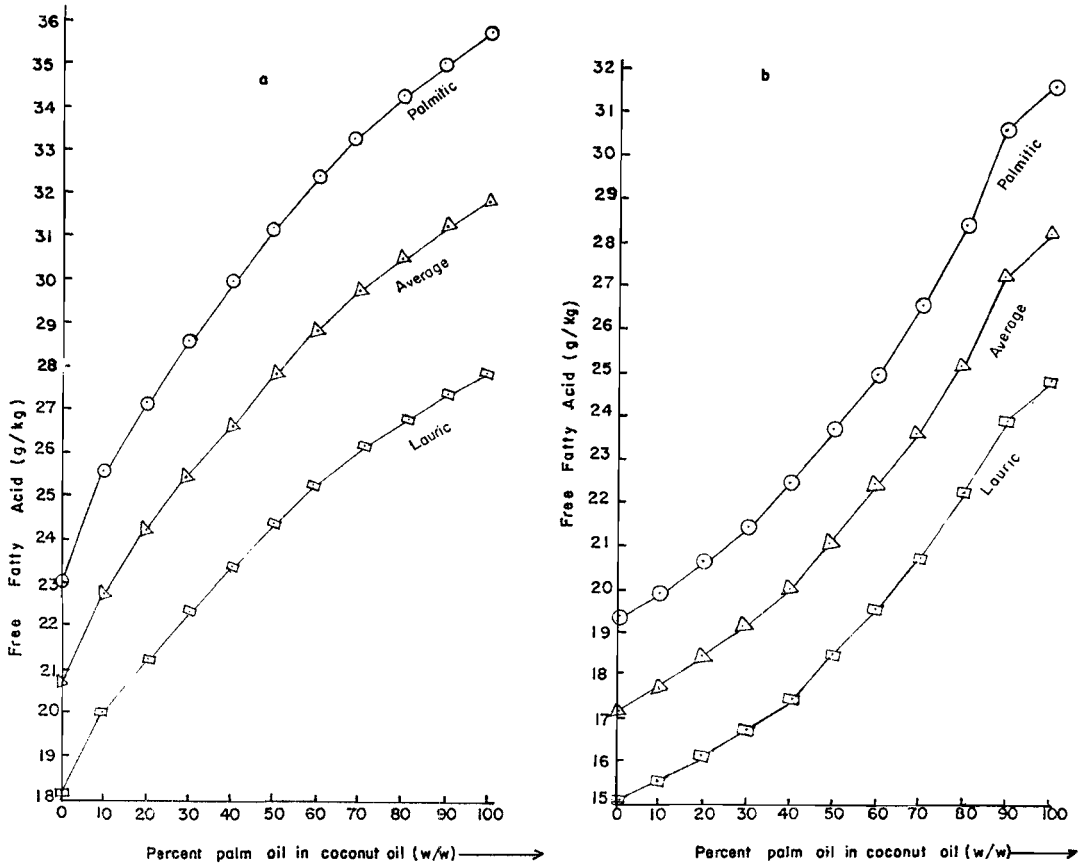

Fig.1 Effect of Coconut Oil Concentration and Exposure on the Free Fatty Acid Content of Palm Oil, (a) Exposed (b) Unexposed

RESULTS AND DISCUSSION

[illegible] the oil blends

Free fatty acids were calculated both as palmitic and lauric acids to represent contributions from palm and coconut oils respectively. Palmitic and lauric acids are the major constituent fatty acids in palm and coconut oils respectively and were therefore chosen as the reference fatty acids for calculating the free fatty acid contents of the respective oil samples. The average of the two are also indicated on the graph. The values of FFA are obtained for both exposed and unexposed samples. The FFA obtained for the unexposed palm oil agrees with the acceptable limit (<3.5%) set by Standards Organization of Nigeria[10]. A general increase in FFA with increase in palm oil concentration was observed for each of the determinations, reflecting the relative oxidative stability of coconut oil compared to palm oil. Oil samples exposed to normal room conditions (room temperature, 28°C) were observed to have higher FFA values than the correspouding unexposed samples.

A plot of the FFA against the oil concentration gave interesting results (Fig. 1). The graph shows that FFA increases as palm oil concentration increases in both unexposed and exposed samples although in different ways. A better understanding of the changes taking place required the calculation of rate constants for the changes in free fatty acid levels. Investigations[11,12] have shown that the rate constant, k, is related to free fatty acid concentration according to the expression

$$k = 2.303/(t_2 - t_1) \log [FFA]_2/[FFA]_1$$

where $[FFA]_1$ and $[FFA]_2$ are concentrations of free fatty acid at time t_1 and t_2 respectively. The rate of a reaction can also be expressed as a function of change in concentration, in which case the rate constant expression becomes

$$k = 2.303/(C_2-C_1) \log [FFA]_2/[FFA]_1$$

where C_2-C_1 is the change in concentration between two successive readings and the other terms are as before. The latter expression was therefore used in the calculation of rate constants given in Table 1 based on the average FFA and the concentration of palm oil (PO). Calculation based on coconut oil (CO) concentrations gave similar but negative rate constants, reflecting the inverse relationship between the concentration of CO in the oil blends and free fatty acid. The data in Table 1 show a decrease in rate constants with increase in palm oil (or decrease in coconut oil) concentration for exposed oil, while the reverse is the case for unexposed oil samples. The data are represented graphically in Fig. 2.

From this graph (and Table 1) it is observed that for the exposed oil, the rate constants decrease rapidly initially and then level out as the concentrations of palm oil increase. For the unexposed samples, the reverse is indicated. Although both the exposed and unexposed oil samples show a general increase in FFA formation with increasing concentration of palm oil, the rate of increase in FFA in the exposed oil samples decreases as the palm oil concentration increases whereas the rate of increase in the unexposed samples increases with increasing palm oil concentration, which explains the inverse relationship in FFA formation between the exposed and unexposed oil samples (Fig. 1)

It is not immediately clear from these data, the cause(s) of the differences in the relative rates of free fatty acid formation between the exposed and unexposed samples. It is, however, possible that there are other factors operating in the case of the exposed samples than the expected hydrolytic cleavage of the glyceride molecule to give the free fatty acids. The samples exposed to air and moisture could have light initiated reaction products such as hydroperoxides, carbonyl compounds and polymers, resulting from the attack of oxygen molecule on the

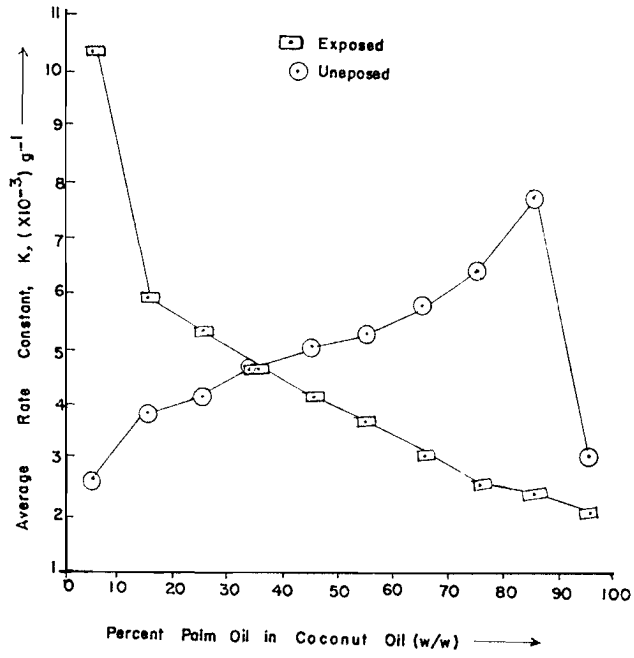

Fig. 2 Rate of formation of free fatty acid against oil composition

double bonds of the triglyceride molecule. The presence of these oxidation products could have affected the formation of FFA as the reaction progressed in the exposed oil samples.

Melting points of the oil samples

Fig. 3 shows a graph of melting point versus the oil composition for the exposed and unexposed samples. The average melting points for unexposed palm oil is 29.3°C, and for exposed oil, 31.8°C. The average melting points for coconut oil were 23.0°C for unexposed sample and 24.0°C for exposed sample. The melting point increased with increase in palm oil concentration (Fig. 3). The higher melting points of exposed samples may be attributed to the increase in free fatty acid contents and the presence of other products in these samples. The smaller increase in melting point between exposed and unexposed coconut oil sample (1°C) shows that coconut oil forms FFA at a slower rate than palm oil which has an increase of 2.5°C.

The narrow melting point range for coconut oil accounts for the limited plastic range of the oil[2]. Palm oil on the other hand, has a higher melting point and a wider plastic range. Thus blending the two oils in desired proportions could give the desired melting point or plastic range for specific consumer requirements.

CONCLUSION

The results obtained from this study have shown that the quality parameters of palm oil and coconut oil could be modified to suit specific food and non-food applications by blending the oils.

Exposure of the oil samples to normal laboratory conditions showed an inverse relationship in the rate of formation of free fatty acids between the exposed samples and the controls. Much of the changes taking place in the samples appeared to be centered round the 40 to 50% portion of the oil blends.

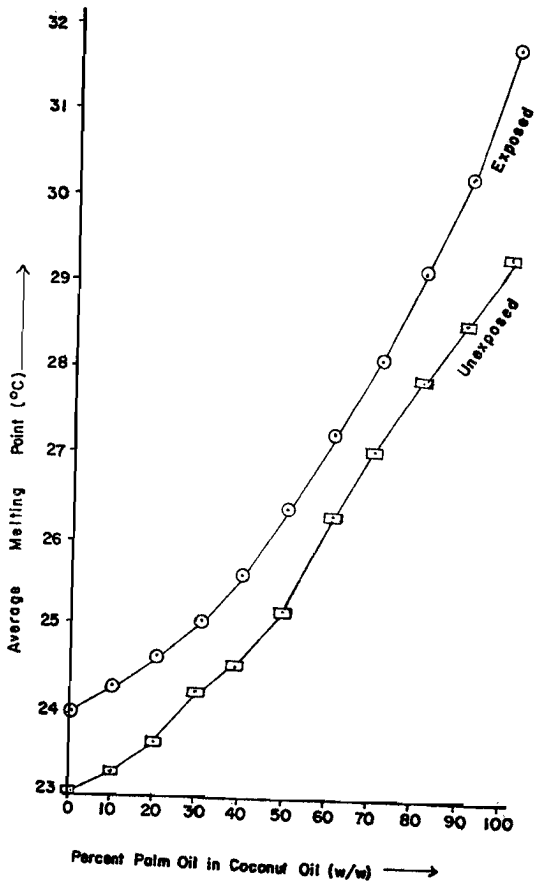

Fig. 3 Effect of Coconut Concentration and Exposure on Melting Point of Palm Oil

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