Elaeis Vol. 7 No.1, June 1995, pp. 64 – 86.

CLARITY AND CHEMICAL COMPOSITION OF PALM OLEIN-SUNFLOWER AND PALM OLEIN -SAFFLOWER OIL BLENDS

Keywords: Clarity; blends; palm olein; sunflower oil; safflower oil; cloud point and fatty acid composition.

NOR AINI, I; HANIRAH, H AND TANG, T S*

Double fractionated palm olein samples of iodine value (IV) 60 (DfPOo IV 60) and IV 65 (DfPOo IV 65) were blended with sunflower oil (SFO) and high-oleic safflower oil (SAFO) in various proportions. The clarity of the blends was determined after storage at various temperatures. The maximum levels of DfPOo IV 65 that could be mixed with SFO and SAFO to give blends that remained clear for at least 240 days at 20°C were 60 and 70% respectively. With DfPOo IV 60, the levels were 30% and 60% respectively. At 15°C, with both SFO and SAFO the maximum levels were 20% with DfPOo IV 60 and 30% with DfPOo IV 65. At 10°C, all blends containing 20% palm olein except DfPOo IV 60 -SFO and SAFO 20:80 remained clear for about 180 days. At 5°C, blends containing 10% palm olein and 90% SFO remained clear for 90 days. Blends of either SFO or SAFO with, up to 20% DfPOo IV 60 or 30% DfPOo IV 65 passed the cold test. Blending of SFO or SAFO with DfPOo improved the fatty acid composition in terms of the saturated: monosaturated: polyunsaturated ratio.

INTRODUCTION

Sunflower oil (SFO) is the fourth most important edible oil in the world in terms of production and consumption, after soya bean,

*Palm Oil Research Institute of Malaysia
P.O. Box 10620
50720 Kuala Lumpur, Malaysia
Original manuscript received: 24 August 1994
Revised manuscript received: 6 December 1994

palm and rapeseed oils. The countries which comprised the former USSR are the largest producers of SFO, followed by Argentina and China (Fick, 1989). The annual production of safflower oil (SAFO) is rather small as compared with that of other seed oils. India is the largest producer, followed by Mexico and the USA (Knowles, 1989). Both SFO and SAFO oils are used in the manufacture of mayonnaise, salad dressings, margarines, spreads, and frying oils.

In an earlier study, Teah and Ahmad (1991) reported that blends of SFO with 50% to 70% single fractionated palm olein crystallized at 10°C. They also reported that a blend of 30% double fractionated palm olein with 70% SFO would be suitable for temperate climates. Nor Aini *et al.* (1992) determined the resistance to crystallization of palm olein (POo) with soya bean oil at different temperatures. They reported that POo of iodine value 65 (POo IV65) was more resistant to crystallization than POo IV60 or IV63. Their study also showed that for applications such as salad oil, the use of POo IV65 is limited to 30% when blended with soya bean oil and that the use of POo IV60 or IV63 is limited to only 10% . However, little is known about the clarity of blends of POo with SAFO. This paper reports a more extensive study carried out on the clarity of blends of double fractionated palm olein (DfPOo) with SFO, and a comparison is made with the clarity of DfPOo SAFO blends. The fatty acid and triglyceride compositions of the blends were also studied.

MATERIALS AND METHODS

Double fractionated palm oleins of IV 60 and 65 were obtained from a local refinery. SFO and SAFO were imported from the USA. The latter was of the high-oleic type, not the standard high-linolenic SAFO. The oil blends were prepared in the same way as reported previously (Nor Aini *et al.*, 1992). However, in this study, the blends were placed in 160 ml plastic bottles instead of 120 ml glass bottles. Before transferring the samples into plastic bottles, they were first heated to 70°C. Then they were cooled and stored at 5°C, 10°C, 15°C and 20°C. Observations to determine the clarity of the samples were conducted, daily for the first 2 months, at intervals of 10 days for the next 4 months, and at intervals of 20 days thereafter.

Cloud point was determined according to AOCS Method Cc 6-25 (AOCS, 1989). The cold test at 0°C was conducted according to AOCS Method Cc 11-53 (AOCS, 1989).

Determination of fatty acid composition

Fatty acids were determined as methyl esters which were prepared and analysed according to the following procedures: The oil (50 mg) was weighed in a 2 ml screw-capped vial. Hexane (1 ml) and sodium methoxide solution (0.05 ml) were added, the mixture was shaken with a vortex mixer and then left to stand. 1 µl of the clear upper ester layer was injected into a Hewlett Packard 5890 II gas chromatograph fitted a with polar SP-2340 (Supelco, USA) capillary column (0.25 mm id × 60 m × 0.2 µm). The conditions used were: injector temperature, 250°C; FID detector, 250°C; oven temperature 195°C; carrier, He (1 ml/min) and split ratio 1:100. Quantification was carried out by calibration using a mixture of methyl esters of known composition. Total saturates, monounsaturates and polyunsaturates were calculated from the fatty acid composition thus determined.

Determination of triglyceride composition by carbon number

The sample of oil was dissolved in chloro-form to give a 2% solution and 1 µl of this was injected into the Hewlett Packard 5890 II chromatograph equipped with column (0.53 mm id × 12 m × 0.15µm) coated with 5% siloxane-carborane copolymer. The conditions used were: injection temperature, 380°C; FID detector temperature, 280°C; oven temperature programming: 280°C–340°C at 4.5°C/min. Quantification was carried out by calibration using a pure triglyceride mixture of known composition.

RESULTS AND DISCUSSION

The cloud points of DfPOo IV60 and DfPOo IV 65 were 3.8°C and 2.0°C, respectively. SFO,

with 61.9% polyunsaturated fatty acids (PUFA), had a lower cloud point (–10.4°C) than SAFO (–9.1°C) which contained only 12.6% PUFA. The saturated fatty acid contents of SFO and SAFO were 9.1% and and 9.9%, respectively. Blending of DfPOo with increasing levels of SFO and SAFO resulted in a lowering of the cloud points (*Table 1*).

The lowering of the cloud points of the blends was related to the decrease in amount of saturated fatty acid (SAFA) as more and more SFO or SAFO was incorporated. There appeared to be a eutectic interaction in blends of SAFO with both palm oleins at a ratio of 10:90, *i.e.* 10% of palm olein in the blends. Such an interaction was not observed in POo-SFO blends. Blends of SAFO with 10% to 30% POo IV60 had lower cloud points than blends of SFO with DfPOo IV60 of similar composition. On the other hand, blends of SAFO with 40% to 90% DfPOo IV60 had slightly higher cloud points than those of DfPOo IV60-SFO blends. The cloud points of blends of SFO with POo IV65 were lower than those of blends with POo-IV60; the same was true for blends of SAFO with more than 20% of POo IV65.

The terms of the cold test state that the oil must remain clear for 5.5 hr at 0°C (AOCS, 1989). This study showed that up to 20% DfPOo IV60 could be blended with SFO or SAFO with acceptable ('positive') results in the cold test (*Table 2*). With DfPOo IV65, however, blends containing up to 30% gave a positive results. In the previous study with soya bean oil (Nor Aini *et al.*, 1992), only 10% DfPOo could be incorporated if the blend was to pass the cold test, while with DfPOo IV65, up to 30% could be used.

The duration of clarity of blends of DfPOo IV60 and IV65 with SFO and SAFO at 5°C is shown in *Table 3*. The results indicated that at 5°C, blends containing 90% SFO remained clear for 90 days. However, blends of DfPOo and SAFO in the same ratio remained clear for less than 17 days (with DfPOo IV60) or for 25 days (with DfPOo IV65). *Figure 1* shows the changes in physical appearance of DfPOo IV65-SAFO blends from day 20 to day 60. A blend consisting of 10% DfPOo IV65 with 90% SAFO remained clear on day 20 but not on day 40 or thereafter. *Figures 2* and *3* show the appearance of DfPOo-SAFO and DfPOo blends

TABLE 1. CLOUD POINTS[a] (°C) OF PALM OLEIN-SUNFLOWER OIL AND PALM OLEIN-SAFFLOWER OIL BLENDS

Blend ratio[b]	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
0:100	–10.4	–9.1	–10.4	–9.1
10:90	–9.5	–10.0	–9.8	–9.8
20:80	–7.5	–9.0	–8.0	–8.0
30:70	–6.5	–7.0	–7.0	–7.6
40:60	–4.5	–3.9	–5.7	–5.6
50:50	–2.7	–2.5	–4.5	–4.7
60:40	–1.5	–1.0	–3.3	–3.0
70:30	0.5	1.4	–2.1	–3.5
80:20	2.0	2.3	–0.7	–1.5
90:10	3.5	3.6	1.0	0.8
100:0	3.8	3.8	2.0	2.0

[a]AOCS method.
[b]Palm olein: SFO or SAFO

TABLE 2. RESULTS OF COLD TEST[a] ON PALM OLEIN-SUNFLOWER OIL AND PALM OLEIN-SAFFLOWER OIL BLENDS

Blend ratio	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
0:100	Positive	Positive	Positive	Positive
10:90	Positive	Positive	Positive	Positive
20:80	Positive	Positive	Positive	Positive
30:70	Negative	Negative	Positive	Positive
40:60	Negative	Negative	Negative	Negative
50:50	Negative	Negative	Negative	Negative
60:40	Negative	Negative	Negative	Negative
70:30	Negative	Negative	Negative	Negative
80:20	Negative	Negative	Negative	Negative
90:10	Negative	Negative	Negative	Negative
100:0	Negative	Negative	Negative	Negative

[a]AOCS Method.

TABLE 3. DURATION OF CLARITY (days) OF BLENDS OF DFPOo-IV60 AND IV65 WITH SUNFLOWER AND SAFFLOWER OILS AT 5°C

Blend ratio	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
10:90	90	< 17	90	25
20:80	< 5	3	7	4
30:70	< 3	1	3	2
40:60	< 1	< 1	> 1	< 2
50:50	< 1	< 1	< 1	< 1
60:40	< 1	< 1	< 1	< 1
70:30	< 1	< 1	< 1	< 1
80:20	< 1	< 1	< 1	< 1
90:10	< 1	< 1	< 1	< 1

TABLE 4. DURATION OF CLARITY (days) OF BLENDS OF DFPOo-IV60 AND IV65 WITH SUNFLOWER AND SAFFLOWER OILS AT 10°C

Blend ratio	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
10:90	> 240	180	> 240	180
20:80	180	37	180	180
30:70	< 10	4	20	10
40:60	< 5	2	< 10	3
50:50	< 1	< 2	< 5	< 2
60:40	< 1	< 2	< 3	< 2
70:30	< 1	1	< 1	1
80:20	< 1	< 1	< 2	< 1
90:10	< 1	< 1	< 2	< 1

TABLE 5. DURATION OF CLARITY (days) OF BLENDS OF DFPOo-IV60 AND IV65 WITH SUNFLOWER AND SAFFLOWER OILS AT 15°C

Blend ratio	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
10:90	> 240	> 240	> 240	> 240
20:80	> 240	> 240	> 240	> 240
30:70	< 120	< 120	240	240
40:60	< 5	< 30	150	150
50:50	< 5	< 10	< 10	18
60:40	< 5	< 10	< 10	< 10
70:30	< 1	< 2	< 5	< 10
80:20	< 1	< 2	< 3	< 2
90:10	< 1	< 1	< 2	< 2

TABLE 6. DURATION OF CLARITY (days) OF BLENDS OF DFPOo - IV60 AND IV65 WITH SUNFLOWER AND SAFFLOWER OILS AT 20°C

Blend ratio	Palm olein IV60:		Palm olein IV65:	
	Sunflower	Safflower	Sunflower	Safflower
10:90	> 240	> 240	> 240	> 240
20:80	> 240	> 240	> 240	> 240
30:70	> 240	> 240	> 240	> 240
40:60	< 90	220–240	> 240	> 240
50:50	< 60	220–240	> 240	> 240
60:40	< 60	220–240	> 240	> 240
70:30	< 10	< 10	> 180	240
80:20	< 10	< 40	< 40	< 120
90:10	< 10	< 10	< 40	< 60

TABLE 7. FATTY ACID COMPOSITIONS OF DOUBLE FRACTIONATED PALM OLEIN (DFPOo) IV60, IV65, SUNFLOWER OIL (SFO) AND SAFFLOWER OIL (SAFO)

Fatty acid Composition (wt %)	DfPOo IV 60	DfPOo IV65	SFO	SAFO
12:0	0.3	0.3		0.1
14:0	1.0	1.0		0.1
16:0	6.6	33.9	5.4	6.3
18:0	4.0	3.4	3.3	2.1
18:1	46.0	47.4	18.8	78.4
18:2	11.8	13.4	71.8	12.2
18:3	0.1	0.3	0.4	0.4
20:0	0.2	0.1	–	0.2
SAFA	42.1	38.1	9.1	9.9
MUFA	46.0	47.4	28.9	77.5
PUFA	11.9	13.7	61.9	12.6
I.V.	60.3	64.8	141.6	109.6

SAFA = saturated fatty acid
MUFA = monounsaturated fatty acid
PUFA = polyunsaturated fatty acid
IV = iodine value.

a

b

c

Figure 1. Physical appearance of double fractionated palm olein IV65-Safflower oil blends at 5°C on a) day 20, b) day 40 and c) day 60.

a b

Figure 2. Appearance of a) double fractionated palm olein IV60-Sunflower Oil Blends and b) double fractionated palm olein IV65-Sunflower Oil Blends on day 90.

a b

Figure 3. Appearance of a) double fractionated palm olein IV60-Safflower Oil Blends and b) double fractionated palm olein IV65-Safflower oil blends at 5°C on day 90.

a

b

c

Figure 4. Appearance of double fractionated palm olein IV60-Sunflower Oil Blends at 10°C on a) day 60, b) day 180 and c) day 240.

Figure 5. Appearance of double fractionated palm olein IV60-Safflower Oil Blends at 10°C on a) day 60, b) day 180 and c) day 240.

a

b

c

Figure 6. Appearance of double fractionated palm olein IV60-Sunflower Oil Blends at 15°C on a) day 60, b) day 180 and c) day 240.

Figure 7. Appearance of double fractionated palm olein IV60-Safflower Oil Blends at 15°C on a) day 60, b) day 180 and c) day 240.

a

b

c

Figure 8. Appearance of double fractionated palm olein IV60-Sunflower oil blends at 15°C on a) day 60, b) day 180 and c) day 240.

a

b

c

Figure 9. Appearance of double fractionated palm olein IV65-Safflower Oil Blends at 15°C on a) day 60, b) day 180 and c) day 240.

a

b

c

Figure 10. Appearance of double fractionated palm olein IV60-Sunflower Oil Blends at 20°C on a) day 60, b) day 180 and c) day 240.

a

b

c

Figure 11. Appearance of double fractionated palm olein IV60-Safflower Oil Blends at 20°C on a) day 60, b) day 180 and c) day 240.

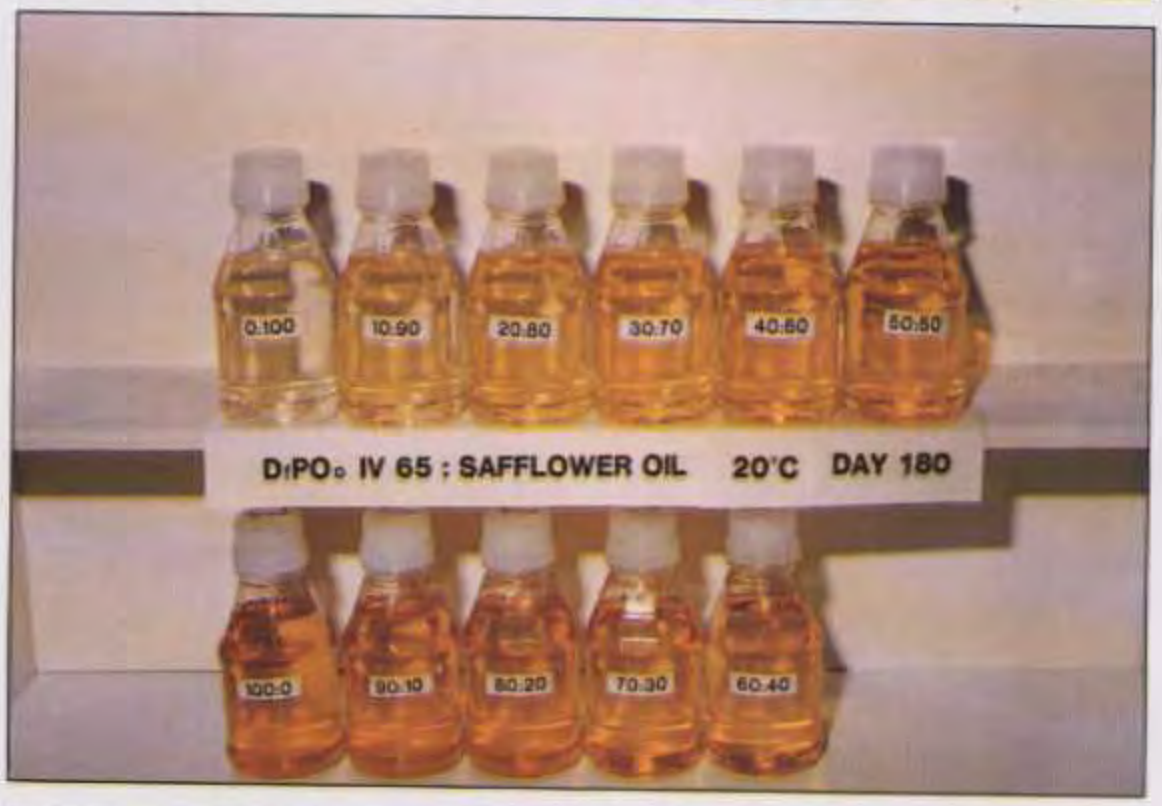
a

b

c

Figure 12. Appearance of double fractionated palm olein IV65-Sunflower Oil Blends at 20°C on a) day 60, b) day 180 and c) day 240.

a



b

c

Figure 13. Appearance of double fractionated palm olein IV65-Safflower Oil Blends at 20°C on a) day 60, b) day 180 and c) day 240.

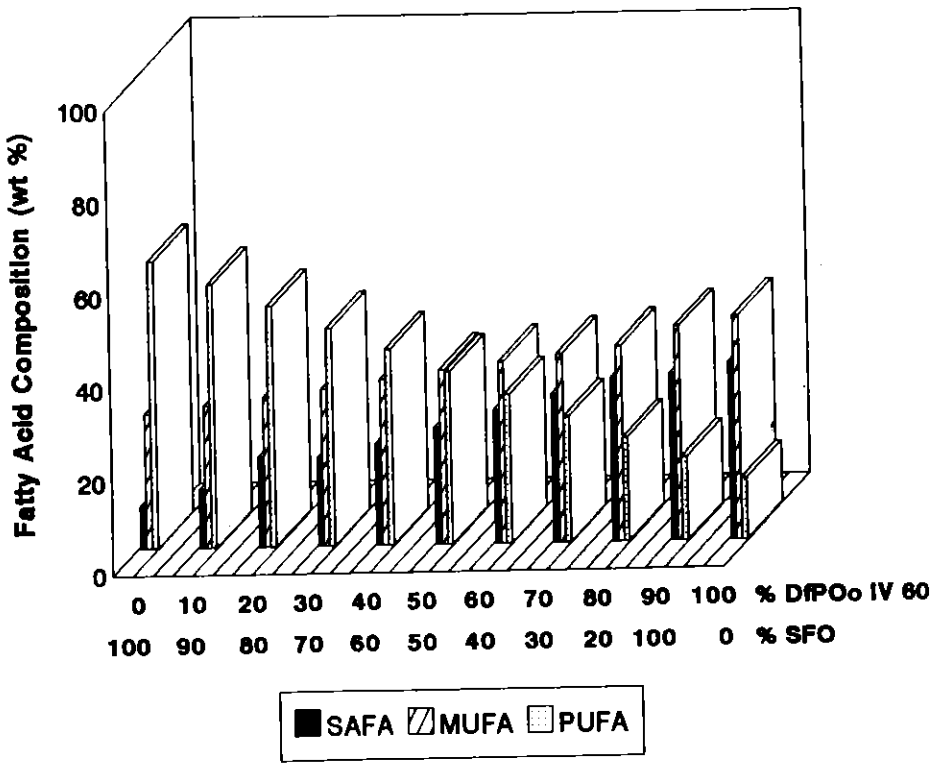


Figure 14(a). Saturated, monounsaturated and polyunsaturated fatty acid composition (wt %) of blends of DfPOo IV 60 with SFO.

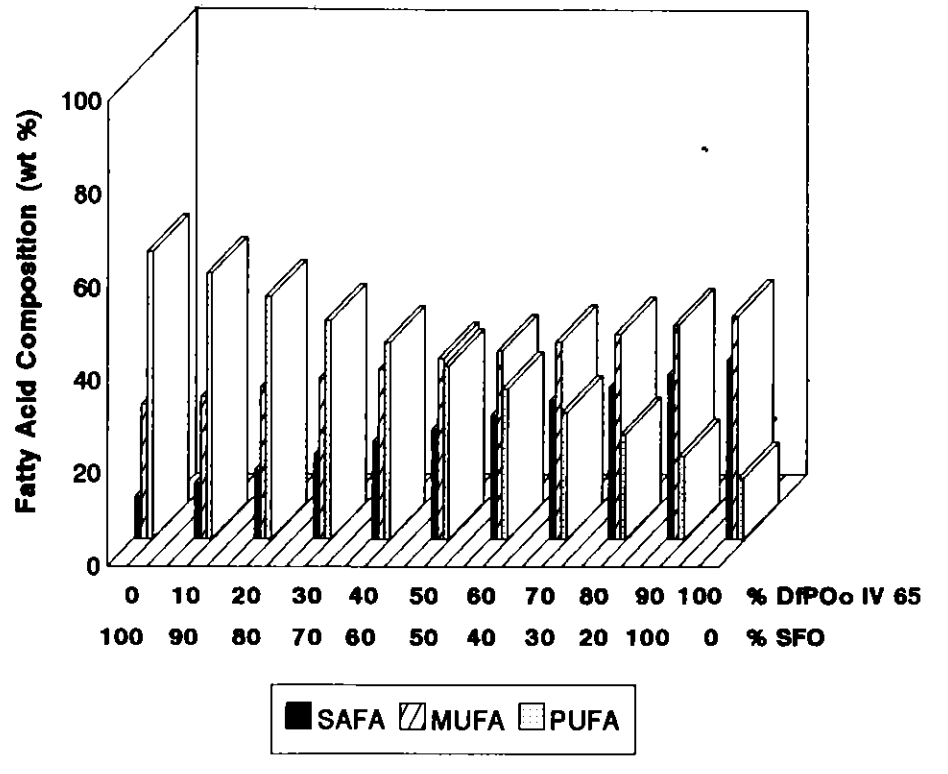


Figure 14(b). Saturated, monounsaturated and polyunsaturated fatty acid composition (wt %) of blends of DfPOo IV 65 with SFO.

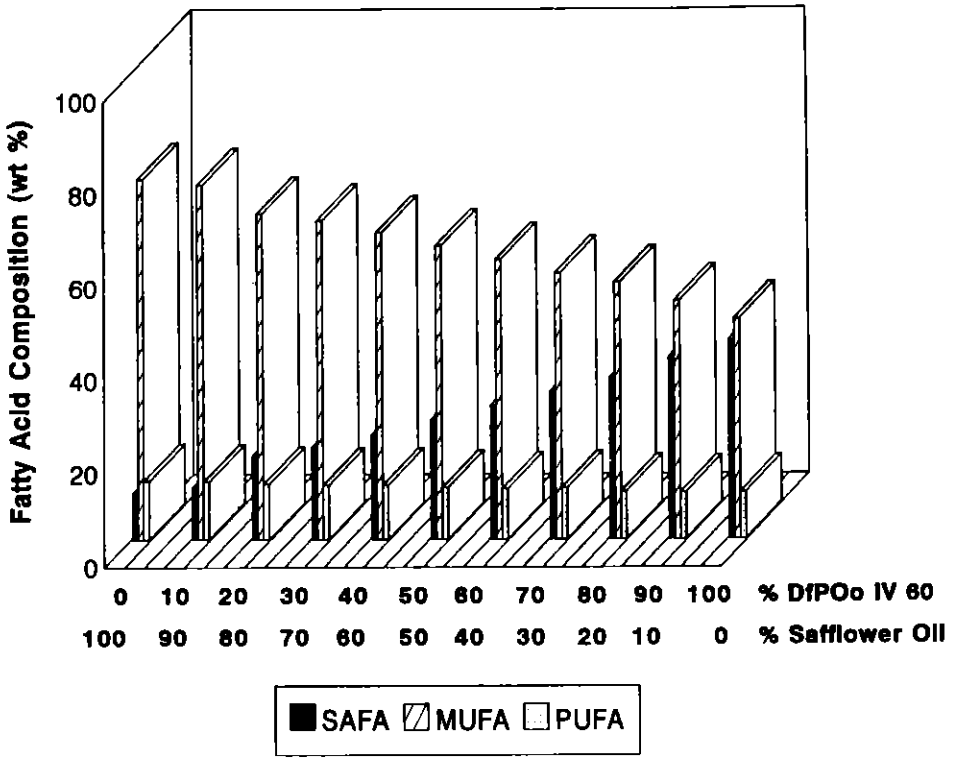


Figure 15(a). Saturated, monounsaturated and polyunsaturated fatty acid composition (wt %) of blends of DfPOo IV 60 with safflower oil.

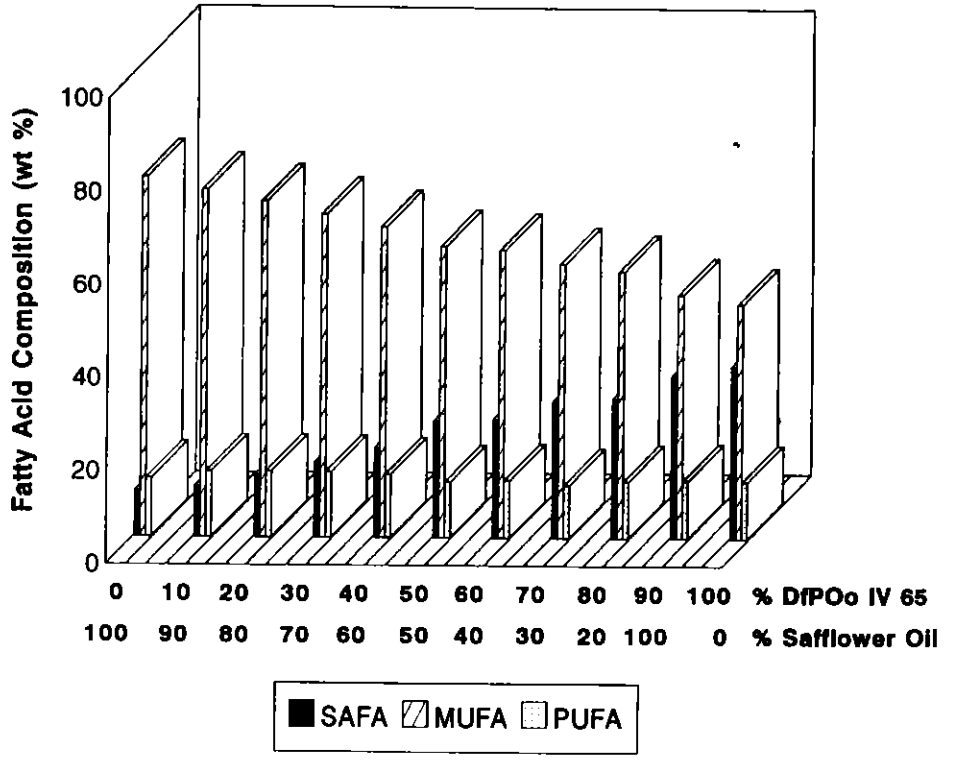


Figure 15(b). Saturated, monounsaturated and polyunsaturated fatty acid composition (wt %) of blends of DfPOo IV 65 with safflower oil.

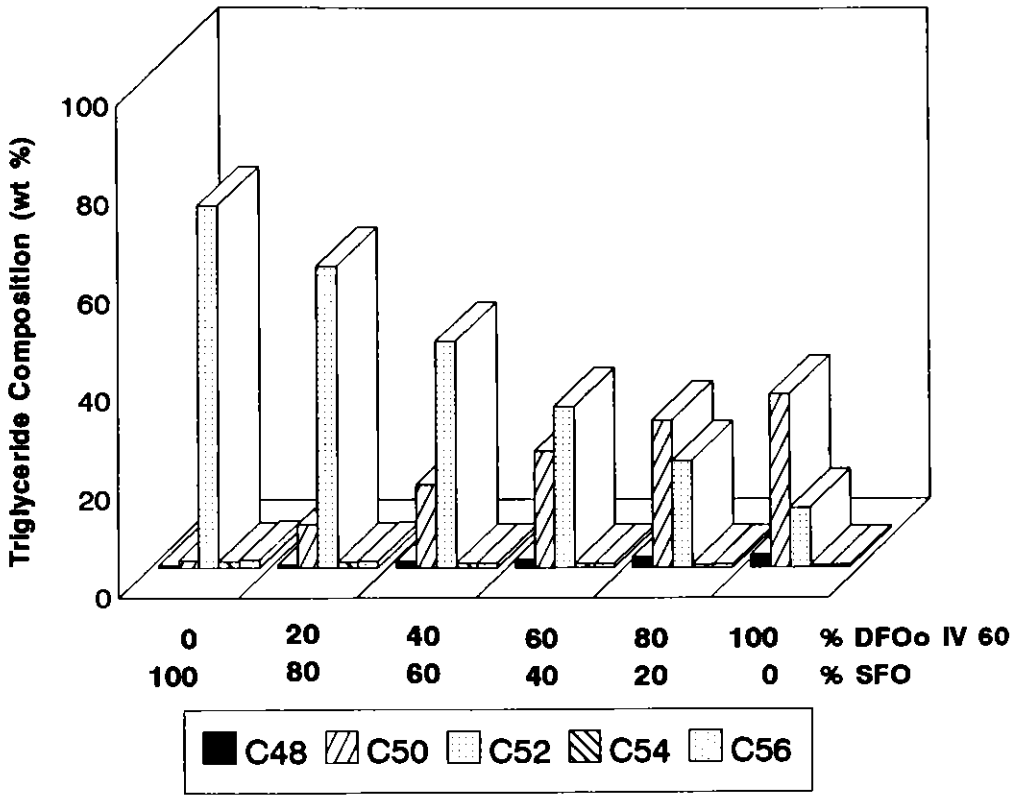


Figure 16. Triglyceride composition (wt %) of DfPOo IV 60-SFO Blends.

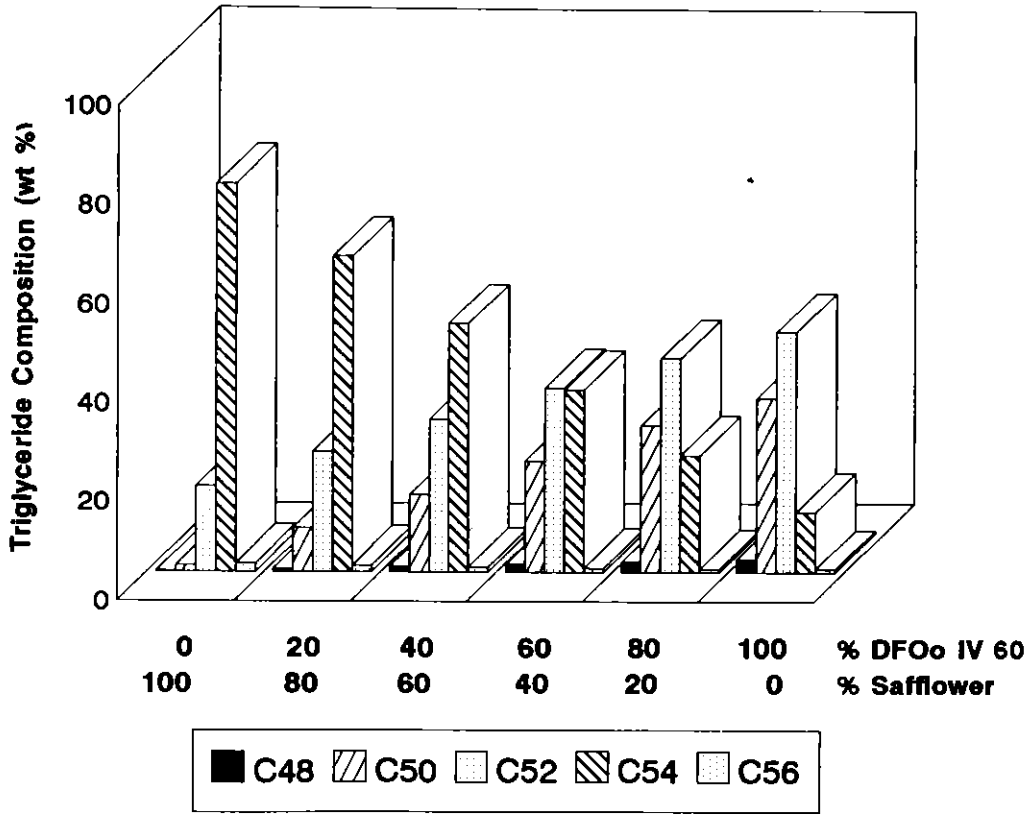


Figure 17. Triglyceride composition (wt %) of DfPOo IV 60-Safflower Oil Blends.

on day 90, respectively. A blend consisting of either 10% DfPOo IV60 or IV65 with 90% SFO was clear but the DfPOo-safflower oil blends were not. The better clarity of SFO blends was evidently due to the higher PUFA content in SFO (61.9%) than in SAFO (12.6%).

At 10°C, similar trends were observed: POo-SFO blends generally remained clear longer than did POo-SAFO blends (*Table 4*). *Figures 4* and *5* show the appearance of DfPOo IV60-SFO and DfPOo-SAFO blends at 10°C, on day 60, day 180 and day 240. Blends containing 10% DfPOo IV60 with 90% SFO remained clear for more than 240 days (8 months) as compared with 180 days (6 months) for DfPOo -SAFO blends in the same ratio. There seemed to be no direct relationship between cloud point and the time the blends remained clear. This is in agreement with previous findings (Nor Aini *et al.*, 1993).

Better stability was observed in samples kept at 15°C (*Figures 6* to *9*). All blends containing 10% and 20% DfPOo remained clear for more than 240 days (*Table 5*). Although blends containing 30% DfPOo IV65 remained clear for at least 240 days, those containing 30% DfPOo IV60 remained clear for only 120 days. Blends containing 40% DfPOo IV65 with either SFO or safflower oil remained clear for 150 days, but those with 40% DfPOo IV60 remained clear for considerably shorter times. We noted better clarity in blends containing DfPOo IV60 with 20%–60% SAFO than in similar blends with SFO (*Table 5*).

Much better stability was achieved at 20°C (*Table 6* and *Figures 10* to *13*). Up to 60% DfPOo of both IVs could be blended with either SFO or SAFO to give oils that remained clear for more than 240 days. With DfPOo IV60, better duration of clarity was obtained when the oil was blended with SAFO than when it was blended with SFO. Throughout the study, 100% SFO and 100% SAFO remained clear for more than 240 days when stored at 10°, 15° or 20°C.

In the previous study with soya bean oil (Nor Aini *et al.*, 1992), the resistance of the blends to crystallization was reported for the period up to day 120. However, observations were continued on the same samples and it was noted that a blend of DfPOo IV 60 with SBO in the ratio 10:90 remained clear at 15°C for more than 8 months – thus behaving like DfPOo IV60-SFO and DfPOo IV60-SAFO blends in the same ratio in the present study. Comparing SFO and SAFO with SBO, a higher percentage of DfPOo could be mixed with SFO or SAFO to give blends remaining clear for the same time. A higher percentage (30%) of DfPOo IV65 could be blended with SBO to give an oil which stayed clear for more than 8 months at 15°C. At 20°C, as much as 60% DfPOo IV65 could be blended with SBO to give an oil that was clear for more than 8 months.

Table 7 shows the fatty acid compositions of the raw materials used in the present study. SFO was rich in PUFA, with of 61.9%; it had a moderate level (28.9%) of monounsaturated fatty acid (MUFA), and a saturated fatty acid (SAFA) content of 9.1 per cent. On the other hand, DfPOo IV 60 contained 42.1% SAFA, 46.0% MUFA and 11.9% PUFA, while DfPOo IV 65 contained 38.1%, 47.4% and 13.7% of SAFA, MUFA and PUFA, respectively. With increasing amounts of DfPOo in the blends, the PUFA content decreased significantly while MUFA and SAFA increased. From nutritional point of view, the ratio of SAFA, MUFA and PUFA of 1:1:1 is recommended for dietary fats. Of course this recommendation refers to the total fat from all sources in an individual's diet, but it is still interesting to consider the SAFA: MUFA: PUFA ratio in individual oils and blends, especially since in some diets the cooking oil used contributes a high percentage of the total fat.

100% SFO used in this study had a SAFA:MUFA:PUFA ratio of 1:3.2:6.9 while the ratios for DfPOo IV60 and 65 were 1:1.26:0.34 and 1:1.25:0.34, respectively. By blending SFO with DfPOo IV 60, a more balanced ratio can be obtained. Blends containing 60% DfPOo IV 60 and 40% SFO gave a SAFA:MUFA:PUFA ratio of 1:1.36:1.11 while a similar blend with DfPOo IV 65 gave a ratio of 1:1.51:1.21.

SAFO is very rich in MUFA (77.5%). Its PUFA content is slightly higher (12.6%) than that of DfPOo and its SAFA content is lower (9.9%). The ratio of SAFA:MUFA:PUFA in safflower oil was 1:7.83:1.27. Blending safflower oil with DfPOo significantly decreased the MUFA but increased the SAFA. There was only a slight decrease in PUFA. The ratio of SAFA:MUFA:PUFA in DfPOo-SAFO

blends was not as good as in DfPOo-SFO blends. A blend consisting of 60% DfPOo IV 60 with 40% SAFO had a SAFA:MUFA:PUFA ratio of 1:2.09:0.38 while with DfPOo IV 65 and SAFO in the same proportions it was 1:2.43:0.48.

Both SFO and SAFO are very rich in C_{54} triglycerides with contents of 74% and 78.6%, respectively. They have moderate amounts of C_{52}: 19.6% in SFO and 17.3% in SAFO. On the other hand, DfPOo IV 60 is rich in C_{52} (49.9%), followed by C_{50} (35.4%) and C_{54} (12.2%). DfPOo IV65 is also rich in C_{52} (51.4%), followed by C_{50} (25.8%) and C_{54} (19.6%). The C_{54} content in blends decreased and that of C_{50} and C_{52} increased with increasing percentages of DfPOo IV60. Similar trends were also observed in blends of SFO and SAFO with DfPOo IV65.

CONCLUSIONS

At 5° and 10°C, blends of DfPOo with higher percentages (70%–90%) of SFO generally showed better clarity than blends of similar composition with SAFO. On the other hand, at 15° and 20°C, better clarity was observed when DfPOo IV60 was blended with SAFO than when it was blended with SFO. Either SFO or SAFO could be blended with up to 30% DfPOo IV65 or up to 20% DfPO IV60 for use as salad oil. Blending SFO with DfPOo shifted the SAFA:MUFA:PUFA ratio closer to the nutritionally recommended value of 1:1:1. SAFO was less useful in this respect.

REFERENCES

AOCS (1969). Official and Tentative Methods of the American Oil Chemists' Society. 4th edn, edited by D. Firestone, American Oil Chemists' Society, Champaign.

FICK, G N (1989). Sunflower. In: Oil Crops of the World, edited by , G.N. (1989) Sunflower. In *Oil Crops of the World*, edited by G. Robbelen. R.K. Downey and A. Ashri. McGraw-Hill Publishing Co. New York. pp. 301–318.

KNOWLES, P F (1989). Safflower. *Ibid.* pp. 363–374.

NOR AINI, I; HANIRAH, H; FLINGOH, C H and SUDIN, N (1992). Resistance to crystallization of blends of palm olein with soybean oil stored at various temperatures *JAOCS* 69: 1206–1209.

PORIM Test Methods (1990). Palm Oil Research Institute of Malaysia.

TEAH, Y K and AHMAD, I (1991). Palm olein improves cooking oil blends. *Palm Oil Developments No. 15,* 2–8, Palm Oil Research Institute of Malaysia.

TIMMS, R E (1978). Artefact Peaks in the Preparation and Gas-Liquid Chromatographic Determination of Methyl Esters. *Aus. J. Dairy Tech. 3*: 4.