Clarity of Blends of Double-Fractionated Palm Olein with Low-Erucic Acid Rapeseed Oil

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ABSTRACT: Double-fractionated palm olein (DfPOo) fractions with iodine values (IV) of 60 and 65 were each blended with low-erucic acid rapeseed (LEAR) oil in various proportions. Clarities of the blends at different temperatures were determined. Maximum levels of DfPOo–IV60 and DfPOo–IV65 in blends that remained clear at 20°C for at least 120 d were 40 and 80%, respectively. At 15°C, the maximum levels were 10 and 40%, and at 10°C, 10 and 20%, respectively. At 5°C, only a blend of 10% DfPOo–IV65 in LEAR remained clear for 120 d. Maximum levels of DfPOo–IV60 and DfPOo–IV65 in blends that passed the cold test were 30% for both palm oleins. Maximum levels of the palm oleins in blends with LEAR were higher than those of blends with soybean oil. Cloud points were lower in palm olein/LEAR blends than those of palm olein/soybean oil blends, probably because LEAR contains less saturated fatty acids than soybean oil.

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KEY WORDS: Blends, clarity, cloud point, double-fractionated palm olein, fatty acid composition, fractionation, low-erucic acid rapeseed oil, palm oil, solid-fat content.

In the last two decades, palm oil has grown in prominence in the world's oils and fats market, and has been widely used in food preparation. Its major use is in industrial frying, but it is also used as feedstock in the manufacture of margarine, shortening, and vanaspati (1). Industrial frying operations require fats that are stable against oxidation and polymerization. Therefore, liquid oils (e.g., soybean, canola, sunflower oils) are hydrogenated to eliminate the oxidation-prone 18:3 acid and to reduce the 18:2 fatty acid content. Hydrogenation also produces *trans* and isomeric fatty acids. The oils become solids or pourable semi-solids. Palm oil does not require hydrogenation and can be texturized as a solid fat. Palm oil is fractionated to separate the solid fat from the liquid oil. The liquid fraction is known as palm olein (POo) and is readily available in the retail market for household use. On occasion, POo can crystallize (become cloudy) upon storage, especially in nontropical countries. Because the consumer perceives a cloudy oil as a deteriorated oil, it is important to prevent crystallization.

Rapeseed is an important oilseed crop, and in Canada it is second only to wheat in area planted (2). While high-erucic acid rapeseed oil is widely used in lubricant manufacture and in other industrial processes, low-erucic acid rapeseed oil (LEAR) is utilized as a cooking and as a salad oil, and in the manufacture of margarines and shortenings, as well (3).

Oils used in the manufacture of mayonnaise or salad dressings must remain clear at refrigerated temperatures, or else the emulsions will not be stable. Due to its low saturates content, LEAR has excellent cold stability (3). Soybean oil, when used for mayonnaise or salad dressing, is often lightly hydrogenated to increase its oxidative stability. The oil is then cold-stabilized, and the precipitate is filtered. Double-fractionated POo (DfPOo), a product of a second fractionation of palm oil, is also commercially available. DfPOo has better cold stability as compared with single-fractionated palm olein.

In an earlier study (4), the resistance to crystallization of POo with soybean oil at different temperatures was determined. It was reported that POo with an iodine value (IV) of 65 (POo–IV65) was more resistant to crystallization than POo–IV60 or POo–IV63. The study also showed that, for applications such as salad oil, the use of POo–IV65 was limited to 30% when blended with soybean oil. For POo–IV60 or POo–IV63, use was limited to 10% only. The goal of this study was to determine to which extent blends of LEAR with DfPOo would remain clear during storage at various temperatures.

MATERIALS AND METHODS

DfPOo of IV60 = (DfPOo–IV60) and 65 (DfPOo–IV65) were obtained from a local refinery. LEAR was obtained from Rotterdam, Holland. Four kg of DfPOo of each IV and 8 kg of LEAR were heated separately to 60°C and then filtered through Whatman qualitative filter paper. Filtration was conducted in a cabinet maintained at 50°C. The filtered oils were then blended to various proportions.

The amount of LEAR used for blending with DfPOo was 6,600 g. The blends were weighed into 120-mL clear glass bottles. The amount of sample in each bottle was 100 g. The

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bottles with samples were sealed with screw caps. Six sets of samples of each blend were prepared. Bottled samples were heated to 70°C for 1 h to destroy any crystal nuclei that might be present. The samples were allowed to cool to room temperature before being stored at 5, 10, 15, and 20°C. Observations were conducted daily to determine any physical changes taking place during storage. Cold testing at 0°C was conducted according to AOCS Method No. Cc 11-53 (5). Cloud points were determined according to AOCS Test Method Cc 6-25 (5).

Solid-fat content (SFC) was determined by pulsed nuclear magnetic resonance (NMR). The sample was melted at 60°C for 1 h, chilled at 0°C for 90 min, and kept at the desired temperatures for 30 min prior to measurements. To estimate solid crystal formation during storage tests, NMR tubes of each sample were prepared in 20 duplicate sets and kept with the bottles at the various storage temperatures. Two tubes of each sample were analyzed, and the average results were reported. Each set was used only once; thus, after measurement at each temperature at day 15, the samples were discarded. Another four sets of samples were measured after 30 d of storage at 5, 10, 15, and 20°C. Similar measurements were made on different sets of samples after 60, 90, and 120 d.

Fatty acid compositions were determined as methyl esters, which were prepared according to a method proposed by Timms (6). Analyses were conducted by using a capillary column (60 m × 0.25 mm i.d.) with a split ratio of 1:100. Flow rate was 0.85 mL N_2/min; oven temperature was set at 230°C. Analyses were conducted under isothermal conditions on a Hewlett-Packard 5890 gas chromatograph (Avondale, PA). Total saturates, monounsaturates, and polyunsaturates were calculated based on the fatty acid composition.

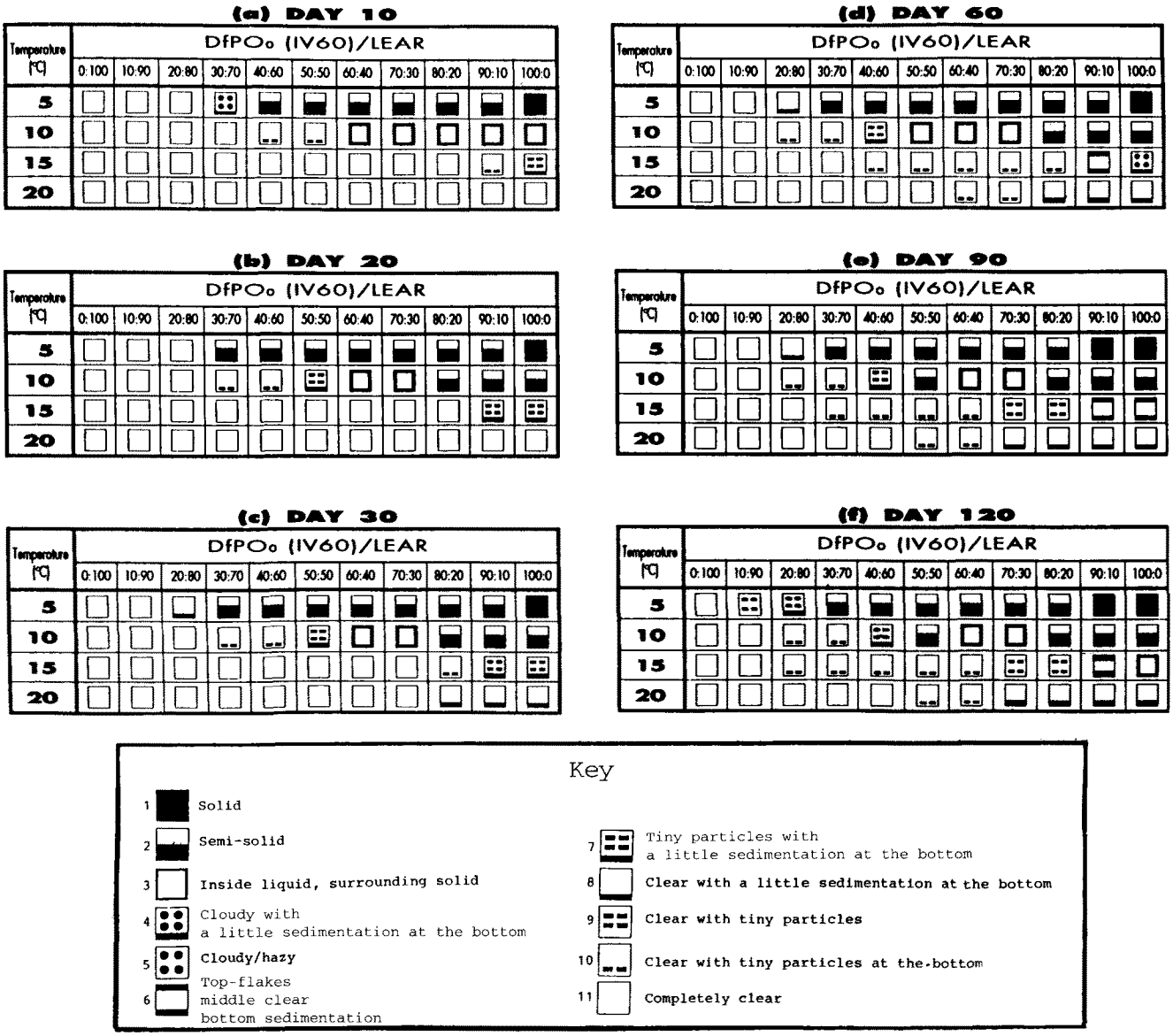

FIG. 1. Physical characteristics of double-fractionated palm olein (DfPOo) of iodine value (IV) 60 blended with low-erucic acid rapeseed (LEAR) oil stored at various temperatures at (a) day 10, (b) day 20, (c) day 30, (d) day 60, (e) day 90, and (f) day 120.

RESULTS AND DISCUSSION

The physical characteristics of the sample blends are graphically depicted in Figure 1. The first symbol indicates that the sample had solidified. The second symbol indicates that the sample was in a semi-solid form. Samples that remained liquid inside but were surrounded by a film of solid crystals are represented by the third symbol. The fourth symbol indicates that the sample was cloudy with a little sedimentation, i.e., some crystals settled at the bottom. The fifth also represents a cloudy or hazy sample, except that there was no sedimentation of crystals at the bottom. The sixth symbol represents a sample which was clear in the middle but formed a layer of flakes at the top, and there was sedimentation of crystals at the bottom. The seventh symbol indicates that a sample formed tiny particles, and some of the crystals has settled at the bottom. Samples that remained clear but had a little sedimentation at the bottom are represented by the eighth symbol. The ninth symbol indicates that the sample was clear, although some tiny particles were present and were evenly distributed. The tenth also represents a clear sample, but tiny particles were seen only at the bottom. The last symbol indicates a completely clear sample.

Figure 1 indicates the physical characteristics of DfPOo–IV60 and its blends with LEAR, stored over a 120-d period at 5, 10, 15, and 20°C. On day 10, samples that were completely clear included blends containing up to 20% DfPOo–IV60 at 5°C, blends containing up to 30% DfPOo–IV60 at 10°C, and blends containing up to 80% DfPOo–IV60 at 15°C (Fig. 1a). All samples kept at 20°C were completely clear on days 10 and 20. Pure LEAR was completely clear at all temperatures throughout the study.

Figure 1f shows that up to day 120, samples that were completely clear included blends containing 10% DfPOo–IV60 at 10 and 15°C, and blends containing up to 40% DfPOo–IV60 stored at 20°C. Blends containing 20–30% DfPOo–IV60 at 10°C and blends containing 20–60% DfPOo–IV60 at 15°C were generally clear except for a few tiny crystals at the bottom.

Figure 2 shows the physical characteristics of DfPOo–IV65 and its blends with LEAR on day 10 through day 120. Samples that remained clear on day 10 included blends containing up to 20% DfPOo–IV65 stored at 5°C, blends of up to 40% DfPOo–IV65 at 10°C, and blends containing up to 70% DfPOo–IV65 stored at 15°C (Fig. 2a). All samples remained completely clear for 60 d at 20°C.

DfPOo–IV65/LEAR blends generally remained clear for longer periods of time compared with DfPOo–IV60/LEAR. At 20°C, all DfPOo–IV65/LEAR blends remained clear for more than 60 d as compared with only 20 d for all DfPOo–IV60/LEAR samples. On day 60, DfPOo–IV60/LEAR blends containing up to 50% DfPOo remained clear at

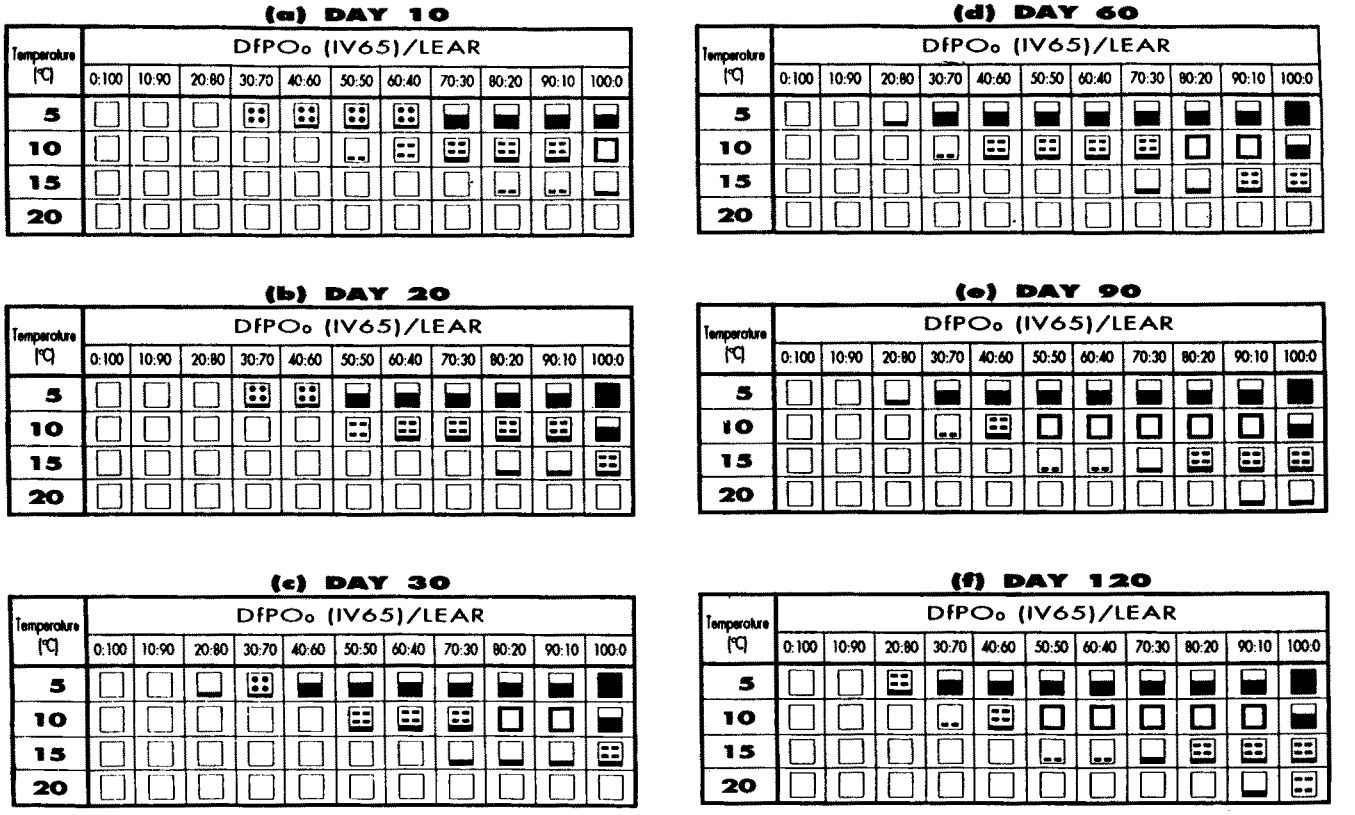

FIG. 2. Physical characteristics of DfPOo of IV65 blended with LEAR oil stored at various temperatures at (a) day 10, (b) day 20, (c) day 30, (d) day 60, (e) day 90, and (f) day 120. Abbreviations and key as in Figure 1.

TABLE 1
Solid Fat Contents (%) of Blends of DfPOo–IV60 with LEAR and Blends of DfPOo–IV65 with LEAR[a]

Composition of DfPOo–LEAR blend	0°C		5°C		Mean[b]	
	IV60	IV65	IV60	IV65	IV60	IV65
50:50	7.9	0.0	5.0	0.0	6.5	0.0
60:40	16.6	0.2	13.0	0.0	14.8	0.1
70:30	25.6	0.3	18.9	0.1	22.3	0.2
80:20	33.9	1.1	26.9	0.6	30.4	0.7
90:10	33.4	2.4	22.0	0.6	27.7	1.7
100:0	34.3	4.0	22.1	0.9	28.2	2.5
Mean	25.28	1.3	17.98	0.3		
	SE = ±0.40 (1.46)					

[a]Df, double fractionated; POo, palm olein; IV, iodine value; LEAR, low-erucic acid rapeseed oil.
[b]SE = ±0.70 (2.33).

20°C. All DfPOo–IV65 blends, except 90:10, remained clear for 120 d at 20°C. On the other hand, for DfPOo–IV60, samples containing only up to 40% POo remained clear.

Blends of DfPOo–IV60/LEAR had significantly ($P < 0.05$) higher solids contents than blends of DfPOo–IV65/LEAR when stored at 0 and 5°C (Table 1). The SFC ranged from 7.9 to 34.3% at 0°C for 50:50 to 100:0 DfPOo–IV60/LEAR blends. At 5°C, the SFC ranged from 5.0 to 22.1% for 50:50 to 100:0 blends. Values for 100% DfPOo–IV60 and 90:10 blends were lower compared with the previous study in which soybean oil was used (4). The reason is that the olein in the previous study was single-fractionated, whereas in this study it was double-fractionated. For 80:20 to 100:0 DfPOo–IV65/LEAR blends, SFC ranged from 1.1 to 4.0% at 0°C, while at 5°C the blends hardly contained any solid. These values were about one-half of those reported for POo–IV65/soybean oil in a previous study (4), probably because LEAR contained less solid glycerides than soybean oil.

Under the isothermal measurement in storage tests, SFC of DfPOo–IV60 significantly ($P < 0.05$) increased from 51.4% after 15 d to 60.5% after 120 d at 5°C (Fig. 3a). Addition of 20% LEAR significantly ($P < 0.05$) reduced the SFC, and further decreases in SFC were observed with greater additions of LEAR. Increases in SFC during storage were also noted in the blends (Fig. 3). The SFC of DfPOo and its blends were lower at 10°C and lower still at 15°C. The 80:20 DfPOo–IV60/LEAR blend did not contain any solids at 15°C after 15 d of storage. However, upon further storage, crystals formed, and the SFC increased to *ca.* 5% after 120 d of storage. Blends containing 40% and more LEAR did not contain any solids at 15°C throughout the study.

SFC of DfPOo–IV65 was lower than that of DfPOo–IV60 at 5, 10, and 15°C (Figs. 3 and 4). Addition of 20% LEAR to DfPOo–IV65 significantly ($P < 0.05$) reduced the SFC at all three temperatures. With higher levels of LEAR, there were further reductions in SFC of the blends, and at 15°C the blend DfPOo–IV65/LEAR 80:20 hardly contained any solids. Over

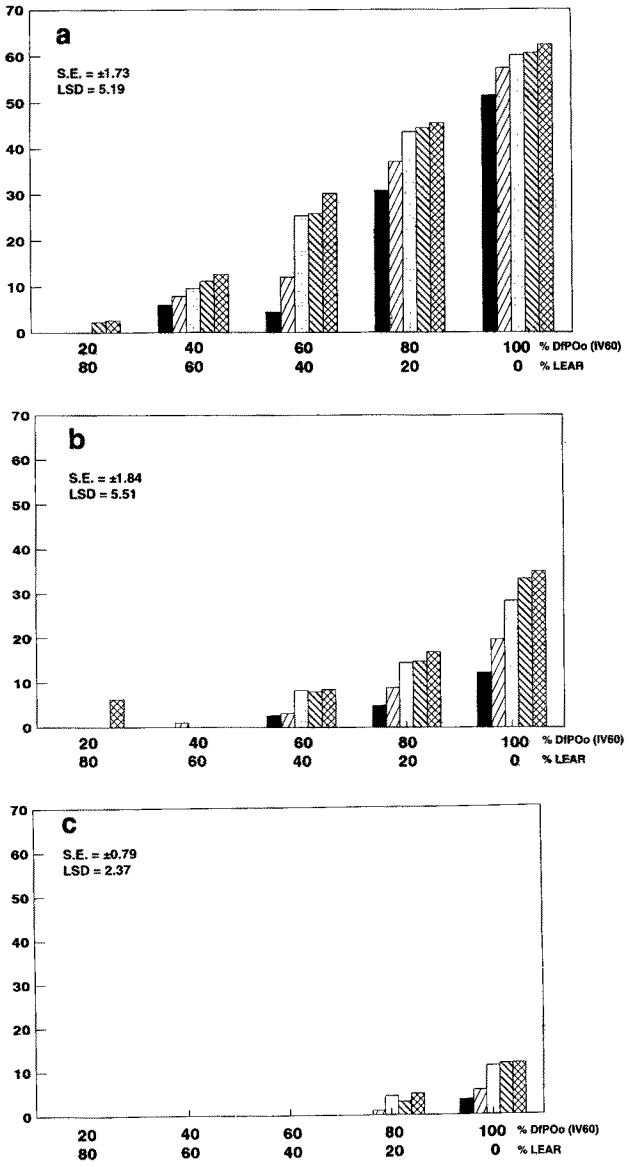

FIG. 3. Increase in solid-fat content of blends of palm olein of IV60 with LEAR at (a) 5, (b) 10, and (c) 15°C on days 15 (black bar), 30 (left-slanted bars), 60 (dotted bars), 90 (right-slanted bars), and 120 (cross-hatched bars). Abbreviations as in Figure 1.

120 d of storage, there were significant ($P < 0.05$) increases in SFC of the 80:20 DfPOo–IV65/LEAR blend and 100% DfPOo–IV65, particularly at 5 and 10°C.

Our study indicated that the maximum amount of DfPOo of both IV60 and IV65 that could be blended with LEAR and achieve acceptable results in the cold test was 30% (Table 2). A previous study (4) showed that with soybean oil, the amount of POo of IV60 that could be used for salad oil was limited to 10%. The lower amount of 10% was primarily due to the fact that the POo used was from single fractionation. In addition, the lower amount was partly due to the greater saturates content of soybean oil compared with that of LEAR.

Addition of LEAR significantly ($P < 0.05$) improved the cloud point of DfPOo (Table 3). With DfPOo–IV60, marked

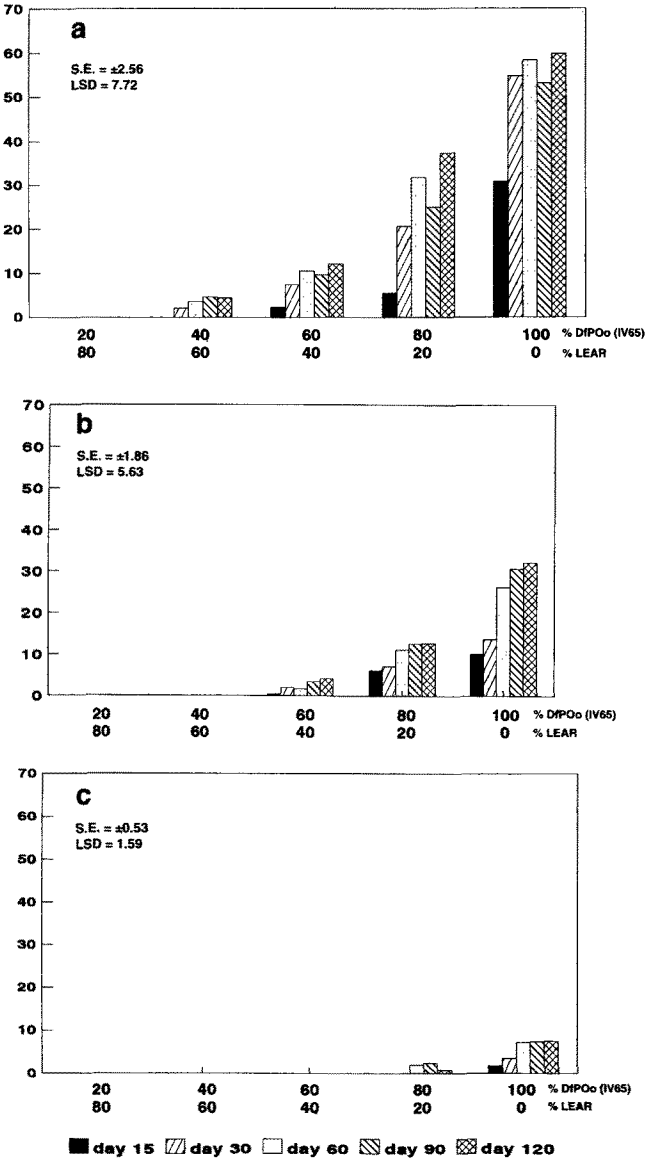

FIG. 4. Increase in solid-fat content of blends of palm olein of IV65 with LEAR at (a) 5, (b) 10, and (c) 15°C on days 15, 30, 60, 90, and 120. Abbreviations as in Figure 1, key as in Figure 3.

TABLE 2
Cold Test[a] on Blends of DfPOo of IV60 and IV65 with LEAR

DfPOo/LEAR	DfPOo–IV60	DfPOo–IV65
0:100	Positive	Positive
10:90	Positive	Positive
20:80	Positive	Positive
30:70	Positive	Positive
40:60	Negative	Negative
50:50	Negative	Negative
60:40	Negative	Negative
70:30	Negative	Negative
80:20	Negative	Negative
90:10	Negative	Negative
100:0	Negative	Negative

[a]At 0°C for 5.5 h (Ref. 5). Abbreviations as in Table 1.

TABLE 3
Cloud Points (°C) of Blends of DfPOo of IV60 and IV65 with LEAR[a]

Blend	DfPOo		
DfPOo/LEAR	IV60	IV65	Mean[b]
0:100	−14.5	−14.5	−14.5
10:90	−11.0	−14.1	−12.6
20:80	−10.1	−10.1	−10.1
30:70	−8.1	−9.5	−8.8
40:60	−6.5	−6.5	−6.5
50:50	−4.2	−6.0	−5.1
60:40	−2.5	4.0	−3.3
70:30	−1.5	−2.8	−2.2
80:20	−0.2	−1.0	−0.6
90:10	1.0	0.0	0.5
100:0	3.5	1.0	2.3
Mean	−4.9	−6.1	
	SE = ±0.22 (0.68)		

[a]Abbreviations as in Table 1.
[b]SE = ±0.51 (1.60)

changes in cloud points were observed when 10, 60, and 80% LEAR oil were added. Cloud points ranged from 3.5 to 1°C (2.5°C difference), from −4.2 to −6.5°C (2.3°C difference), and from −8.1 to −10.1°C (2.0°C difference), respectively. At levels of 10, 60, and 80% of LEAR, improvements in cloud points were 2.5, 10, and 13.6°C, respectively (from a cloud point of 3.5°C when no LEAR oil was added). For DfPOo–IV65, notable changes were observed when 50, 70, and 90% of LEAR oil was added. At these levels, cloud

TABLE 4
Saturated, Monounsaturated, and Polyunsaturated Fatty Acid Composition (wt%) of Blends of DfPOo–IV60 and DfPOo–IV65 with LEAR

Blend ratio	Saturated	Monounsaturated	Polyunsaturated
DfPOo–IV60/LEAR			
10:90	10.5	56.9	32.6
20:80	13.8	55.7	30.5
30:70	17.0	55.1	27.9
40:60	20.5	53.7	25.8
50:50	26.7	57.3	16.0
60:40	27.5	53.6	18.4
70:30	30.4	51.9	17.3
80:20	33.2	50.8	15.5
90:10	36.7	49.7	13.6
100:0	39.1	49.3	11.6
DfPOo–IV65/LEAR			
0:100	6.2	60.5	33.3
10:90	8.5	60.3	31.2
20:80	11.6	59.3	29.1
30:70	14.8	58.3	26.1
40:60	18.0	56.7	25.3
50:50	21.5	58.0	20.5
60:40	25.5	59.0	15.5
70:30	27.4	56.4	16.2
80:20	31.6	54.9	13.5
90:10	33.9	54.0	12.1
100:0	37.4	51.2	11.4

points were improved by 7, 10.5, and 15.1°C, respectively (from a cloud point of 1°C in the absence of LEAR).

Table 4 shows the fatty acid compositions of LEAR, DfPOo–IV60 and DfPOo–65 and blends of the oils. LEAR was rich in monounsaturated fatty acid (C18:1) with a content of 60.5%. Because its polyunsaturated fatty acid content accounts for another 33.3%, its saturated fatty acid is low. On the other hand, POo was rich in both saturated and monounsaturated fatty acids (C16:0 and C18:1). The DfPOo–IV60 used in this study contained slightly higher amounts of saturated fatty acids (39.1%) than DfPOo–IV65 (37.4%). On the other hand, DfPOo–IV65 contained slightly more monounsaturated fatty acids (51.2%) than did DfPOo–IV60. The levels of polyunsaturated fatty acids in both palm oleins were more or less the same (11.4–11.6%). With increasing amounts of added DfPOo, there were corresponding increases in saturated fatty acids in the blends. On the other hand, the mono- and polyunsaturates decreased with lower amounts of LEAR in the blends.

Nutritionally, the current trend now is toward a balanced fatty acid composition in the ratio of 1:1:1 of saturates, monounsaturates and polyunsaturates. All blends made in this study were rich in monounsaturates. A more balanced mixture of the three types of fatty acids could be achieved by adding another oil rich in polyunsaturates while keeping the level of POo high to maintain the level of saturates.

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