# Resistance to Crystallization of Blends of Palm Olein with Soybean Oil Stored at Various Temperatures

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**The aim of the study was to determine the resistance to crystallization of palm olein (POo) with soybean oil (SBO) at different temperatures. POo of iodine value (IV) 65 gave better resistance to crystallization than POo of IV 60 or IV 63. For applications such as salad oil, the use of POo of IV 65 is limited to 30% when blended with SBO. If POo of either IV 60 or IV 63 is chosen, its use in salad oil is limited to 10% only. However, for applications other than salad oil, such as for cooking or frying, 100% POo of any IV could be used. For cold climates, the amount of POo (IV 60 or 63) recommended to get a clear oil is 10–30%. Alternatively, up to 40% POo of IV 65 can be blended with SBO. For temperate climates, the amount of POo (IV 60 or 63) recommended can be up to 60%. With POo of IV 65, the amount recommended is as high as 80–90% for application as a cooking or frying oil.**

KEY WORDS: Blends, crystallization, palm olein, salad oil, soybean oil.

Palm olein is the liquid fraction obtained from the fractionation of palm oil. A second fractionation of palm olein yields a product of higher iodine value (IV) and is called double-fractionated palm olein (DfPOo). Besides having a higher IV, DfPOo has a lower cloud point and, therefore, remains clear or resists crystallization at lower temperature better than single-fractionated palm olein.

It has been reported that a blend of 30% single-fractionated palm olein and 70% sunflower oil remained clear at 15°C for less than two months (1). Transparent stability of DfPOo with soybean oil (SBO) stored in plastic containers at 10, 15 and 20°C also has been reported by Teah and Ahmad (1).

Commercial frying operations usually use solid fats (2) such as tallow, hydrogenated oils (soybean, canola or sunflower) or texturized palm oils to minimize oxidation and polymerization of the oils and to extend the shelf-life of the fried products. Some companies may use a lightly hydrogenated pourable oil in which the solids are suspended. Only the retail market demands clear oils. Consumers perceive cloudy oils as deteriorated oils. Oils destined for the manufacture of salad dressings must remain clear at refrigerated temperatures, because crystallization will destabilize emulsions. Oils for the retail market are sold in plastic containers or glass bottles. The objective of this study was to determine the clarity or transparency of blends of SBO with POo of three different IVs (60, 63 and 65) during storage in glass containers at various temperatures.

## MATERIALS AND METHODS

POo of IV 60, 63 and 65 were obtained from local refineries. Single-fractionated POo of high IV (60) was obtained from one local refinery, and POo of higher IV (63 and 65), were double-fractionated, obtained from another local refinery. SBO was obtained from a local supermarket. The oils were heated to 60°C and then filtered through a Whatman qualitative filter paper of 240-cm diameter (Whatman International Ltd., Maidstone, England). Filtration was conducted in a cabinet maintained at a temperature of 50°C. The filtered oils were then blended at various levels, and the blends were transferred into 120-mL glass bottles. The amount of sample in each bottle was 100 g. Samples in the bottles were covered with screw caps. Four sets of samples were prepared for each experiment. Samples in the bottles were heated to 70°C for 1 h to destroy any crystal nuclei that may have been 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 the transparency of the samples and to observe any physical changes occurring during storage. The cold test at 0°C was conducted according to AOCS Method Cc 11-53 (3). Cloud points were determined according to AOCS Method Cc 6-25 (3). Solid fat content of the blends was determined according to procedures of Oh and Berger (4). Samples were melted at 70°C and chilled at 0°C for 90 min and were then held at each measuring temperature for 30 min prior to measurements.

## RESULTS AND DISCUSSION

Results of transparent stability of blends containing POo (IV 60) are shown in Table 1. These results indicate that at 5°C a blend consisting of 10% POo (IV 60) and 90% SBO remained clear for 11 d. A blend containing 20% POo (IV 60) was less stable, being clear only until day 2 at 5°C. Blends containing 30–40% POo (IV 60) remained clear for less than 24 h, while those containing 50–60% and 70–90% were clear for only 5 and 3 h, respectively (Table 1). Better stability was observed in samples kept at 10°C. Blends of 10% POo (IV 60) and 90% SBO kept at 10°C remained clear for much longer periods (at least 120 d) than similar samples kept at 5°C. However, increasing the level of POo (IV 60) resulted in decreased stability of the blends. A blend containing 20% POo (IV 60) remained clear for a period of 20 d, whereas one containing 30% POo of similar IV was clear for only 10 d at 10°C.

Better stability was observed in samples kept at temperatures of 15 and 20°C. At day 120, a blend containing 10% POo (IV 60) was clear when stored at 15 and 20°C. Over a similar time period (120 d) a blend containing up to 30% POo (IV 60) was still clear when kept at 20°C, but not at 15°C. The SBO remained clear at all temperatures for the duration of the experiment, which lasted 120 d.

At 15°C, a blend of only up to 20% POo (IV 60) could be used to give a clear product for 3 mon. Increasing the level of POo (IV 60) to 30% resulted in a clear product only up until 35 days. Still higher levels of POo (IV 60)

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TABLE 1

**Resistance to Crystallization[a] of Palm Olein (POo) of Iodine Value (IV) 60 with Soybean Oil (SBO) in Glass Bottles at 5, 10, 15 and 20°C**

| Storage temperature (°C) | POo (IV 60)/SBO | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10:90 | 20:80 | 30:70 | 40:60 | 50:50 | 60:40 | 70:30 | 80:20 | 90:10 | 100:0 |
| 5 | 11 d | 2 d | <24 h | <24 h | 5 h | 5 h | 3 h | 3 h | 3 h | 3 h |
| 10 | >120 d | 20 d | 10 d | 2 d | <48 h | >5 h | >5 h | >5 h | >5 h | >5 h |
| 15 | >120 d | 92 d | 35 d | 25 d | 11 d | 4 d | >5 h | >5 h | >5 h | >5 h |
| 20 | >120 d | >120 d | >120 d | 101 d | 74 d | 73 d | 44 d | 16 d | 7 d | 7 d |

[a]Duration of oil blends to remain clear (d denotes days and h denotes hours).

at 40 and 50% gave a stable product up to 25 and 11 d, respectively.

At 20°C, up to 70% POo (IV 60) could be added to SBO to give a clear product for more than 1 mon (44 d). For a storage period of 100 d and more, the amount of POo (IV 60) that could be incorporated is limited to 40%.

Transparency of the blends was better when POo of a higher IV (63) was used (Table 2). At 5°C, a blend containing 10% POo (IV 63) and 90% SBO was still clear at day 30 as compared with 11 d for PO of IV 60. A blend containng 20% POo (IV 63) remained clear for a much longer period of time (110 d), compared to 20 d for POo (IV 60) when stored at 10°C. At 15°C, a similar blend was still clear at day 120. At 30%, POo (IV 63) gave a clear oil up to day 66, whereas an oil blend with POo (IV 63) at 40% was clear until day 46. Blends containing 50 and 60% POo (IV 63) were clear till day 26. On the other hand, blends containing 70, 80 and 90% POo (IV 63) remained clear only until days 10, 4 and 2, respectively. POo (IV 63) by itself was stable at 15°C for one day only. Much better stability was observed in samples stored at 20°C. Up to 40% POo (IV 63) could be blended with SBO to give a clear oil until day 120. Blends containing higher amounts of POo (IV 63) at 50, 60, 70–80 and 90% were stable until days 88, 71, 40 and 37, respectively.

When POo of still higher IV (65) was used, better stability, compared with POo of either IV 60 or IV 63, was observed at all temperatures of storage (Table 3). At 5°C, a blend containing 10% POo (IV 65) was clear for more than 120 d (Table 3), compared with only 11 and 30 d, respectively, for POo of IV 60 and IV 63 (Tables 1 and 2). Increasing the level of POo (IV 65) to 20, 30, 40 and 50% shortened the duration for the blends remaining clear to 8, 4, 2 and 1 d, respectively. A further increase in the level of POo (IV 65) gave clear oils for less than one day. Up to 30% of POo (IV 65) could be added to SBO, resulting in a clear product for 90 d at 10°C. Blends containing 40% POo (IV 65) remained clear at 10°C for more

TABLE 2

**Resistance to Crystallization[a] of Palm Olein (POo) of Iodine Value (IV) 63 with Soybean Oil (SBO) in Glass Bottles at 5, 10, 15 and 20°C**

| Storage temperature (°C) | POo (IV 62)/SBO | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10:90 | 20:80 | 30:70 | 40:60 | 50:50 | 60:40 | 70:30 | 80:20 | 90:10 | 100:0 |
| 5 | 30 d | 4 d | 1 d | <1 d (23 h) | <1 d (>5 h) | <1 d (>5 h) | <1 d (>3 h) | <1 d (>3 h) | <1 d (>1 h) | <1 d (>1 h) |
| 10 | 120 d | 110 d | 12 d | 2 d | 1 d | <1 d (>5 h) | <1 d (>5 h) | <1 d (>5 h) | ><1 d (>5 h) | >1 d (3 h) |
| 15 | 120 d | 120 d | 66 d | 46 d | 26 d | 26 d | 10 d | 4 d | 2 d | 1 d |
| 20 | 120 d | 120 d | 120 d | 120 d | 88 d | 17 d | 50 d | 40 d | >37 d | 37 d |

[a]Duration of oil blends to remain clear (d denotes days and h denotes hours).

TABLE 3

**Resistance to Crystallization[a] of Palm Olein (POo) of Iodine Value (IV) 65 with Soybean Oil (SBO) in Glass Bottles at 5, 10, 15 and 20°C**

| Storage temperature (°C) | POo (IV 65)/SBO | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10:90 | 20:80 | 30:70 | 40:60 | 50:50 | 60:40 | 70:30 | 80:20 | 90:10 | 100:0 |
| 5 | >120 d | 8 d | 4 d | 2 d | 1 d | <1 d | <1 d | <1 d | <1 d | <1 d |
| 10 | >120 d | >90 d | 90 d | >40 d | 3 d | 1 d | 1 d | 1 d | 1 d | 1 d |
| 15 | 120 d | 120 d | 120 d | 70 d | 34 d | 18 d | 13 d | 13 d | 6 d | 4 d |
| 20 | >120 d | >120 d | >120 d | >120 d | >120 d | >120 d | >120 d | 61 d | 56 d | 35 d |

[a]Duration of oil blends to remain clear (d denotes days).

than 40 d. At 15°C, a similar blend (POo/SBO, 40:60) remained clear for a period of 70 d. A blend containing 50% POo was clear until day 34. Much better stability was observed in the blends kept at 20°C. At such a temperature (20°C) blends containing up to 70% POo (IV 65) remained clear for more than 120 d (Table 3). Up to 90% POo (IV 65) could be blended with SBO and could be kept for about 2 mon at 20°C and still have a clear appearance. If 100% POo (IV 65) is used, the oil would remain clear for approximately a month if kept at 20°C.

Good-quality salad oil should remain clear even at a relatively low temperature. This requirement is called the "cold test," which states that the oil must remain clear for 5.5 h at 0°C (3). Our study indicated that the amount of POo of IV 60 and IV 63 that could be blended with SBO for acceptable results in the cold test was limited to only 10% (Table 4). However, with POo of higher IV (65), a level of up to 30% showed a positive result. Therefore, for applications such as salad oil, POo of high IV (65) is recommended. Ordinary single-fractionated palm olein (IV 56–58), which has been shown to be good for frying (5), will not be suitable for use as salad oil because it is not likely to pass the cold test.

Cloud points of POo of IV 60, IV 63 and IV 65 were 3.5, 2.5 and 1.0°C, respectively (Table 5). Blending POo of the various IVs with increasing levels of SBO resulted in a lowering of their cloud points (Table 5). Blends of SBO with POo of IV 65 had lower cloud points than those of POo IV 63, which in turn had lower cloud points than those of POo of IV 60.

Solid fat content (SFC) of POo (IV 60) at 0 and 5°C was not different from that of the POo (IV 60)/SBO 90:10 blend (Fig. 1a). At 10° and 15°C, the SFC of 100% POo (IV 60) was slightly higher than at 0 and 5°C. With increasing levels of SBO in the blends there was a gradual decrease

TABLE 4

**Cold Test[a] at 0°C for 5.5 h on Blends of Palm Olein (POo) of Iodine Values (IV) 60, 63 and 65 with Soybean Oil (SBO)**

| POo/SBO | POo (IV 60) | POo (IV 63) | POo (IV 65) |
|---|---|---|---|
| 0:100 | Positive | Positive | Positive |
| 10:90 | Positive | Positive | Positive |
| 20:80 | Negative | Negative | Positive |
| 30:70 | Negative | Negative | Positive |
| 40:60 | Negative | Negative | Negative |
| 50:50 | Negative | Negative | Negative |
| 60:40 | Negative | Negative | Negative |
| 70:30 | Negative | Negative | Negative |
| 80:20 | Negative | Negative | Negative |
| 90:10 | Negative | Negative | Negative |
| 100:0 | Negative | Negative | Negative |

[a]Reference 3.

TABLE 5

**Cloud Points[a] (°C) of Blends of Palm Olein (POo) of Iodine Values (IV) 60, 63 and 65 with Soybean Oil (SBO)**

| Blend (POo/SBO) | POo | | |
|---|---|---|---|
| | IV 60 | IV 63 | IV 65 |
| 0:100 | −10.1 | −10.1 | −10.1 |
| 10:90 | −7.1 | −7.1 | −8.2 |
| 20:80 | −5.3 | −5.8 | −6.0 |
| 30:70 | −4.0 | −5.0 | −5.2 |
| 40:60 | −3.1 | −3.8 | −5.0 |
| 50:50 | −1.3 | −3.0 | −3.0 |
| 60:40 | 0.0 | −1.2 | −2.0 |
| 80:20 | 2.0 | 1.0 | −1.0 |
| 90:10 | 2.5 | 1.9 | −0.5 |
| 100:0 | 3.5 | 2.5 | 1.0 |

[a]Reference 3.

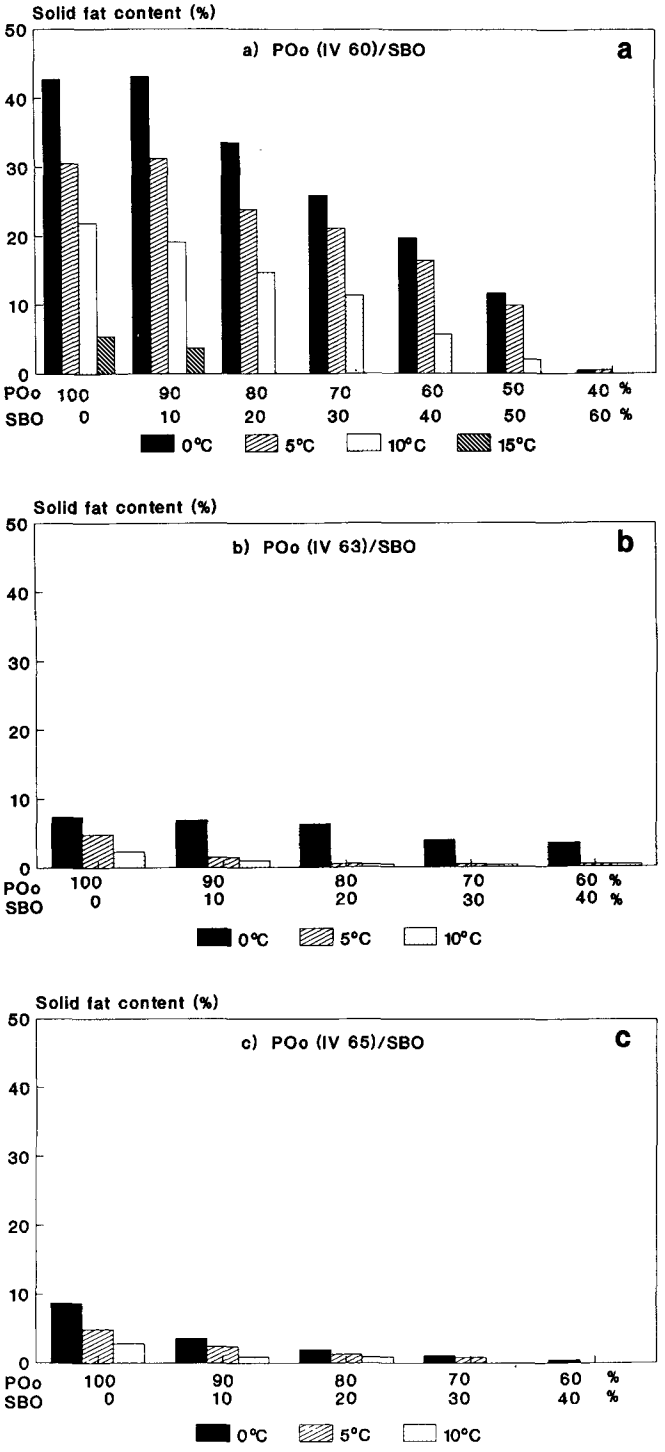


FIG. 1. Solid fat content of blends of palm olein of a, IV 60; b, IV 63; and c, IV 65; with soybean oil at 0, 5, 10 and 15°C.

in SFC at all temperatures (0, 5, 10 and 15°C); the higher the temperature, the lower the SFC. Blend POo (IV 60)/SBO 40:60 hardly contained any solids.

Although SFC of POo (IV 63) was not much different from that of POo (IV 65), blends of POo (IV 65)/SBO showed slightly lower SFC values at 0°C than did POo (IV 63)/SBO blends (Fig. 1b). SFC values of POo of both IV 63 and IV 65 were much lower than that of POo of IV 60 (Fig. 1). This was due to their lower saturation as well as to the fact that POo of IV 60 was single-fractionated, whereas that of IV 63 and 65 was double-fractionated. Similarly, there was a significant decrease in SFC of the POo/SBO blends when POo of IV 63 or IV 65 were used. Judging from the results, it is recommended that for blends to remain clear on the supermarket shelf, the level of POo (IV 60 or 63) should not exceed 30%, and the level of POo (IV 65) should not exceed 40%. Supermarkets are usually air-conditioned in the summer in seasonal countries and all year in tropical countries. In tropical climates where oils are sold in a nonair-conditioned environment, the level of POos can be increased. In the manufacture of salad dressings or mayonnaise, which require a salad oil of proven cold stability, only blends of 10% POo of IV 60 or IV 63 or of 30% POo of IV 65 with soybean oil are suitable.

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