Oxidative Stability of Blends and Interesterified Blends of Soybean Oil and Palm Olein

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Improvement of oxidative stability of soybean oil by blending with a more stable oil was investigated. Autoxidation of blends and interesterified blends (9:1, 8:2, 7:3 and 1:1, w/w) of soybean oil and palm olein was studied with respect to fatty acid composition, fatty acid location and triacylglycerol composition. Rates of formation of triacylglycerol hydroperoxides, peroxide value and volatiles were evaluated. The fatty acid composition of soybean oil was changed by blending. Linolenic and linoleic acids decreased and oleic acid increased. The triacylglycerol composition of blends and interesterified blends was different from that of soybean oil. Relative to soybean oil, LnLL, LLL, LLO, LLP, LOO and LLS triacylglycerols were lowered and POO, POP and PLP were higher in blends and interesterified blends (where Ln, L, O, P and S represent linolenic, linoleic, oleic, palmitic and stearic acids, respectively). Interesterification of the blends leads to a decrease in POO and POP and an increase in LOP. Linoleic acid concentration at triacylglycerol carbon-2 was decreased by blending and interesterification. Rates of change for peroxide value and oxidation product formation confirmed the improvement of soybean oil stability by blending and interesterification. But, blends were more stable than interesterified blends. Also, the formation of hexanal, the major volatile of linoleate hydroperoxides of soybean oil, was decreased by blending and interesterification.

KEY WORDS: Blend, interesterification, oxidative stability, palm olein, soybean oil, triacylglycerol.

Autoxidation is a chemical reaction whereby oxygen is added to unsaturated fatty acids in vegetable oils like soybean oil (SBO), with the ultimate production of compounds such as shorter-chain alcohols, aldehydes and ketones, as well as high-molecular weight polymers. The reaction has major implications in the food industry because it causes a disagreeable alteration in flavor and viscosity (1).

Efforts to improve SBO resistance to oxidation or oxidative stability have involved partial hydrogenation, addition of synthetic antioxidants and metal inactivators (2-5), and natural selection and induced mutation breeding to reduce the linolenic acid content (6-12). Also, SBO stability has been improved through changes in triacylglycerol (TAG) composition and TAG fatty acid location (13,14).

The present study reports the effects of chemical interesterification of SBO and palm olein (PO) blends on TAG composition and fatty acid (FA) location on the resulting oxidative stability.

EXPERIMENTAL PROCEDURES

Materials. Refined, bleached and deodorized SBO was purchased from a commercial source, and PO was obtained from Premier Edible Oils Corporation (Portland, Oregon). Blends were prepared by directly mixing the appropriate amount of PO with SBO to obtain SBO/PO blends of 9:1, 8:2, 7:3 and 1:1 (w/w). Other materials used in this study have been described previously (13).

Interesterification. A 600-g sample of each blend was interesterified. The blend was heated to 70°C with stirring, and 0.5% sodium methoxide was added. The reactants were stirred for 30 min and then quenched with 2% aqueous citric acid (20%) with stirring for 15 min. The product was filtered under vacuum through Celite 545. For the oxidation study, the interesterified oil was dissolved in diethyl ether and washed two times with distilled water; the ether layer was dried over anhydrous sodium sulfate, and the solvent was removed with a roto-evaporator.

Solid-phase extraction (SE) chromatography. Oil samples (SBO, PO, blends and interesterified blends) were stripped of non-TAG components by a previously reported silica SE chromatography procedure (15).

FA analysis. FA composition was determined by capillary gas chromatography (GC) of the methyl esters after transmethylation of the SE-purified TAG. A 15-m sample was transmethylated by reaction with 5 mL of 0.5 N KOH in methanol at 50°C for 30 min. The reaction mixture was neutralized to pH 7 with dilute hydrochloric acid and extracted with 5 mL petroleum ether/diethylether (1:1, vol/vol) and dried with 5 mL acetone azeotrope under helium. Fatty acid methyl ester (FAME) samples were analyzed by direct-injection capillary GC with an SP2380 column (30 m, 0.25 mm i.d., and 0.2 μm film thickness; Supelco, Inc., Bellefonte, PA) in a Varian Gas Chromatograph, Star 3400, equipped with a flame-ionization detector (Varian, Inc., Walnut Creek, CA). The column was operated at 150°C with a hold for 35 min and then programmed to 210°C at 3°C/min with helium head pressure of 10 psi. The injector and detector temperatures were 240 and 280°C, respectively. FA composition was obtained by chromatogram peak integration accomplished by computer procedures (16).

TAG analysis. TAG molecular species analysis was performed by a previously reported procedure of reverse-phase high-performance liquid chromatography (RP-HPLC) with flame-ionization detection (13).

Stereospecific analysis. Stereospecific analysis was by a lipolysis-GC procedure reported previously (13, 15,17).

TAG oxidation product (TAG-OX) analysis. RP-HPLC (14) was performed in duplicate on each oxidized sample at 24, 48 and 72 h. The TAG-OX formed from LLnLn, LLLn, LLL (LnLP and LnOP), LLO, LLP, LOO, LOP and PLP were monitored with ultraviolet (UV) detection at 235 nm for conjugated diene (where L = linoleic acid, P = palmitic acid; O = oleic acid; Ln = linolenic acid). These oxidation products were identified by matching peak retention times with those of the standard oxidized TAGs.

Analysis of volatiles. Volatile analysis was performed by the static headspace procedure (15). The volatiles monitored (and their precursor FA) were pentane (L); propanal (Ln); pentanal (L); hexanal (L); 2-heptenal (L); 2,4-heptadienal (Ln) and nonanal (O).

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Oxidation of purified TAG. Purified TAG were oxidized at 60 ± 2°C in the dark in oxygen in a forced-air oven (Precision Scientific Co., Chicago, IL). Samples (225 mg each) were weighed into 20-mL vials, which were purged with oxygen and sealed. One sample of each TAG was prepared for each oxidation period (24, 48 and 72 h). After each period of oxidation, three 15-mg aliquots were removed from each sample for peroxide value (PV) determination by a colorimetric ferric thiocyanate method (13,15). Two 50-mg aliquots were removed for volatile headspace analysis, and one 50-mg aliquot was removed for analysis of TAG-OX by RP-HPLC. Due to limited sample amounts, each oxidation experiment was performed once. However, under the same conditions used in previous work (13), a soybean oil TAG standard had a coefficient of variation for ΔPV of 5% or less for 20 oxidation experiments. This allowed valid comparisons of the data between oxidation experiments.

Experimental oxidative stability parameters. The peroxide change with oxidation time (ΔPV) was determined from linear regression (two-dimensional) of plots of PV vs. time for the oxidized TAG. The hydroperoxide formation rate (ΔTAG-OX), a second measure of experimental oxidative stability was determined from a linear regression of the plot of TAG-OX [summation of chromatogram peak areas (area counts) from the detector response for the above TAG-OX] vs. oxidation time. A linear regression plot of the sum of the gas chromatogram peak areas (area counts) from the detector response for the above volatiles (ΔTV) vs. oxidation time was used as a third measure of experimental oxidative stability for the SBO/PO blends.

RESULTS AND DISCUSSION

FA composition of blends and interesterified blends. L is the predominant FA in SBO (53.4%), whereas O followed by P were the major acids, FA, in PO (Table 1). Blending SBO with PO caused O to increase and L to decrease. Ln was decreased from 7.0% in SBO to 3.8% in the 1:1 SBO/PO blend. The FA composition thus was changed by blending, and this decreased the calculated oxidizability from 0.6788 (for SBO) to 0.4107 (SBO/PO, 1:1). Blending with PO would be expected to improve SBO stability due to predicted or calculated oxidative stability (13,18). The oxidizability is calculated as 0.2 [0%] + [L%] + 2 (Ln%)/100 GC area percent composition (18). Also, the ratios of L and Ln to O decreased in blends. This too would be expected to improve SBO stability (13). Also, as with the blends, O increased and Ln, L, L/O, and Ln/O ratios decreased in interesterified products compared to SBO. This would be expected to improve stability of the products compared to SBO (13). As expected (Table 1), the FA composition of TAG and calculated oxidizability of blends and interesterified blends were almost the same.

TAG FA location for blends and interesterified blends. Positional analysis data for SBO, PO, their blends and interesterified blends are presented in Tables 2 and 3. Comparison of FA located at glycerol carbon-2 relative to carbons-1 and -3 in the blends and their interesterified products revealed that interesterification was successful in randomizing FA distribution. The data indicated that for these blends and most interesterified blends (9:1, 8:2 and 7:3; SBO/PO), L was greater than O at both glycerol carbon-2, -1 and -3. However, for the 1:1 blend and its interesterified blend, L and O at carbon-2 or -1 and -3 did not differ greatly. L at carbon-2 was the highest in SBO (69.3%) and was decreased by blending to 45.8% in blend 1:1 due to the introduction of TAG with less L. Interesterification decreased L at carbon-2 to 31.2% for the 1:1 interesterified blend. The O level at carbon-2 for the blends also was greater than in interesterified blends, especially blends 7:3 (37.1% vs. 29.8%) and 1:1 (45.5% vs. 32.7%). The content of L at carbons-1 and -3 was greater in the 9:1 interesterified blend (49.9%) than in SBO (45.4%). L decreased to 26.5% at carbons-1 and -3 in blend 1:1. Based on previous studies, reduction of L content at carbon-2 should improve the oxidative stability of the blends and interesterified products of SBO and PO (13–15).

TAG composition for blends and interesterified blends. TAG composition data for SBO, PO and their blends and interesterified blends are presented in Table 4. The major TAG of SBO oil were LLO, LLL, LLP, LOP, LOO, LnLL,

TABLE 1

Calculated Oxidizability (OX)[a], Fatty Acid Composition[b] and Ratios of Linoleic (L) and Linolenic (Ln) Acid to Oleic (O) Acid for Soybean Oil (SBO), Palm Olein (PO) and Their Blends and Interesterified Blends

		Fatty acid area percent								
	OX	14:0	16:0	18:0	18:1	18:2	20:0	18:3	L/O	Ln/O
SBO	0.679	—	10.0	4.2	25.4	53.4	—	7.0	2.10	0.28
Blend (SBO/PO)										
9:1	0.618	—	13.2	4.2	27.5	49.2	—	6.0	1.79	0.22
8:2	0.562	—	16.7	4.3	29.1	44.5	—	5.6	1.53	0.19
7:3	0.517	0.4	18.2	4.5	30.5	41.0	0.4	5.1	1.34	0.17
1:1	0.411	0.6	23.8	4.6	34.0	33.0	0.3	3.8	0.97	0.11
Interesterified										
9:1	0.627	0.2	12.8	4.1	26.9	49.1	0.3	6.5	1.83	0.24
8:2	0.571	0.3	15.9	4.2	28.6	45.0	0.3	5.8	1.58	0.20
7:3	0.519	0.4	18.4	4.2	30.4	41.0	0.4	5.2	1.35	0.17
1:1	0.409	0.6	24.1	4.4	34.2	32.8	0.3	3.7	0.96	0.11
PO	0.132	1.3	40.0	4.6	41.7	12.4	—	—	0.30	—

[a]OX, Oxidizability = [(0.02 (0%)) + L% + 2 (Ln%)]/100 (Ref. 18).
[b]See Experimental Procedures section for conditions for gas chromatography analysis of fatty acid composition.

TABLE 2

Fatty Acid Composition and Ratios of L and Ln Acids to O on Glycerol Carbon-2 for SBO, PO and Their Blends and Interesterified Blends[a]

	Fatty acid area percent								
	14:0	16:0	18:0	18:1	18:2	20:0	18:3	L/O	Ln/O
SBO	—	—	—	24.6	69.3	—	6.2	2.82	0.25
Blend (SBO/PO)									
9:1	—	1.3	0.3	28.9	63.9	—	5.6	2.21	0.20
8:2	—	2.2	0.4	32.8	59.5	—	5.2	1.81	0.16
7:3	—	3.3	—	37.1	55.0	—	4.6	1.48	0.13
1:1	—	4.9	0.7	45.5	45.8	—	3.1	1.01	0.07
Interesterified									
9:1	0.3	14.1	5.3	26.3	47.6	0.4	6.0	1.81	0.23
8:2	0.5	15.2	4.7	28.9	45.2	0.3	5.2	1.56	0.18
7:3	0.9	20.0	6.7	29.8	38.2	—	4.4	1.29	0.15
1:1	0.8	26.0	5.6	32.7	31.2	0.4	3.4	0.95	0.10
PO	0.6	9.2	1.1	66.7	22.4	—	—	0.34	—

[a]See Experimental Procedures section for analysis conditions for fatty acid composition at glycerol carbon-2. See Table 1 for abbreviations.

TABLE 3

Fatty Acid Composition and Ratios of L and Ln Acids to O on Glycerol Carbons-1 and -3 for SBO, PO and Their Blends and Interesterified Blends[a]

	Fatty acid area percent								
	14:0	16:0	18:0	18:1	18:2	20:0	18:3	L/O	Ln/O
SBO	—	15.0	6.3	25.9	45.4	—	7.4	1.76	0.29
Blends (SBO/PO)									
9:1	—	19.1	6.1	26.8	41.8	—	6.2	1.56	0.23
8:2	—	23.9	6.2	27.2	37.0	—	5.8	1.36	0.21
7:3	0.5	25.6	6.8	27.2	34.0	0.6	5.4	1.25	0.20
1:1	0.9	33.3	6.5	28.2	26.5	0.5	4.1	0.94	0.15
Interesterified									
9:1	0.1	12.2	3.6	27.2	49.9	0.3	6.8	1.84	0.25
8:2	0.3	16.3	3.9	28.4	45.0	0.3	6.0	1.59	0.21
7:3	0.2	17.7	3.0	30.7	42.4	0.5	5.5	1.38	0.18
1:1	0.5	23.1	3.7	34.9	33.6	0.3	3.8	0.97	0.11
PO	1.7	55.4	6.4	29.2	7.4	—	—	0.25	—

[a]See Experimental Procedures section for analysis conditions for fatty acid composition at glycerol carbons-1 and -3. See Table 1 for abbreviations.

LnLO, LnLP, LOS (S = stearic acid) and OOO. For PO, the major TAG were POP, POO, LOP, PLP, SOP, LLP and SOO. Blending of PO and SBO [SBO/PO, 9:1, 8:2, 7:3 and 1:1 (w/w)], decreased LnLL, LLL, LnLO, LLO, LLP, LOO and LLS, whereas LOP, POO, PLP and POP were increased as PO increased in the blend. For blend 1:1, LLL, LLO and LLP contents decreased, compared to SBO, from 15.6 to 8.3, 15.8 to 8.4 and 12.4 to 7.9%, respectively; and POP, POO and PLP increased from 0.6 to 15.3, 2.9 to 12.8 and 1.7 to 5.7%, respectively. Thus, the more oxidizable TAGs in SBO oil decreased, and the more oxidatively stable TAGs increased (13).

Data in Table 4 show the remarkable decrease in LLL for interesterified blends compared to the physical blends. LOO and LOP increased in interesterified blends compared to blends, with the greatest increase occurring in blend 1:1 (SBO/PO). These TAGs were 5.2 and 10.4% in blend 1:1 and increased to 9.5 and 17.2% in the interesterified product, respectively. However, the decrease in LLL and increase in LOO and LOP occurred with a sharp decrease in POO and POP, which are more stable than LOO and LOP (13), for the product from blend 1:1 SBO/PO. The POO and POP were 12.8 and 15.3% for the blend and decreased to 9.1 and 7.0% in the interesterified product, respectively.

Oxidative stability of blends and interesterified blends. Experimental oxidative stability of SBO, PO and their blends and interesterified blends were determined according to ΔPV, ΔTAG-OX and ΔTV methods used previously (13–15).

PV and ΔPV results for SBO, PO, blends and interesterified blends are given in Table 5. These results show, as predicted by oxidizability (Table 1), that PO is the most stable and SBO is the least stable. The blends and interesterified blends all were more stable than SBO, and each blend, except for 1:1, was more stable than its corresponding interesterified product. However, blends and interesterified blends had the same FA composition (Table 1). This indicated that, in addition to FA composition, TAG composition and FA location at glycerol have an effect on oxidative stability (13,14).

The TAG-OX composition for the blends oxidized in ox-

TABLE 4

Triacylglycerol (TAG)[a] Composition of SBO, PO and Their Blends (B) (SBO/PO) and Interesterified Blends (I)[b]

	TAG area percent									
TAG	SBO	PO	B 90:10	I 90:10	B 80:20	I 80:20	B 70:30	I 70:30	B 50:50	I 50:50
LnLnLn	0.1	—	—	—	—	—	—	—	—	—
LnLnL	0.8	—	0.9	0.7	1.0	0.6	0.9	0.3	0.7	0.4
LnLL	6.6	—	6.4	4.8	5.6	3.9	5.1	2.7	3.4	1.3
LnLnO	0.4	—	0.4	0.5	0.3	0.5	0.2	0.5	0.3	0.5
LLL	15.6	—	15.4	10.9	12.6	9.0	12.2	5.9	8.3	2.9
LnLO	5.6	—	4.0	5.7	4.7	4.9	3.5	4.4	2.4	2.7
LnLP	3.6	—	3.6	3.7	3.1	3.6	2.9	3.5	2.2	2.7
LLO	15.8	0.4	14.2	18.3	13.1	14.8	11.2	13.2	8.4	9.0
LnOO	1.1	—	1.0	1.2	0.8	1.6	1.0	1.3	0.4	1.2
LLP	12.4	2.5	12.1	11.4	11.0	11.8	10.1	11.4	7.9	8.9
LnOP	2.0	0.7	1.4	2.2	1.5	2.3	1.3	2.7	1.2	3.1
LOO	8.2	1.6	8.0	9.3	7.2	9.3	6.5	9.8	5.2	9.5
LLS	2.7	—	2.9	2.3	2.6	1.8	1.7	1.7	1.6	1.9
LOP	9.5	11.2	9.5	12.3	9.8	14.0	10.2	16.0	10.4	17.2
PLP	1.7	9.9	2.7	3.0	3.4	4.1	4.0	5.4	5.7	7.0
OOO	3.2	2.7	3.0	1.7	3.2	2.2	3.3	2.4	3.4	3.2
LOS	3.3	—	2.7	3.5	2.3	3.3	1.9	3.1	2.0	2.4
POO	2.9	25.3	4.7	3.0	7.1	4.6	9.4	5.8	12.8	9.1
SLP	1.5	—	1.1	1.6	1.3	1.7	1.0	1.9	1.5	1.9
POP	0.6	34.4	3.0	1.5	6.1	2.7	9.2	3.9	15.3	7.0
PPP	0.1	0.5	0.1	0.0	0.1	0.1	0.2	0.2	0.5	0.4
SOO	0.9	2.4	0.9	0.6	0.9	0.7	1.2	0.8	1.5	1.1
SLS	0.3	—	0.1	0.2	0.1	0.1	0.0	0.0	0.2	0.0
SOP	0.4	5.6	0.7	0.6	1.2	0.8	1.5	1.1	2.3	1.8
PPS	0.1	0.2	0.1	0.2	0.1	0.3	0.1	0.5	—	0.8
SOS	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.2	—	0.4
PSS	0.1	0.6	0.3	0.2	0.2	0.2	0.0	0.2	—	0.3
SSS	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.3	0.1
Unknown	0.4	1.8	0.7	0.9	0.8	1.2	1.1	1.1	1.8	3.4

[a]Determined by reverse-phase high-performance liquid chromatography with flame-ionization detection. See Experimental Procedures section for details.
[b]P and S are palmitic and stearic acids, respectively. See Table 1 for other abbreviations.

ygen for up to 72 h at 60°C is presented in Table 6. These data show that LLL, LLO, LLP and PLP remained the abundant TAG-OX in blends, even when the blend was 1:1. However, even though LLP TAG-OX decreased as a result of blending (from 12.6% in SBO to 7.9% in blend 1:1), the LLP TAG-OX increased as the PO composition increased in the blend.

The TAG-OX of interesterified blends is presented in Table 7. Data in the table show that LLP, LLO and PLP TAG-OX were the abundant TAG-OX. As noted before from the TAG composition of the blends and interesterified blends (Table 4), the LLP and LLO in the two products were somewhat lower than in SBO, especially at 1:1. That may be why blends and interesterified blends were more stable than SBO (Tables 5–7) (13,14). However, comparing blends to their interesterified products, the lower content of LLO and LLP and higher POO and POP in blends, in part, might explain why blends were more stable than interesterified blends (13,14). This observation is supported by ΔTAG-OX (Table 6), which was 28.0 for SBO and decreased to 13.9, 11.4, 2.6 and 2.0 detector area counts/h for blends 9:1, 8:2, 7:3 and 1:1, respectively. ΔTAG-OX in the interesterified blends (Table 7) was lower than in SBO but higher than in each corresponding blend (Table 6).

The composition of the major volatiles after oxidation for 72 h at 60°C in the dark from SBO, PO and their blends and interesterified blends are presented in Table 8. The data show that hexanal, pentane, propanal, 2-heptenal and 2,4-heptadienal were the major volatiles from oxidized SBO. Major volatiles from PO were pentane,

TABLE 5

Oxidative Stability of SBO, PO and Their Blends and Interesterified Blends Measured by Oxidative Stability Parameter Peroxide Value (PV)[a]

	Time (h) PV (meq/kg)				ΔPV[b] (PV/h, meq/kg/h)
Product	0	24	48	72	
SBO	0.2	7.0	16.5	33.2	0.45
Blends (SBO/PO)					
9:1	0.6	5.3	10.8	18.3	0.25
8:2	0.4	4.9	9.9	16.8	0.23
7:3	0.2	3.4	7.0	11.4	0.15
1:1	0.3	2.3	4.4	7.2	0.10
Interesterified					
9:1	0.8	8.0	17.0	31.4	0.42
8:2	0.5	6.6	14.3	26.3	0.35
7:3	0.5	4.8	10.9	17.5	0.24
1:1	0.3	2.9	5.8	8.1	0.11
PO	0.1	0.4	0.6	0.9	0.01

[a]See Experimental Procedures section for PV determination and oxidation conditions. See Table 1 for other abbreviations.
[b]ΔPV is the rate of change of PV with oxidation time. See Experimental Procedures section for ΔPV determination.

TABLE 6

Composition of the Oxidized Triacylglycerols (TAG-OX) in SBO, PO and Their Blends After 24, 48 and 72 H Autoxidation[a]

	TAG-OX area percent																	
	SBO			9:1 (SBO/PO)			8:2 (SBO/PO)			7:3 (SBO/PO)			1:1 (SBO/PO)			PO		
TAG-OX	24	48	72	24	48	72	24	48	72	24	48	72	24	48	72	24	48	72
LLLn	0.4	3.8	6.5	1.9	2.6	4.7	2.5	4.7	5.1	1.3	3.0	1.4	0.0	2.1	3.3	—	—	—
LLL	9.8	16.8	22.9	8.8	12.3	19.3	9.8	14.5	18.9	5.8	9.8	15.4	4.2	9.8	13.0	—	—	—
LnLO + LnLP	0.8	1.0	1.4	5.3	1.3	1.2	1.6	0.7	1.3	1.8	1.6	1.0	0.9	1.3	1.4	—	—	—
LLO	17.5	20.4	22.0	13.7	17.2	18.5	19.4	21.0	18.7	18.9	16.8	21.9	19.9	18.9	21.8	—	—	—
LLP	22.9	17.1	12.2	28.8	30.7	16.9	36.5	23.8	17.3	33.0	28.7	21.9	39.0	35.5	26.9	14.7	13.9	4.0
LOO	7.8	9.7	8.2	11.5	6.9	8.8	6.3	5.2	7.4	6.2	8.8	4.6	8.6	7.9	5.5	7.9	13.0	5.1
LLS	11.3	9.6	8.2	7.6	3.7	7.5	7.4	8.2	60.0	1.3	3.3	7.1	2.3	3.1	8.7	—	—	—
LOP	12.9	11.9	7.7	9.7	12.4	9.1	7.7	11.9	10.3	14.8	13.5	11.1	9.5	8.6	9.9	31.8	24.3	10.6
PLP	16.6	9.7	10.9	12.7	12.9	14.0	8.8	10.6	14.6	16.9	15.5	13.2	15.6	12.7	9.5	45.6	48.8	80.5
ΔTAG-OX[b] (detector area counts per h)			28.0			13.9			11.4			2.6			2.0			0.2

[a]TAG-OX formation with oxidation time determination by reverse-phase high-performance liquid chromatography with ultraviolet detection of oxidized TAG conjugated diene at 235 nm. See Experimental Procedures section for analysis and oxidation conditions. See Tables 1 and 4 for other abbreviations.
[b]ΔTAG-OX is rate of TAG-OX formation with respect to oxidation time of 72 h. See Experimental Procedures section for ΔTAG-OX determination.

TABLE 7

Composition of TAG-OX in Interesterified Blends (SBO/PO) After 24, 48 and 72 H Autoxidation[a]

	9:1 (SBO/PO)			8:2 (SBO/PO)			7:3 (SBO/PO)			1:1 (SBO/PO)		
TAG-OX	24	48	72	24	48	72	24	48	72	24	48	72
LLLn	3.2	3.1	4.9	1.9	3.5	4.2	1.6	2.4	3.1	1.5	2.5	2.6
LLL	10.0	10.0	17.5	6.4	14.9	18.1	4.0	7.8	11.4	1.6	4.2	4.9
LnLO + LnLP	0.8	0.9	1.7	0.8	0.8	1.1	0.5	0.6	0.9	0.3	0.6	0.6
LLO	15.4	15.5	22.4	13.4	19.9	20.8	16.8	16.3	19.1	7.8	14.3	15.7
LLP	20.6	20.1	12.1	21.6	15.6	10.9	18.5	14.3	10.7	17.8	11.1	10.3
LOO	8.1	8.1	8.5	7.8	9.1	10.8	6.4	7.6	9.4	5.9	5.0	7.5
LLS	14.9	15.2	12.8	16.7	13.6	10.6	22.5	20.2	19.3	28.3	24.4	21.7
LOP	12.3	12.3	9.1	13.8	7.7	6.6	15.2	13.2	9.3	16.5	13.4	10.9
PLP	14.7	14.8	11.0	17.7	15.0	16.9	16.6	17.5	17.0	20.3	24.6	25.6
ΔTAG-OX (detector area counts/h)			16.4			15.1			9.9			5.5

[a]See Experimental Procedures section for TAG-OX, oxidation conditions and ΔTAG-OX determination. See Tables 1 and 6 for other abbreviations.

TABLE 8

Volatile Decomposition of SBO, PO and Their Blends and Interesterified Blends at 72 h Autoxidation[a]

	Volatile area percent									
		Blend				Interesterified				
Volatile	SBO	9:1	8:2	7:3	1:1	9:1	8:2	7:3	1:1	PO
Pentane	24.1	26.8	23.7	27.4	26.3	23.3	24.3	28.3	28.0	28.8
Propanal	15.7	18.1	17.9	16.1	14.1	19.6	19.3	17.5	13.2	—
Pentanal	6.2	7.9	9.6	8.7	10.2	8.5	9.1	7.8	8.8	11.2
Hexanal	26.6	12.3	13.1	12.4	13.2	14.0	12.5	13.1	13.7	16.2
c,t-2-Heptenal	14.1	20.0	22.3	20.7	20.8	21.2	21.2	18.6	21.3	15.6
2,4-Heptadienal	10.3	13.0	11.5	12.3	12.1	11.8	11.9	12.3	11.0	—
Nonanal	2.9	1.8	1.9	2.4	3.3	1.7	1.7	2.5	4.0	28.1
ΔTV[b] (detector area counts per h)	0.60	0.25	0.25	0.16	0.11	0.34	0.37	0.09	0.06	0.02

[a]Volatile composition from thermal decomposition of oxidized samples determined by static headspace gas chromatography. See Experimental Procedures section for analysis and oxidation conditions. See Tables 1 and 5 for other abbreviations.
[b]ΔTV is the rate of volatile formation from samples oxidized to 72 h. See Experimental Procedures section for ΔTV determination.

nonanal, hexanal and heptenal. These volatiles also were found as major components in blends and interesterified blends. Pentane production was not greatly affected by blending or interesterification; its concentration made up 24.1% of SBO volatiles and ranged from 23–28% in the blends and interesterified blends. Hexanal, the major volatile derived from L, was found in the same amount (about 13%) in blends and interesterified blends, whereas volatiles from SBO contained 26.6% hexanal. This reduction in hexanal content was apparently due to the lower content of L acid at carbon-2 (Table 2). These results are in agreement with those reported by Frankel *et al.* (19) for volatile studies of L and mixed L and Ln TAG. Propanal and 2-heptenal increased to approximately the same level in blends and interesterified blends. In regard to oxidative stability, measured by volatile generation, SBO had the lowest stability, with a ΔTV of 0.60 detector area counts/h.

Comparison of ΔTV of blends to that of their interesterified products showed that blends 9:1 and 8:2 were more stable than their interesterified products. This is in agreement with results from ΔPV and ΔTAG-OX. But, for blends 7:3 and 1:1, the ΔTV indicates that they were less stable with respect to volatile generation than their interesterified products.

The results presented here indicate that the oxidative stability of SBO can be improved by blending and interesterification of SBO and PO. Blending and interesterification lead to decreased Ln and L and increased O. Also, L decreased at carbon-2 on the glycerol moiety. The decrease in L at carbon-2 in blends was accompanied by an increase of O at carbon-2, which may be partly responsible for better stability of blends compared to interesterified blends (13,15). Also, blends had less L at glycerol carbon-1(3). The total FA composition of blends and interesterified blends were about equal, as expected. However, the TAG composition of the blend was different from that of its interesterified blend. LnLL, LLL, LLO, LLP and LLO were lower and POP, POO and PLP were higher in both blends and products. However, POO and POP in interesterified blends were less than in blends. These noted differences in TAG composition may, in part, explain why the blends were more stable than the interesterified blends. That is, the effect of the decrease in LLL, which is known to decrease oxidative stability, in interesterified products was countered by decreased POO and POP, which are known to improve oxidative stability (13). However, the blends and interesterified products were still more stable than SBO.

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