Oxidative Stability of Soybean and Sesame Oil Mixture during Frying of Flour Dough

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ABSTRACT: Effects of roasted sesame seed oil on the oxidative stability of soybean oil during frying of flour dough at 160 °C were studied by determining fatty acid composition and conjugated dienoic acid (CDA), *p*-anisidine (PA), and free fatty acid (FFA) values. Concentration of sesame oil in frying oil was 0%, 10%, 20%, or 30% (v/v). Tocopherols and lignan compounds in the frying oil were also determined by high-performance liquid chromatography. As the number of fryings performed by the oil increased, linolenic acid content in frying oil decreased, and the decreasing rate was lower in frying oil containing sesame oil than in the oil containing no sesame oil. CDA and FFA values of frying oil increased during frying and their relative values to the initial value were lower in frying oil containing sesame oil than in the oil containing no sesame oil. This indicates that the addition of sesame oil improved thermooxidative stability of frying oil, possibly due to the presence of lignan compounds in sesame oil. Tocopherols and lignan compounds in frying oil decreased during frying. As the amount of sesame oil in frying oil increased, degradation of tocopherols increased and lignan compounds degradation decreased. Tocopherols were suggested to protect lignan compounds in sesame oil from decomposition during frying.

Keywords: soybean and sesame oil mixture, frying, oxidation, tocopherols, lignans

Introduction

During frying, oil is continuously exposed to the air at high temperature and contact with moisture, which accelerates the oxidation of oil. Oil oxidation products transferred to fried foods reduce consumer acceptability and have been associated with adverse health effects (Lopaczynski and Zeisel 2001; Beeharry and others 2003).

Oxidative stability of oil can be improved by modification of fatty acid composition and addition of antioxidants to the oil. Fatty acid composition and functional properties of oils can be modified by hydrogenation, interesterification, genetic modification, and blending of different oils (Liu and White 1992; Chu and Kung 1998; Melton and others 1993; Moussata and Akoh 1998). Unpleasant characteristic odor and possible adverse health effects of hydrogenated oil have been reported (Warner and Mount 1993; Craig-Schmidt 2001; Sundram and others 2003). Blending of oils modifies fatty acid composition of oils without any chemical or biological process. Oil blending also introduces some antioxidants to the oil. Vegetable oils naturally contain antioxidants, tocopherols in soybean oil, tocotrienols in palm oil, and lignans in sesame oil (Kochhar 2000; Yanishlieva and Marinova 2001). Lignan compounds in sesame oil include sesamol, sesamin, and sesaminol. Sesame oils are more stable to the autoxidation than other vegetable oils due to lignan compounds and tocopherols (Fukuda and others 1986b; Gertz and others 2000). Sesame oil is manufactured by solvent extraction from raw sesame seeds, followed by the refining process. Sesame oil can also be obtained by pressing roasted sesame seeds without the refining process. Roasted sesame oil is more stable to oxidation than unroasted sesame oil (Mohamed and Awatif 1998; Yoshida and others 2000). Roasting of sesame seeds increases the concentration of lignan compounds (Kim 2000) and produces Maillard reaction products. Maillard reaction products give good flavor (Soliman and others 1985; Kim and others 2000) and prevent the lipid oxidation (Lingnert and Eriksson 1980; Fukuda and others 1986a).

Soybean oil contains a high amount of tocopherols and essential fatty acids (Buczenko and others 2003; Wang and others 2003). Soybean oil, however, is susceptible to the oxidation due to the high contents of polyunsaturated fatty acids during frying (Sebedio and others 1996). Addition of oxidation-stable roasted sesame seed oil to soybean oil might affect the oxidative stability of soybean oil during frying. This study was performed to investigate the effects of sesame oil on the oxidative stability of soybean oil during continuous frying of flour dough. Contents of tocopherols and lignan compounds in the blended frying oil during frying were also determined.

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Materials and Methods

Samples and chemicals

Refined, bleached, and deodorized soybean oil and roasted sesame seed oil were obtained from Heinz Co. (Seoul, Korea) and Cheiljedang Co. (Seoul, Korea), respectively. Wheat flour was a product of Daehan Flour Mills Co., Ltd. (Seoul, Korea).

Isooctane, n-hexane, isopropanol, methanol, and water were purchased from J.T. Baker (Phillipsburg, N.J., U.S.A.). Anisidine, tocopherols, and sesamol were products of Sigma-Aldrich Co. (St. Louis, Mo., U.S.A.). All other chemicals were of reagent grade.

Frying of flour dough

Dough was prepared with wheat flour as described previously (Lee and others 2003). Sixty-one batches of square-shaped dough ($2 \times 2 \times 0.1$ cm), 100 g of each batch, were fried in an electric fryer holding 3 L of frying oil at 160 °C. Frying time for each batch was 1 min, and frying was repeated every 20 min. Frying oil was a mixture of soybean oil and roasted sesame oil at a volume ratio of 100:0, 90:10, 80:20, or 70:30. Frying oil was taken every 12 fryings into glass bottles.

Table 1—Fatty acid composition of soybean and sesame oil mixture during repeated frying of flour dough at 160 °C

Frying oil composition (sesame oil: soybean oil, v/v)	Nth frying	Relative content (%) C16:0	C18:0	C18:1	C18:2	C18:3
0:100	1	12.4 ± 0.06	4.4 ± 0.08	23.6 ± 0.21	53.9 ± 0.22	5.6 ± 0.21
	13	12.7 ± 0.75	4.4 ± 0.15	23.3 ± 0.22	53.7 ± 0.41	5.4 ± 0.26
	25	13.1 ± 0.11	4.3 ± 0.14	23.4 ± 0.11	53.7 ± 0.37	5.2 ± 0.12
	37	13.2 ± 0.76	4.3 ± 0.19	23.2 ± 0.15	54.3 ± 0.52	5.0 ± 0.06
	49	13.0 ± 0.59	4.0 ± 0.36	23.4 ± 0.47	54.2 ± 0.81	4.8 ± 0.20
	61	13.6 ± 0.25	4.5 ± 0.25	24.3 ± 0.10	53.9 ± 0.36	4.7 ± 0.05
10:90	1	12.1 ± 0.43	4.4 ± 0.02	24.9 ± 0.23	53.9 ± 0.37	4.7 ± 0.08
	13	12.0 ± 0.13	4.2 ± 0.11	25.3 ± 0.14	53.8 ± 0.38	4.7 ± 0.21
	25	12.2 ± 0.12	4.4 ± 0.26	25.6 ± 0.08	53.4 ± 0.23	4.4 ± 0.18
	37	12.4 ± 0.12	4.5 ± 0.20	25.6 ± 0.14	53.3 ± 0.25	4.2 ± 0.17
	49	13.0 ± 0.42	4.1 ± 0.25	25.5 ± 0.29	53.5 ± 0.19	3.9 ± 0.04
	61	12.7 ± 0.32	4.8 ± 0.31	26.6 ± 0.14	52.1 ± 0.38	3.8 ± 0.05
20:80	1	11.6 ± 0.17	5.1 ± 0.07	27.8 ± 0.08	51.2 ± 0.18	4.3 ± 0.24
	13	12.0 ± 0.64	4.9 ± 0.26	27.6 ± 0.24	51.3 ± 0.15	4.2 ± 0.17
	25	12.0 ± 0.19	5.1 ± 0.20	27.9 ± 0.17	51.0 ± 0.10	4.0 ± 0.10
	37	12.3 ± 0.24	5.1 ± 0.19	28.1 ± 0.15	50.7 ± 0.30	3.8 ± 0.06
	49	12.5 ± 0.44	4.9 ± 0.02	28.3 ± 0.28	50.6 ± 0.17	3.8 ± 0.10
	61	12.5 ± 0.31	4.6 ± 0.30	27.7 ± 0.52	50.6 ± 0.54	3.6 ± 0.24
30:70	1	11.8 ± 0.38	5.1 ± 0.09	29.6 ± 0.39	49.5 ± 0.65	3.6 ± 0.14
	13	11.9 ± 0.23	5.3 ± 0.24	29.6 ± 0.19	49.7 ± 0.12	3.5 ± 0.06
	25	11.6 ± 0.58	5.1 ± 0.17	29.5 ± 0.20	49.4 ± 0.69	3.4 ± 0.05
	37	11.9 ± 0.74	5.1 ± 0.22	29.7 ± 0.07	49.4 ± 0.41	3.4 ± 0.08
	49	11.9 ± 0.22	5.0 ± 0.27	29.9 ± 0.10	49.9 ± 0.19	3.3 ± 0.08
	61	11.8 ± 0.10	5.1 ± 0.16	30.0 ± 0.14	49.9 ± 0.08	3.2 ± 0.06

Table 2—Regression analysis between linolenic acid contents and the number of fryings performed in frying oil mixture

Frying oil composition (sesame oil: soybean oil, v/v)	Regression parameters[a] a	b	r^2
0:100	–0.016	5.589	0.988
10:90	–0.017	4.797	0.973
20:80	–0.012	4.312	0.978
30:70	–0.007	3.609	0.945

[a]$y = ax + b$, where x = number of fryings performed in the frying oil, y = content of linolenic acid in frying oil, r = correlation coefficient.

Heated frying oil in another fryer that was being run in parallel to the test fryer was replenished to make up 3 L of frying oil. Bottles having frying oil were tightly sealed after nitrogen flushing and placed in a –20 °C freezer for analyses. All samples were prepared in duplicate.

Determination of frying oil oxidation during frying of flour dough

Oxidative stability of frying oil during repeated frying was evaluated by determining fatty acid composition by gas chromatography (GC; Lee and others 2002) and measuring conjugated dienoic acid (CDA), *p*-anisidine (PA), and free fatty acid (FFA) values by AOCS method (1990).

Analysis of tocopherols in frying oil

Tocopherols in frying oil were analyzed by high-performance liquid chromatography (HPLC; Lee and Choe 2003). Frying oil was dissolved in n-hexane and passed through a polytetrafluoroethylene membrane filter (0.2 μm × 25 mm; Natl. Scientific Co., Lawrenceville, N.J., U.S.A.). The filtrate (20 μL) was injected to a high-performance liquid chromatograph (Orom Vintage 2000LC, Seoul, Korea) equipped with a fluorescence detector. The column was a μ-porasil column (3.9 ×300 mm; Waters, Milford, Mass., U.S.A.) and the eluting solvent was a mixture of n-hexane and isopropanol (99.5:0.5, v/v) at a flow rate of 1.5 mL/ min. Wavelengths for tocopherol determination were 300 nm for the excitation and 338 nm for the emission. Tocopherols in frying oil were quantitated from the calibration curves of standard α, γ-, and δ-tocopherols.

Analysis of lignan compounds in frying oil

Lignan compounds in frying oil were analyzed by HPLC (Han and others 1997) with some modifications. Frying oil, dissolved in methanol and passed through a sep-pak cartridge (Sep-Pak Silica; Waters), was injected to an Orom Vintage 2000 LC (Orom Co., Seoul, Korea) equipped with a C18 Symmetry reverse column (4.6 mm × 150 mm; inner dia, 5 μm; Waters) and a UV-VIS detector (Uvis-200, SSI, Lemont, Pa., U.S.A.) set at 288 nm. The eluting solvent was a mixture of methanol and water (70:30, v/v) at a flow rate of 0.8 mL/ min. Concentration of lignan compounds in the oil was determined from the calibration curve of standard sesamol.

Statistical analysis

One-way analysis of variance (Ott 1984) at 5% significance level was used to analyze the data.

Results and Discussion

Oxidative stability of frying oil during frying of flour dough

Soybean oil contained palmitic (12.4%), stearic (4.4%), oleic (23.6%), linoleic (53.9%), and linolenic (5.6%) acids. Roasted sesame seed oil consisted of palmitic (9.7%), oleic (45.4%), linoleic (45.4%), and linolenic (0.3%) acids. Content ratios of unsaturated fatty acids to saturated fatty acids (U/S ratio) of soybean oil and sesame oil were 4.9 and 5.5, respectively.

Fatty acid composition changes of frying oil during consecutive 61 fryings of flour dough at 160 °C are shown in Table 1. Frying oil containing sesame oil had more oleic acid and less linoleic and linolenic acids than the oil containing no sesame oil. The more the sesame oil in frying oil, the more the oleic acid and the less the linoleic and linolenic acids. As the number of fryings performed by the oil

Table 3—Conjugated dienoic acid contents (%) of soybean and sesame oil mixture after repeated frying of flour dough at 160 °C

Nth	Frying oil composition (sesame oil:soybean oil, v/v)			
frying	0:100	10:90	20:80	30:70
1	0.42 ± 0.01 (100)[a]	0.48 ± 0.01 (100)	0.50 ± 0.03 (100)	0.49 ± 0.01 (100)
13	0.47 ± 0.01 (112)	0.51 ± 0.01 (106)	0.51 ± 0.01 (102)	0.59 ± 0.01 (120)
25	0.62 ± 0.01 (148)	0.71 ± 0.02 (148)	0.60 ± 0.02 (120)	0.61 ± 0.01 (124)
37	0.63 ± 0.01(150)	0.76 ± 0.01 (158)	0.72 ± 0.01 (144)	0.64 ± 0.01 (131)
49	0.71 ± 0.01(169)	0.81 ± 0.01 (169)	0.74 ± 0.01 (148)	0.74 ± 0.01 (151)
61	0.83 ± 0.02(198)	0.87 ± 0.01 (181)	0.84 ± 0.02 (168)	0.76 ± 0.01 (155)
Means	0.61A[b]	0.69A	0.65A	0.64A

[a]Number in parenthesis is relative % of conjugated dienoic acid (CDA) values based on the initial CDA value of each frying oil.
[b]The same letter means that there is no significant differences among CDA means of oils during 61 fryings at α = 0.05.

Table 4—*p*-Anisidine value in soybean and sesame oil mixture after repeated frying of flour dough at 160 °C

Nth	Frying oil composition (sesameoil:soybean oil, v/v)			
frying	0:100	10:90	20:80	30:70
1	2 ± 0.1	6 ± 0.2	2 ± 0.2	3 ± 0.5
13	14 ± 0.1	10 ± 0.4	10 ± 0.4	9 ± 0.4
25	27 ± 0.5	28 ± 0.2	19 ± 0.1	15 ± 0.1
37	35 ± 0.6	38 ± 0.5	43 ± 0.0	24 ± 1.1
49	43 ± 0.1	47 ± 0.2	55 ± 0.1	33 ± 1.8
61	51 ± 0.1	63 ± 0.4	63 ± 0.1	46 ± 0.1
Means	29A[a]	32A	32A	22A

[a]The same letter means that there is no significant differences among PAV means of oils during 61 fryings at α = 0.05.

increased, the relative content of linolenic acid in the oil decreased. It has been shown that heating of oil causes a fast decrease in more unsaturated fatty acids than less unsaturated or saturated fatty acids (Warner and Mount 1993; Tyagi and Vasishtha 1996). Regression equations between linolenic acid contents of the oil and the number of fryings performed by the oil are shown in Table 2. Frying oil containing sesame oil showed lower a-values, rates of linolenic acid content decrease, than frying oil containing no sesame oil. The more the sesame oil in the frying oil, the lower the rate of linolenic acid content decrease. This suggests that sesame oil could improve the oxidative stability of frying oil during frying of flour dough. Higher oxidative stability of frying oil containing sesame oil might be due to the presence of lignan compounds and Maillard reaction products, which showed antioxidant activity in autoxidation of roasted sesame oil (Fukuda and others 1986b).

CDA content changes in frying oil during 61 fryings are shown in Table 3. The initial CDA value of frying oil containing no sesame oil (0.42%) was lower than those of frying oils containing sesame oil (0.48% to 0.50%). This is due to higher CDA contents of roasted sesame seed oil than soybean oil as reported by Chung and Choe (2001). CDA contents in frying oil increased as the number of fryings performed by the oil increased. It is well known that nonconjugated fatty acids become more stable conjugated fatty acids during oxidation or processing. CDA values of frying oil containing no sesame oil tended to be lower than those of the oil containing sesame oil. This is possibly due to higher initial CDA values of frying oil containing sesame oil, not due to higher susceptibility of frying oil containing sesame oil to the oxidation. Mean CDA values of frying oils containing sesame oil at 10%, 20%, or 30% through 61 fryings were not significantly different from that of frying oil containing no sesame oil. CDA contents of frying oil containing no sesame oil increased to 112%, 148%, 150%, 169%, and 198% of initial value after the 13th, 25th, 37th, 49th, and 61th frying, respectively. Frying oil containing sesame oil at 20% showed 102%, 120%, 144%, 148%, and 168% relative to the initial CDA value after the corresponding number of fryings. Frying oil containing sesame oil at 10% or 30% tended to be lower relative to the initial CDA values than the oil containing no sesame oil. This suggests that sesame oil addition to the frying oil decelerate CDA formation in the oil during frying.

PA values of frying oil during 61 fryings of flour dough at 160 °C are shown in Table 4. As the number of fryings performed by the oil increased, PA values of frying oil increased due to decomposition of oil hydroperoxides (Nawar 1984). PA values of frying oil containing sesame oil were not significantly different from those of frying oil containing no sesame oil during 61 fryings ($P > 0.05$). This suggests that sesame oil did not affect the formation of secondary oxidation products from primary oxidation products in frying oil during frying.

FFA contents of frying oil during frying of flour dough at 160 °C are shown in Table 5. Initial FFA values (0.140% to 0.320%) of frying oil containing sesame oil were much higher than that (0.017%) of frying oil containing no sesame oil. The more sesame oil in frying oil, the higher the FFA values of the oil. Roasted sesame oil contains higher amount of FFA than soybean oil (Chung and Choe 2001). FFAs in roasted sesame oil are resulted from hydrolysis of oil by enzymes present in sesame seed (Wanasundara and others 2001) or during roasting of sesame seeds (Abou-Gharbia and others

Table 5—Free fatty acid values (%) of soybean and sesame oil mixture after repeated frying of flour dough at 160 °C

Nth	Frying oil composition (sesame oil:soybean oil, v/v			
frying	0:100	10:90	20:80	30:70
1	0.017 ± 0.001 (100)[a]	0.140 ± 0.001 (100)	0.264 ± 0.007 (100)	0.320 ± 0.002 (100)
13	0.062 ± 0.001 (365)	0.218 ± 0.008 (156)	0.309 ± 0.007 (117)	0.421 ± 0.004 (132)
25	0.084 ± 0.001 (494)	0.295 ± 0.007 (211)	0.422 ± 0.004 (160)	0.537 ± 0.008 (168)
37	0.115 ± 0.004 (676)	0.381 ± 0.001 (272)	0.562 ± 0.003 (213)	0.705 ± 0.001 (220)
49	0.143 ± 0.012 (841)	0.459 ± 0.001 (328)	0.679 ± 0.005 (257)	0.886 ± 0.007 (277)
61	0.174 ± 0.001 (1024)	0.562 ± 0.002 (401)	0.884 ± 0.003 (335)	1.090 ± 0.013 (341)

[a]Numbers in parenthesis is relative % of conjugated dienoic acid (CDA) values based on the initial CDA value of each frying oil.

2000). As the number of fryings performed by the oil increased, FFA values of frying oil increased. This is due to hydrolysis of frying oil during frying (Dobarganes and others 2000). Frying oil containing roasted sesame oil showed higher FFA values than the oil containing no sesame oil. This does not mean that oxidative stability of frying oil containing sesame oil during frying was lower than that of frying oil containing no sesame oil. Higher initial FFA values of frying oil containing sesame oil could contribute to higher FFA values during frying. FFA values of frying oil containing no sesame oil increased to 365%, 494%, 676%, 841%, and 1024% of the initial FFA value after the 13th, 25th, 37th, 49th, and 61th frying, respectively. However, frying oil containing sesame oil showed much lower FFA values relative to the initial FFA values than the oil containing no sesame oil after the corresponding number of fryings. FFA contents relative to the initial values of frying oil containing sesame oil at 20% were 117%, 160%, 213%, 257%, and 335% after the 13th, 25th, 37th, 49th, and 61th frying, respectively. This suggests that sesame oil addition to the frying oil decelerate FFA formation in frying oil.

The previous results clearly indicate that the addition of sesame oil to frying oil improved oxidative stability of soybean oil during frying of flour dough.

Tocopherol contents changes in frying oil during frying of flour dough

Changes in tocopherol contents of frying oil during 61 fryings of flour dough at 160 °C are shown in Table 6. Frying oil contained γ-, δ-, and α-tocopherols in decreasing order. Tocopherol contents of frying oil containing sesame oil were lower than those of frying oil containing no sesame oil. The more the sesame oil in frying oil, the lower the tocopherol contents in the oil. It was reported that soybean oil contains α-, β-, γ-, and δ-tocopherol at 81, 33, 584, and 252 ppm (Yanishlieva and others 2002), respectively. Roasted sesame seed oil contains less tocopherols than soybean oil and the contents of α-, γ-, and δ-tocopherols are 4, 584, and 9 ppm, respectively (Kamal-Eldin and Andersson 1997).

Tocopherol contents of frying oil decreased as the number of fryings performed by the oil increased. This indicates that tocopherols in the frying oil were decomposed during frying. Decomposition of tocopherols in frying oil containing sesame oil increased as the amount of sesame oil in frying oil increased. δ-Tocopherol was relatively stable during 61 fryings of flour dough, which was similar to others (Gordon and Kourimska 1995; Barrera-Arellano and others 1999).

Lignan compounds contents changes in frying oil during frying of flour dough

Contents of lignan compounds in frying oil during frying of flour dough at 160 °C are shown in Table 7. Frying oil contained sesamin, sesamolin, and sesamol in decreasing order. As the amount of sesame oil in frying oil increased, total lignan contents increased. Total lignan compounds contents of frying oil tended to decrease during frying, possibly due to degradation. Degradation of lignan compounds was lower in frying oil containing higher amount of sesame oil, in which more tocopherols were degraded. This strongly suggests that tocopherols protected lignan compounds in sesame oil from degradation during frying of flour dough. Higher amount of lignan compounds in frying oil could have contributed to lower the oxidation of frying oil during frying of flour dough. Kim (2000) suggested that lignan compounds contribute to high oxidative stability of roasted sesame oil more than tocopherols do. Synergistic effects of tocopherols and lignan compounds on the lipid oxidation have been also reported (Fukuda and others 1986a; Gertz and others 2000).

Table 6—Tocopherol contents in soybean and sesame oil mixture during repeated frying of flour dough at 160 °C

Frying oil composition (sesame oil: soybean oil, v/v)	Nth frying	Tocopherol content (ppm)				Relativity of tocopherol remained (%)
		α-	γ-	Δ-	Total	
0:100	1	25	306	38	369 ± 5.8	100
	13	25	307	42	373 ± 5.1	101
	25	24	291	38	353 ± 20.2	96
	37	24	283	32	339 ± 8.6	92
	49	22	251	31	304 ± 21.5	83
	61	20	246	31	297 ± 16.7	80
10:90	1	25	256	23	304 ± 0.2	100
	13	23	256	23	302 ± 5.2	99
	25	20	253	23	296 ± 0.2	98
	37	19	253	21	293 ± 4.3	97
	49	0	254	20	274 ± 0.5	90
	61	0	245	21	266 ± 1.8	87
20:80	1	22	245	23	290 ± 4.9	100
	13	19	213	20	253 ± 17.7	87
	25	20	237	20	278 ± 6.5	96
	37	0	226	22	248 ± 1.8	85
	49	0	233	22	254 ± 3.1	88
	61	0	217	21	238 ± 15.9	82
30:70	1	18	96	23	138 ± 22.7	100
	13	17	100	23	140 ± 5.6	101
	25	0	79	24	102 ± 8.8	74
	37	0	79	23	102 ± 14.6	74
	49	0	78	22	100 ± 3.4	73
	61	0	79	22	101 ± 1.0	73

Table 7—Lignan contents in soybean and sesame oil mixture during repeated frying of flour dough at 160 °C

Frying oil composition (sesame oil:soybean oil, v/v)	Nth frying	Lignan content (ppm)				Relativity of lignans remained (%)
		Sesamol	Sesamin	Sesamolin	Total	
10:90	1	9.6	104.3	19.0	132.9 ± 4.06	100
	13	5.9	50.5	20.6	77.0 ± 0.73	58
	25	5.7	45.9	20.1	71.7 ± 2.01	54
	37	5.2	45.6	18.5	69.3 ± 2.05	52
	49	5.4	46.5	18.8	70.7 ± 0.50	53
	61	7.1	50.3	19.3	78.2 ± 4.61	59
20:80	1	22.4	151.2	30.8	204.4 ± 1.88	100
	13	17.3	142.2	30.4	189.9 ± 6.88	93
	25	16.5	151.6	39.3	207.4 ± 11.70	101
	37	16.1	134.9	42.2	194.5 ± 6.12	95
	49	23.5	125.6	38.7	187.8 ± 0.86	92
	61	41.7	98.1	33.5	131.5 ± 3.91	64
30:70	1	67.0	184.9	95.0	346.9 ± 22.04	100
	13	40.0	175.4	74.1	289.5 ± 4.33	84
	25	34.5	198.1	73.0	301.2 ± 10.43	87
	37	28.6	206.0	67.6	302.2 ± 11.46	87
	49	35.5	232.1	63.6	331.2 ± 19.00	95
	61	45.4	232.4	49.5	327.3 ± 9.66	94

Frying oil containing sesame oil at 30% showed continuous decrease in sesamolin with an increase in sesamin, and this might be partly due to decomposition of sesamolin to sesamin. It has been reported that sesamolin decomposed to sesamol and sesamin during frying (Namiki and others 2002).

Conclusions

Addition of sesame oil to soybean oil as frying oil at 10%, 20%, and 30% (v/v) improved thermooxidative stability of the frying oil. Contents of tocopherols and lignan compounds in frying oil decreased during frying of flour dough. Tocopherols protected lignan compounds in sesame oil from degradation during frying.

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