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Blending of Oils-Does it Improve the Quality and Storage Stability, an Experimental Approach on Soyabean and Palmolein Based Blends

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Abstract: The present study of nutritional evaluation of two different oil blends were investigated using sesame oil as control. The blends selected were soyabean and palmolein with sesame in the ratios of 80:20 and 20:80. These blends were stored for 12 months and their physicochemical changes and fatty acid composition were studied every month till the end of the storage period. Though, there was a slight increase in the physical characteristics like specific gravity, lovibond color and refractive index of the blends studied, significant changes were mostly observed only in refractive index ($p<0.005$). There was a significant difference of increase ($p<0.005$) in comparison with control in all the chemical characteristics studied like peroxide value, free fatty acids, para-anisidine value, totox value, thiobarbituric acid value, kreis test and iodine value. Slight variations of increase in saturated fats and decrease in unsaturated fats were seen over time, which were significantly different than control. Based on the fatty acid composition of the blends proportion of S:M:P calculated showed that no blend had achieved the ideal ratio of 1:1:1. Results indicated that in terms of stability sesame-palmolein blends proved to be superior during storage.

Key words: Oil blends, storage, physico-chemical characteristics, fatty acids, soyabean oil, palmolein, sesame oil

INTRODUCTION

By blending different types of oils, the consumer can be offered a better quality product with respect to flavor and nutritive value (Chopra *et al*., 2004). In the last century, there has been more emphasis on edible oils based on regional production due to traditional taste and flavor preferences in the different regions. Some unconventional oils such as soyabean and palmolein came into production since the last 20 years, which were being accepted by the general public only in their refined form. Blending would also reduce the pressure for regional preferences of specific individual oil, thereby indirectly helping in stabilizing the edible oil price in a country (Chopra *et al*., 2004). There are basically three parameters to adjudge any oil as the healthiest cooking oil i.e., ratio of saturated/mono unsaturated/polyunsaturated fatty acid, ratio of essential fatty acids (Omega 6/Omega 3) and presence of natural

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antioxidants (White, 2000). The oils can be blended even to derive the protective advantage due to the presence of specific ingredients that offer protection against oxidation to improve frying recyclability (Toliwal *et al*., 2005).

Various workers had done studies on the quality and storage stability of soybean oil and palmolein both as blends and as single oils (Nirmala *et al*., 1996; Agarwal *et al*., 1998; Parvatham *et al*., 1998; Tatum and Chow, 2000) for a period of 12 months. Blending of oils modifies fatty acid composition without any chemical or biological process (Liu and White, 1992). With several national and local brands introducing blends of different oils to the consumers and taking into consideration the regional preferences of the population to sesame oil and at the same time under utilization of sesame oil as a blend, it was conceived and the present study planned to blend sesame oil with other refined oils like soyabean oil and palmolein, thus, exploiting the anti-oxidant properties of sesame oil with the objective to study the physicochemical characteristics and fatty acid composition of the oil blends during storage.

MATERIALS AND METHODS

The project was done during the period from June 2003 to June 2006 in the Department of Food Technology, Osmania University, Hyderabad, India under a major research scheme sanctioned by University Grants Commission. All oils were available locally and have been purchased in bulk from the oil millers association of Hyderabad, India. Sesame oil has been used as control and soyabean and palmolein were used as experimental oils. Sesame oil was blended with soyabean and palmolein in the ratios of 80:20 and 20:80 in the laboratory using a blender cum mixer and stored in PET bottles.

Analysis

All individual blends were initially analysed for their physico-chemical parameters like specific gravity (30°C), refractive index, lovibond color (Y+5R), peroxide value (meq kg^{-1}), free fatty acids (oleic acid %), Para-Anisidine Value (PAV), Totox Value, (TV), thiobarbituric acid value (TBA), kreis test, Free Fatty Acid (FFA) value, Iodine Value (IV) and its fatty acid composition. All the samples were analysed in triplicates. The blends were then analysed for their physicochemical parameters therein after every month for 12 months.

The physico parameters of specific gravity, refractive index were estimated by the method described in A Manual of Laboratory Techniques (Raghuramulu *et al*., 2003), where as lovibond color was estimated using the lovibond tintometer (Mathur, 1983). The chemical parameters of PV (AOCS Official and Tentative Methods, 1973), FFA (AOCS, 1993), PAV (IUPAC, 1997), TV (Akoh and Min, 1998) TBA (Bureau of Indian Standards, 2000), Kreis test (Toteja *et al*., 1990), IV (Raghuramulu *et al*., 2003) were estimated by standardized methods and fatty acid composition by Gas Chromatography (AOCS, 1993). Methyl esters of fatty acids were separated and determined quantitatively by gas chromatography. The data was tabulated and subjected to two way Analysis of Variance (ANOVA), tests of significance, means and standard deviation using the SPSS 15.0 windows version.

RESULTS AND DISCUSSION

Effect of Storage on Physico-Chemical Characteristics

A steady increase in specific gravity has been observed in control and all the blends as shown in Table 1. The specific gravity of fresh sesame oil was 0.922 units and the specific

Table 1: Changes in the specific gravity, refractive index and lovibond color value of the chosen oil blends during storage

			Storage period-Months				
Parameters	Sample	Ratio	0	3	6	9	12
Specific gravity	Control	100	0.922±0.001	1.018±0.035	1.05±0.035	1.135±0.029	1.162±0.036
	Sesame-	80:20	0.93±0.0106	1.004±0.029	1.05±0.026	1.152±0.039	1.167±0.036
	Soybean	20:80	0.93±0.007*	1.022±0.035	1.09±0.035	1.1447±.036	1.186±0.028
	Sesame-	80:20	0.93±0.0031	1.00±0.0251	1.08±0.036	1.166±0.035	1.17±0.037
	Palmolein	20:80	0.82±0.0086	0.938±0.025*	1.09±0.029*	1.152±0.016	1.18±0.0293
Refractive index	Control	100	1.465±0.0002	1.465±0.0001	1.465±0.00009	1.465±0.0001	1.465±0.0001
	Sesame-	80:20	1.47±0.0004*	1.47±0.0001*	1.47±0.0001*	1.47±0.0001*	1.47±0.0002*
	Soybean	20:80	1.46±0.0001*	1.47±0.0001*	1.47±0.0003*	1.47±0.0001*	1.47±0.0003*
	Sesame-	80:20	1.46±0.0002*	1.46±0.00009*	1.46±0.0002*	1.46±0.0001*	1.46±0.00009*
	Palmolein	20:80	1.45±0.0004*	1.45±0.0005*	1.45±0.0001*	1.45±0.0001*	1.46±0.0001*
Lovibond color value	Control	100	15.26±0.305	102.3±0.3000	110.8±0.3	115.18±0.236	116.35±0.312
	Sesame-	80:20	7.26±0.3055*	100.1±0.236*	108.26±0.20*	110.33±0.305	112.3±0.305*
	Soybean	20:80	1.16±0.2081*	10.8±0.300*	19.7±0.3*	20.25±0.229*	23.75±0.229*
	Sesame-	80:20	9.2±0.2645*	67.70±0.200*	76.65±0.312*	80.23±0.321	84.23±0.321*
	Palmolein	20:80	6.3±0.3605*	50.40±0.200*	67.31±0.262*	70.2±0.200	72.18±0.236*

Values are expressed by Mean±SD, *Significant at 5% level

gravity of the oil blends ranged from 0.928 units in sesame-palmolein (20:80) to 1.186 units in sesame-soyabean (20:80) for a period of one year. It was observed that sesame- soybean (20:80) at the initial stages of analysis was significantly different than control. Except for sesame-palmolein (20:80) the other blends did not show any significant difference when compared to control. The rise in the specific gravity observed in the study may be attributed to the formation of polymeric fractions of high molecular weight.

No vivid differences were observed during storage for refractive index of various oil blends up to 12 months and it ranged from 1.465 to 1.47 units in all the oil blends which were seen to be significantly different than control ($p<0.005$) (Table 1). Similar observations were reported (Parvatham *et al*., 1998; Murthi *et al*., 1987; Premavalli *et al*., 1998; Agarwal *et al*., 1998; Semwal and Arya, 2001; Padmavathy *et al*., 2001) with various oil blends. Storage period also did not show any differences in case of refractive index (Table 1).

The change in the color in control was seen to be from 15.26 to 116.35 units from the initial to the final months of storage. Pure fats and fatty acids are colorless and devoid of spectral properties in the visible range. However, all natural fats and oils contain pigments, which have more or less characteristic absorption patterns (Gupta, 2005). All the oil blends showed an increase in color as the storage period increased, ranging from 1.16 and 112.7 units and were seen to be significantly different than control which is depicted in Table 1. Changes in the lovibond color value of the selected oil blends during storage after every month showed a significant increase.

The intensity of the color was seen to be lighter in sesame-soyabean (20:80) probably because of its refined state and were seen to have lower lovibond color value of 23.75 units. The color of sesame was deep yellow and that of soyabean and palmolein a lighter yellow. Darkening of the color may be attributed to several factors such as storage conditions, condition of sterilization and oxidative effects during storage. The lovibond color units of red palm oil blends with refined sunflower and groundnut oil had no change in color upon storage for 6 months in contradiction to the present study (Sarojini and Bhavani, 1997; Sundararaj *et al*., 2002; Khan *et al*., 1979).

The PV of oil blends and control stored for 12 months registered a progressive increase with the storage period which is shown in Table 2. Steady increase in all the blends in accordance to the extent of oxidation caused by the formation of hydro peroxides during fat oxidation was observed. The increase in PV of control was from 1.83-14.79 meq kg^{-1} during

Table 2: Monthly changes in the peroxide value (meq kg^{-1}) of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	1.83±0.0088	4.63±0.0571*	5.14±0.0427*	7.25±0.0403*	6.63±0.0108*
1	6.20±0.0896	7.20±0.0750*	10.24±0.180*	7.33±0.1800*	9.20±0.0960*
2	8.14±0.1563	9.04±0.0960*	12.21±0.155*	8.91±0.1800*	10.59±0.243*
3	9.50±0.1625	10.49±0.162*	13.92±0.180*	10.57±0.089*	12.07±0.089*
4	10.37±0.0896	11.93±0.243*	15.05±0.096*	12.26±0.156*	14.15±0.180*
5	10.82±0.1625	12.17±0.1800	15.88±0.096*	12.80±0.1001*	15.00±0.0953*
6	11.49±0.1620	14.19±0.162*	17.08±0.075*	14.02±0.180*	16.58±0.156*
7	12.14±0.0350	15.00±0.1234*	17.96±0.180*	14.91±0.089*	16.95±0.112*
8	12.92±0.0890	15.24±0.075*	18.25±0.180	15.54±4.675	17.85±0.096*
9	13.64±0.1800	16.39±0.096*	19.28±0.155*	15.93±0.089*	18.96±0.243*
10	13.93±0.0890	16.70±0.0896*	19.86±0.155*	16.33±0.100*	20.24±0.162*
11	14.34±0.0960	17.05±0.123*	20.91±0.180*	16.93±0.089*	20.88±0.112*
12	14.79±0.1560	17.55±0.096*	20.97±0.155*	17.30±0.18*	21.27±0.243*

Values are expressed by Mean±SD, *Significant at 5% level

the 12 months of storage. The initial PV were seen to be higher in blends in comparison to control between 0 to 12 months of storage, showing the oxygen uptake by the oil in the blends studied. However, the increase in PV was seen to be the highest in sesame-palmolein (20:80) from 6.63 to 21.27 meq kg^{-1} followed by sesame-soyabean (20:80) from 5.14 to 20.97 meq kg^{-1}. Although, peroxides are possibly not directly responsible for the taste and odour of rancid fats, their concentration as represented by the PV is often useful in assessing the extent to which the rancidity has advanced.

According to Prevention of Food and Adulteration Act (PFA), fresh oils usually have PV well below 10 meq kg^{-1}. A rancid taste often begins to be noticeable when the PV is >20 meq kg^{-1}. Though, there is a progressive increase in PV upto 12 months of storage, it did not exceed the limits specified by PFA in the blends except sesame-palmolein (20:80) and sesame-soyabean (20:80), which has exceeded by 11 months of storage itself. The greater the magnitude of unsaturation the greater was the liability of fat to undergo oxidative rancidity, which of course was prominent in the case of sesame-soyabean (20:80).

Unlike in the present study the changes in the PV of edible oils stored at room temperature were not regular which was proved by a few other workers (Murthi *et al*., 1987; Murthy *et al*., 1996; Schnepf *et al*., 1991; Nasirullah *et al*., 1982). In most raw edible oils, there was a steady increase to a peak value and slight decline thereafter, refined oils showed irregular behaviour. The PV in the sesame-soyabean (80:20) increased from 4.63-17.55 meq kg^{-1} and for sesame-soyabean (20:80) it increased from 5.14-20.97 meq kg^{-1}. The rate of degradation of hydro peroxides is seen to be higher than control in case of blended oils. The higher increase in soyabean blend with sesame may be due to oxidation of linoleate because of the presence of active methylene groups in linoleate. It may also be due to greater oxidation rate of linoleic and linolenic acids as compared to oleic acid. In addition to changes to double bond position there is isomerism from cis to trans configuration. Trans configuration yields about 90% of the peroxides formed.

The formation of secondary oxidation products under storage conditions every month was determined by (PAV) and shown in Table 3. The blended oils were compared for their (PAV) with control during storage. The value for fresh sesame oil (control) was 1.04 units and after 1 month, the values of PAV did not differ significantly from this value. After 10 months, the PAV increased slightly to 1.28 units, thereafter 1.46 and 1.63 units. The same trend was seen in all the oil blends.

Table 3: Changes in the Para-anisidine value of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	1.04±0.0165	0.02±0.001*	0.71±0.002*	0.92±0.002*	2.67±0.022*
1	1.04±0.0188	0.02±0.039*	0.71±0.008*	0.92±0.012*	2.68±0.039
2	1.05±0.0173	0.02±0.019*	0.71±0.012*	0.93±0.049*	2.68±0.039*
3	1.05±0.025	0.02±0.039*	0.71±0.024*	0.94±0.018*	2.69±0.018*
4	1.07±0.018	0.04±0.012*	0.74±0.049*	0.95±0.039*	2.70±0.017*
5	1.07±0.024	0.04±0.012*	0.74±0.039*	0.96±0.031*	2.70±0.005*
6	1.08±0.024	0.04±0.008*	0.75±0.024	0.97±0.017*	2.70±0.039*
7	1.09±0.056	0.05±0.039*	0.76±0.033*	0.97±0.021*	2.71±0.018*
8	1.09±0.018	0.05±0.039	0.77±0.008	0.98±0.012	2.71±6.439
9	1.15±0.039	0.05±0.019*	0.78±0.012*	0.99±0.049*	2.72±0.018*
10	1.28±0.018	0.09±0.019*	0.95±0.018*	1.23±0.024*	2.92±0.005*
11	1.46±0.012	0.12±0.039*	1.24±0.033*	1.39±0.021*	3.09±0.018*
12	1.63±0.017	0.24±0.019*	1.53±0.012*	1.42±0.049*	3.21±0.039*

Values are expressed by Mean±SD, *Significant at 5% level

Table 4: Monthly changes in the Totox value of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	4.70±0.034	9.28±0.0856*	10.99±0.116*	15.42±.0209*	15.93±0.102*
1	13.64±0.1903	14.42±0.151*	21.19±0.396*	15.58±0.198*	21.08±0.396*
2	17.33±2.162	18.10±0.327*	25.13±0.090*	18.75±0.198*	23.86±0.533*
3	20.05±0.3469	21.00±0.346*	28.55±0.396*	22.08±0.190*	26.83±0.19*
4	21.81±0.1903	23.90±0.533*	30.84±0.198*	25.47±0.396*	30.37±0.32*
5	22.71±0.346	24.38±0.396*	32.50±0.198*	26.52±0.219*	32.70±0.20*
6	24.06±0.346	29.86±0.346*	34.91±0.151*	29.01±0.328*	33.82±0.396*
7	25.37±0.098	30.05±0.276*	36.68±0.396*	30.79±0.240*	36.61±0.190*
8	26.93±0.190	30.53±0.151*	37.27±0.396	32.06±0.198*	38.41±0.157*
9	28.43±0.396	32.83±0.198*	39.34±0.327*	32.85±0.533*	40.64±0.193*
10	29.14±0.018	33.49±0.018*	40.67±0.019*	33.89±0.024*	43.40±0.005*
11	30.14±0.198	34.22±0.276*	43.06±0.396*	35.25±0.24*	44.80±0.19*
12	31.21±0.320	35.34±0.198*	43.47±0.327*	36.02±0.533*	45.75±0.39*

Values are expressed by Mean±SD, *Significant at 5% level

However, the initial values of PAV for blends were seen to be different. Sesame-soyabean (80:20) showed the lowest PAV of 0.02 units initially which rose to 0.24 units by the end of 12th month storage period and 0.71 to 1.53 units in the sesame-soyabean (20:80). The lower PAV in soyabean oils may be because the beans are of sound origin and since, the PAV of sound oils were lower than for damaged oils, or since, the PAV represent secondary oxidation products. It may also be possible that the oxidation level may still be too low to be detected by this procedure. The PAV of sesame-palmolein (80:20) initially was 0.92 which increased to 1.42 units and sesame-palmolein (20:80), 2.67 initially and 3.21 units, respectively after 12 months of storage.

Totox value represents total description of the oil/fat quality, oxidation status and presence of degradation products formed from previous oxidation. The lower the TV the better is the quality of the oil (Wai *et al*., 2009). In Table 4, the changes in the TV of the selected oil blends during storage is presented and similarly to changes in peroxide value and para-anisidine value, TV showed a significant concomitant rise during the entire storage period. The para-anisidine value is often used in conjunction with peroxide value to calculate the so called total oxidation or totox value (Akoh and Min, 1998). The TV of control was seen to increase from 4.7 to 31.21 units. The highest increases were seen in sesame-palmolein (20:80) 15.93 to 45.75 units followed by sesame-soybean (20:80) 10.99 to 43.47 units. As said these increases that could be seen were a parameter of the increase of peroxide value and para-anisidine value, hence, the increases were significant to that of peroxide values of the oil blends.

Table 5: Monthly changes in the Thiobarbituric acid value of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	0.007±0.0015	0.081±0.006*	0.100±0.0017*	0.170±0.0019*	0.190±0.0030*
1	0.097±0.0015	0.090±0.0007*	0.196±0.003*	0.196±0.001*	0.202±0.003*
2	0.121±0.0020	0.105±0.001*	0.241±0.002*	0.199±0.004*	0.211±0.003*
3	0.211±0.0024	0.217±0.002*	0.326±0.003*	0.363±0.001*	0.391±0.001*
4	0.295±0.0015	0.328±0.0045	0.456±0.0011	0.479±0.0035	0.500±0.0020
5	0.320±0.00247	0.410±0.0035*	0.520±0.0011*	0.500±0.0025*	0.540±0.0008*
6	0.399±0.002	0.490±0.0024*	0.590±0.0007*	0.590±0.0020*	0.610±0.0035*
7	0.427±0.013	0.522±0.002*	0.646±0.003*	0.622±0.001*	0.696±0.001*
8	0.490±0.0015	0.590±0.0007*	0.690±0.0035	0.710±0.0011*	0.540±0.2977
9	0.516±0.003	0.631±0.001*	0.743±0.002*	0.778±0.004*	0.791±0.001*
10	0.570±0.0015	0.680±0.0015*	0.780±0.0020*	0.810±0.0024*	0.830±0.0008*
11	0.592±0.001	0.710±0.002*	0.799±0.003*	0.838±0.001*	0.866±0.001*
12	0.619±0.0020	0.736±0.001*	0.818±0.002*	0.891±0.004*	0.932±0.003*

Values are expressed by Mean±SD, *Significant at 5% level

Table 6: Changes in the Kries test value of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	0.130±0.00208	0.130±0.0015	0.130±0.0019	0.130±0.0018	0.1300±0.0023*
1	0.140±0.0025	0.150±0.005*	0.153±0.001*	0.156±0.002*	0.1680±0.005*
2	0.188±0.0035	0.149±0.003*	0.168±0.002*	0.169±0.007*	0.1800±0.005*
3	0.258±0.0041	0.164±0.005*	0.193±0.004*	0.194±0.002*	0.1980±0.002*
4	0.294±0.0025	0.183±0.002*	0.201±0.007*	0.202±0.005*	0.2080±0.003*
5	0.310±0.0041	0.19±0.0020*	0.260±0.0057*	0.270±0.0040*	0.2900±0.0016*
6	0.396±0.004	0.214±0.001*	0.298±0.004*	0.327±0.003*	0.3840±0.005*
7	0.439±0.019	0.268±0.005*	0.306±0.004*	0.398±0.003*	0.4260±0.002
8	0.490±0.0025	0.300±0.0057*	0.310±0.0013*	0.440±0.0020	0.3800±0.1953
9	0.520±0.0057	0.360±0.0036*	0.390±0.0020*	0.480±0.0075*	0.5100±0.0025*
10	0.583±0.002	0.394±0.003*	0.414±0.002*	0.515±0.004*	0.5620±0.001*
11	0.618±0.002	0.413±0.005*	0.430±0.004*	0.560±0.003*	0.5790±0.002*
12	0.624±0.0035	0.430±0.0036*	0.459±0.002*	0.590±0.0075*	0.6005±0.005*

Values are expressed by Mean±SD, *Significant at 5% level

The TBA value of control and the blends are shown in Table 5 and represents the change on storage for twelve months. Significant increase in TBA values could be noticed between the initial and final periods of storage in all the blends indicating the development of off flavor, but there were not large enough to cause perceptible changes upto 12 months of storage at room temperature. Sesame-palmolein has recorded higher initial values and also higher values after 12 months of storage. The results of the present study are in agreement with that of a few workers (Semwal and Arya, 2001; Melton, 1983), who reported the TBA values on storage for a few oil blends.

The changes in the kreis test value of selected oil blends during storage is shown in Table 6. Detection of epoxy aldehydes and their acetals is the basis of the kreis test (Narasimhan *et al.*, 1999). Control had a kreis test value of 0.13 initially and as the period of storage increased the kreis test value increased to 0.62. All the blends studied had an initial kreis test value of 0.13. A kreis test value of less than 0.15 is considered as being not rancid and between 0.15 to 0.5 as incipient rancidity and above 1 as highly rancid (Toteja *et al.*, 1990). Among the blends sesame-soybean blends of both the proportions recorded lowest values after 12 months of storage in relation to control and were significantly better than control. Sesame-Palmolein (20:80) recorded the highest values. According to kreis test value the blends and control were seen to be within the normal limits and only incipient rancidity could be seen, though however, by the end of storage period the blends were significantly superior than control. Relevant studies regarding kreis test values in blends were unreported.

Table 7: Changes in the free fatty acid value (% oleic acid) of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	0.53±0.0066	0.29±00483*	0.53±0.0027*	0.70±0.0017*	0.09±0.0046*
1	0.65±0.0000	0.47±0058*	0.62±0.0005*	0.98±0.0005*	0.11±0.0005*
2	0.89±0.0000	0.54±0.000*	0.73±0.001*	1.01±0.0005*	0.23±0.000*
3	0.99±0.0005	0.56±0.0005*	0.76±0.0005*	1.09±0.0005*	0.26±0.0011*
4	1.02±0.0005	0.99±0.0010*	0.99±0.001*	1.37±0.0005*	0.38±0.000*
5	1.19±0.0005	1.01±0.001*	1.06±0.0005*	1.48±0.000*	0.47±0.000*
6	1.35±0.0005	1.34±0.0005*	1.45±0.0005*	1.77±0.0005*	0.67±0.0005*
7	1.47±0.0352	1.43±0.1234*	1.57±0.1126*	1.98±0.0896*	0.96±0.1800*
8	1.54±0.0003	1.44±0.0001*	1.99±0.0002*	2.22±0.6267*	1.01±0.0007*
9	1.71±0.0005	1.57±0.0000*	2.02±0.001*	2.40±0.000*	1.19±0.0005*
10	1.82±0.0000	1.88±0.0000*	2.38±0.0005*	2.59±0.000*	1.31±0.0005*
11	1.93±0.0000	2.02±0.0005*	2.50±0.0005*	2.73±0.000*	1.46±0.001*
12	2.00±0.0003	2.13±0.002*	2.63±0.0009*	2.97±0.0007*	1.54±0.0003*

Values are expressed by Mean±SD, *Significant at 5% level

The changes in FFA expressed in % oleic acid during storage for a period of 12 months is shown in Table 7. The initial FFA of control was seen to be 0.53, which increased slowly and steadily to 2 units after a storage period of 12 months. In the present study sesame-palmolein blends had the highest increase of FFA ranging from 0.53 to 2.97 units between the two blends of 80:20 and 20:80 which were significantly superior than control. In practice, because of the susceptibility of the oil to enzymatic hydrolysis, the FFA content may vary with age and storage history. A few workers (Semwal and Arya, 2001; Padmavathy *et al*., 2001; Sarojini and Bhavani, 1997) had quoted the same on the stability of edible oils and their blends during storage.

The hydrolytic reaction was slower in sesame-soybean blends in the present study as indicated by the increase in FFA from 0.09 to 1.54 units in sesame-soybean (20:80) and 0.29 to 2.13 in the sesame-soybean (80:20) which may be because of the refined state of the soyabean oil. Refining removes FFA and hence, the initial value were low and by the end of the storage period it remained within the limits (2.5%) as stipulated by PFA. Similar observations were seen by Parvatham *et al.* (1998) and confirmed the increase in FFA content in the soyabean oil blends. Formation of FFA was found to increase with increase in time of storage, though the hydrolytic changes were not predominant. Though, the initial levels of FFA were found to be different in the blends because of the different grades of oils (i.e., refined and filtered forms), the rate of formation was found to be almost parallel, recording a drastic increase after 12 months of storage for all the blends.

Data on changes in the IV of the selected oil blends during storage is shown in Table 8. It was observed that IV decreased gradually during storage. Maximum IV was 128 units initially in sesame-soybean (20:80) and 120 units in sesame-soyabean (80:20) blend which decreased to 125.7 and 116.9 units by the end of the storage period. Minimum IV was 55.6 units in sesame-palmolein (20:80), which further decreased to 51.3 units on storage. Slow decrease in IV of oil blends may be due to induction period where fat was oxidized slowly showing initiation stage of auto oxidation reaction. Rapid changes in IV of oil blends may be attributed to propagation of auto oxidation process where hydro peroxides are formed from free radicals in fatty acids generated in initiation stage or auto oxidation reaction. During the end of storage period slight change in IV was observed which might be due to termination stage of reaction. The results of the present study are in agreement with a few workers (Parvatham *et al*., 1998; Semwal and Arya, 2001; Padmavathy *et al*., 2001; Premavalli *et al*., 1998; Nasirullah *et al*., 1991; Handoo *et al*., 1992). The IV of palmolein blend was seen to be low, which suggests that it is rich in saturated fats and the higher iodine value in soybean oil suggests that it is rich in polyunsaturated fats.

Table 8: Changes in the Iodine value of selected oil blends during storage

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	106.9±0.264	120.0±0.458*	128.0±0.173*	96.3±0.296*	55.6±0.427*
1	106.8±0.100	119.9±0.200*	127.8±0.100*	95.9±0.180*	55.2±0.180*
2	106.3±0.100	119.7±0.100*	127.6.±0.200*	95.7±0.025*	54.8±0.086*
3	106.1±0.100	119.6±0.173*	127.4±0.180*	95.5±0.086*	54.5±0.132*
4	105.8±0.086	119.2±0.180*	127.2±0.200*	95.2±0.165*	54.1±0.152*
5	105.4±0.100	118.8±0.173*	126.9±0.100*	94.9±0.129*	53.8±0.132*
6	105.3±0.086	118.4±0.132*	126.8±0.346*	94.8±0.231*	53.5±0.125*
7	105.1±0.264	118.1±0.264*	126.5±0.100*	94.6±0.125*	53.2±0.180*
8	104.8±0.100	117.7±0.100*	126.3±0.200*	94.3±0.090*	52.8±0.086*
9	104.5±0.100	117.3±0.173*	126.2±0.173*	94.0±0.108*	52.4±0.132*
10	103.8±0.100	117.2±0.200*	126.0±0.100*	93.7±0.156*	51.9±0.180*
11	103.5±0.086	117.0±0.132*	125.8±0.173*	93.5±0.081*	51.6±0.125*
12	103.2±0.100	116.9±0.200*	125.7±0.3605*	93.2±0.086*	51.3±0.180*

Values are expressed by Mean±SD, *Significant at 5% level

Table 9: Changes in the fatty acid composition of control during storage (%)

	Control	Ses:Soybean		Ses:Palmolein	
Month	100	80:20	20:80	80:20	20:80
0	10.03±0.0194	5.26±0.00305	37.94±0.0114	46.74±0.0187	Negligible
1	10.28±0.2516	5.29±0.17054	37.40±0.4633	46.78±0.1654	Negligible
2	10.59±0.2516	5.54±0.2757	36.95±0.9614	46.58±0.2203	Negligible
3	10.63±0.3013	5.57±0.3058	36.35±0.5473	46.33±0.8458	Negligible
4	10.67±0.3167	5.60±0.2019	36.15±1.8704	46.19±1.0010	Negligible
5	10.68±0.3010	5.63±0.300	35.71±0.5470	46.09±1.0700	Negligible
6	10.83±0.3010	5.69±0.381	35.28±0.4400	45.89±1.0720	Negligible
7	10.86±0.1550	5.72±0.1705	34.87±0.9000	45.75±1.0910	Negligible
8	10.86±0.2510	5.73±0.3058	34.21±0.7170	44.89±1.9880	Negligible
9	10.53±0.2780	5.76±0.210	33.99±1.3080	44.35±0.3790	Negligible
10	11.17±0.2510	5.79±0.2174	33.74±1.3770	44.3±0.14500	Negligible
11	11.28±0.2460	5.835±0.160	33.113±2.750	44.29±3.0500	Negligible
12	11.89±0.3160	5.867±0.156	33.05±2.1060	44.24±1.0600	Negligible

Values are expressed by Mean±SD, *Significant at 5% level

Effect of Storage on Fatty Acids

Fatty acid composition of edible oils does not obey to a standard pattern because this composition is modified by the amount of saturated, mono unsaturated and polyunsaturated fatty acids (Valenzuela *et al*., 2002). According to current concepts the influence of high fat intake on cardiovascular status depends on the fatty acid profile and the P:S ratio, both of which can be modified by fatty acids (Rao, 1994). Use of different edible oils and blending them to make up for the deficient factors is essential. The possibility of developing nutritionally more suitable oils with recommended fatty acid ratios and their effect during storage is the point of discussion n selected oil blends.

Fatty acid composition and changes during storage of control is shown in Table 9 and the results indicated that control is deficient in C-18:3. During storage there is a gradual increase in C-16:0 from 10.03 to 11.89 units, in C-18:0 from 5.26 to 5.86 units and a gradual decrease in C-18:1 from 37.94 to 33.05 units, in C-18:2 from 46.74 to 44.24 units upto 9 months of storage and faster changes from 10 to 12 months of storage. The proportion of S:M:P is 1:2.4:3 for the same, whereas Saha (2001) reported the fatty acid composition of sesame oil derived an S:M:P ratio as 1.0:1.6:1.7.

Gradual increase in saturated fats and a decrease in unsaturated fats were seen over time, which were significantly different than control in the oil blends studied. This may

Table 10: Changes in the fatty acid composition of sesame: soybean blends during storage (%)

	16:0 (Palmitic acid)		18:0 (Stearic acid)		18:1 (Oleic acid)	
Month	80:20	20:80	80:20	20:80	80:20	20:80
0	12.15±0.005*	12.66±0.035*	1.74±0.0155*	3.57±0.0008*	32.74±0.035*	28.27±0.005*
1	12.28±0.307*	12.96±0.256*	1.69±0.3819*	3.65±0.1127	32.89±0.254*	28.05±0.494*
2	12.65±0.321*	13.06±0.246*	2.19±0.2777*	3.73±0.1606*	32.26±0.090*	28.02±0.479*
3	12.56±0.307*	13.48±0.744*	1.96±0.3819*	3.89±0.3058*	32.62±0.254*	27.82±0.556*
4	12.86±0.246*	13.77±0.971*	2.84±0.1606*	3.97±0.5061*	32.66±0.107*	27.61±0.526*
5	12.97±0.246*	14.18±0.720*	3.07±0.16*	4.10±0.27*	33.03±0.107*	27.29±0.767*
6	13.55±0.256*	14.61±0.327*	3.12±0.1127*	4.40±0.4775*	33.31±0.106*	26.96±0.983*
7	14.09±0.307*	14.86±1.247*	3.37±0.3819*	4.47±0.5228*	33.75±0.254	26.91±0.965*
8	14.19±0.307*	14.95±0.256*	3.52±0.3819	4.71±0.6575	33.92±0.254	26.57±0.666*
9	14.72±0.321	15.05±0.319	4.08±0.277*	4.73±0.659*	33.98±0.09*	26.44±0.49
10	15.10±0.321*	15.10±0.873*	4.69±0.2777*	5.02±0.1705*	34.04±0.090	26.40±0.463*
11	15.09±0.307*	15.37±0.453*	4.677±0.381*	5.07±0.54*	33.83±0.552	26.22±0.638*
12	15.64±0.321*	15.64±1.11*	5.19±0.277	5.19±0.879	33.41±0.646	26.209±0.49*

	18:2 (Linoleic acid)		18:3 (Linolenic acid)	
Month	20:80	80:20	20:80	80:20
0	38.91±0.926*	51.840±0.022*	0.7700±0.3226	3.600±0.00611
1	38.83±0.228*	51.830±0.836*	0.7920±0.0123	3.430±0.2959
2	38.73±0.782*	51.380±0.129*	0.8357±0.011	3.362±0.287
3	37.14±0.228	51.230±0.269*	0.8590±0.0123	3.309±0.3367
4	35.17±0.379*	51.010±0.489*	0.9000±0.007	3.260±0.24434
5	33.86±0.379*	50.550±0.379*	0.9120±0.007	3.120±0.107
6	31.66±0.083*	49.490±0.269*	0.9200±0.0060	3.080±0.0674
7	30.88±0.129*	49.440±0.297*	0.9400±0.0123	2.910±0.1467
8	30.29±0.129*	49.410±0.170*	0.9600±0.0123	2.840±0.1572
9	30.25±0.379*	49.370±0.259*	1.0000±0.0115	2.620±0.1963
10	29.74±0.228*	49.330±0.521*	1.0500±0.0115	2.600±0.4916
11	29.97±0.379*	48.830±0.152*	1.0640±0.012	2.434±0.130
12	29.84±0.019*	48.207±0.12*	1.0580±0.076	2.420±0.007

Values are expressed by Mean±SD, *Significant at 5% level

probably be due to oxidative cleavage of these fatty acids on storage. The C-18:2 was seen to be the major fatty acid in soybean blends at 38.73 and 51.84 units followed by C-18:1 at 32.74 and 28.27 units (Table 10). The S:M:P ratio was seen to be 1:2.3:2.2 and 1:1.7:3.4 for both 80:20 and 20:80 blends respectively of the same as shown in Table 12.

Palmolein blends showed higher C-18:1 and C-16:0, followed by C-18:2, C-18:0 and C-18:3 (Table 11). The 1:1.9:2 and 1:1:0.4 were the ratios of S:M:P observed in both the blends of palmolein before storage, respectively. Semwal and Arya (2001) contradicted the changes in the fatty acid composition during storage as not significant in oil blends and Murthy *et al.* (1996) and Nasirullah *et al.* (1982) were in total agreement with increase in total saturates and a decrease in total unsaturates of fatty acids during storage.

The objective of this part of the study was to determine the optimal fatty acid composition to achieve a balance between the storage stability, frying property and health aspect. Both soyabean oil and sesame oil contained palmitic, stearic, oleic, linoleic and linolenic acids. Among the fatty acids, content of linoleic acid was the highest in all the samples. The higher the sesame oil content, the higher the oleic and stearic acid contents and the lower the palmitic, linoleic and linolenic acid content. This resulted in higher unsaturation ratio, which is a content ratio of unsaturated fatty acids to saturated fatty acids in sesame oil blended samples.

Based on the fatty acid composition of various blends proportion of S:M:P is calculated and shown in Table 12. These values indicate that though the ideal proportion of 1:1:1 is not

Table 11: Changes in the fatty acid composition of sesame-palmolein blends during storage (%)

	16:0 (Palmitic acid)		18:0 (Stearic acid)		18:1 (Oleic acid)	
Month	80:20	20:80	80:20	20:80	80:20	20:80
0	14.64±0.027*	35.58±0.089*	5.160±0.0293*	3.730±0.23105	39.33±0.027*	41.23±0.033*
1	14.90±0.246*	35.67±0.307*	5.250±0.1606*	3.900±0.3819	39.25±0.170*	41.05±0.328*
2	15.08±0.378*	36.05±0.307*	5.180±0.5061	3.924±0.381*	39.06±0.288*	40.76±0.328*
3	15.28±0.251*	36.66±0.251*	5.203±0.1705	4.020±0.1705*	38.94±0.444*	40.19±0.150*
4	15.75±0.307*	37.22±0.316*	5.138±0.3819	4.290±0.2758*	38.80±0.709*	39.40±0.066*
5	15.01±0.152*	37.33±0.281*	5.380±0.352	4.560±0.364*	38.01±0.762*	39.11±0.062*
6	16.26±0.316*	37.64±0.278*	5.530±0.2277	4.630±0.3414*	37.97±0.769*	38.43±0.254*
7	16.98±0.238*	40.2±0.251*	5.740±0.3848	4.780±0.1261*	37.61±0.480*	38.13±0.611*
8	17.20±0.2462*	37.90±1.6987*	5.760±0.4080	4.870±0.1341	37.27±1.056*	37.22±0.850*
9	17.51±0.458	39.15±0.251	5.990±0.262	4.890±0.626*	37.04±0.86	37.11±0.15*
10	17.88±0.301*	39.46±1.026*	6.170±0.2733	5.010±0.4790*	36.98±0.394*	36.79±0.062*
11	18.17±0.238*	39.86±0.360*	6.257±0.062	5.186±0.17*	36.92±0.429*	36.07±1.03*
12	18.75±0.378*	41.15±0.307*	6.390±0.495	5.490±0.27	36.91±0.288*	34.93±0.254*

	18:2 (Linoleic acid)		18:3 (Linolenic acid)	
Month	20:80	80:20	20:80	80:20
0	40.30±0.005*	19.28±0.020*	0.59±0.00300	Negligible
1	40.25±0.129*	19.04±0.231*	0.602±0.00743	Negligible
2	38.28±0.489*	18.74±0.409*	0.535±0.01681	Negligible
3	36.20±0.165*	18.72±0.572*	0.513±0.0066	Negligible
4	34.26±0.379*	18.33±0.220*	0.458±0.012	Negligible
5	32.99±0.271*	18.30±0.161*	0.410±0.005	Negligible
6	30.64±0.220*	18.26±0.063*	0.370±0.0116	Negligible
7	29.97±0.203*	18.25±0.249*	0.370±0.0602	Negligible
8	29.48±0.129*	18.08±0.269*	0.340±0.0576	Negligible
9	28.95±0.489	17.79±0.047	0.314±0.011	Negligible
10	28.03±0.269*	17.35±0.659*	0.300±0.0043	Negligible
11	27.87±0.203*	16.82±0.902*	0.287±0.052	Negligible
12	27.09±0.489*	15.81±0.888*	0.226±0.021	Negligible

Values are expressed by Mean±SD, *Significant at 5% level

Table 12: Proportion of S:M:P of the selected oil blends

	Control	Ses:Soybean		Ses:Palmolein	
	100	80:20	20:80	80:20	20:80
Month	S:M:P	S:M:P	S:M:P	S:M:P	S:M:P
0	1:2.4:3	1:2.3:2.2	1:1.7:3.4	1:1.9:2	1:1:0.4
1	1:2.4:3	1:2.3:2.2	1:1.6:3.3	1:1.9:2	1:1:0.4
2	1:2.2:3.8	1:2.1:2	1:1.6:3.2	1:1.9:1.9	1:1:0.4
3	1:2.2:2.8	1:2.2:2.1	1:1.6:3.1	1:1.9:1.7	1:0.9:0.4
4	1:2.2:2.8	1:2:1.9	1:1.5:3	1:1.8:1.6	1:0.9:0.4
5	1:2.1:2.8	1:2:1.9	1:1.4:2.9	1:1.7:1.5	1:0.9:0.4
6	1:2.1:2.7	1:2:1.9	1:1.4:2.7	1:1.7:1.4	1:0.9:0.4
7	1:2:2.7	1:1.9:1.9	1:1.3:2.7	1:1.6:1.3	1:0.8:0.4
8	1:2.1:.2.7	1:1.9:2	1:1.3:2.5	1:1.6:1.3	1:0.8:0.4
9	1:2.1:2.7	1:1.8:2	1:1.3:0.4	1:1.5:1.2	1:0.8:0.4
10	1:2:2.6	1:1.7:2	1:1.3:0.1	1:1.5:1.1	1:0.8:0.3
11	1:1.9:2.5	1:1.7:2	1:1.2:0.1	1:1.5:1.1	1:0.8:0.3
12	1:1.9:2.5	1:1.6:1.9	1:1.2:0.1	1:1.4:1	1:0.7:0.3

achieved there is an improvement in the proportion of fatty acids when compared to control. It was interestingly seen that as the storage period was increasing, the proportion of S:M:P came closely to the standard ratios of 1:1:1 due to increase in saturated fats and decrease in unsaturated fats during storage. With the present oil blends studied it was seen that sesame-palmolein (80:20) showed a near ideal fatty acid proportion.

CONCLUSIONS

The blends could be stored for a period of 12 months without any adverse changes in their peroxide values, which were seen to be under the limits specified by regulations mentioned by PFA. Based on the fatty acid composition of the blends proportion of S:M:P calculated showed that no blend had achieved the ideal ratio of 1:1:1. But with the present oil blends studied the fatty acid combination studied initially before storage, it was seen that sesame-palmolein (20:80) showed a closer ratio to the ideal combination of S:M:P. It was noted that as the storage period was increasing the proportion of S:M:P which came more closer to the ideal ratios which of course could not taken as the correct measure for the ideal ratios since, storage showed a gradual increase in saturated fats and a decrease in unsaturated fats over time due to oxidative cleavage of fatty acids.

Considering the merits and demerits of single oil as a cooking medium, blended oils seem to be just as or even more suitable than single oil for culinary purposes. Blending of course could be so designed as to achieving an ideal fatty acid combination. Oil blends having nutritional merits and have more stability during heating could thus be expected to receive acceptance if sufficient time is given for adjustment. Based on the results of the present study, the following recommendations can be suggested. The blends chosen should be based on fatty acid composition to obtain a nearer balance of fatty acid proportion of 1:1:1 as per the recommendations of American Heart Association. Suitability of blending of unconventional oils with traditional oils to obtain a near fatty acid combination can be done and it also reduces the demand on traditional oils.

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