Storage Stability Evaluation of Some Packed Vegetable Oil Blends

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ABSTRACT: The physicochemical characteristics and minor component contents of blended oils packed in pouches in relation to starting oils used for blending were studied over a period of 6 mon at two storage temperatures and humidity conditions: 27°C/65% RH and 40°C/30–40% RH. Color, PV, FFA value, β-carotene content, tocopherol content, and oryzanol content of the oils were monitored at regular intervals. The color, PV (0.6–20.7 meq O_2/kg , FFA value (0.08–2.1%), tocopherol content (360–1700 ppm%), oryzanol content (460–2,000 mg%), and sesame oil antioxidants (400–2,000 mg%) were not changed in either the starting oils or their blends. Oils and oil blends containing a higher initial PV (18.9–20.7 meq O_2/kg) showed a slight reduction in value at 40°C, whereas oils having lesser PV of 5-10 showed a slight increase during the storage period. Among the minor components studied, only β-carotene showed a reduction, 8.9–60.2% at 27°C and 48–71% at 40°C, for the different oil blends studied. The observed results indicated that the packed oil blends studied were stable under the conditions of the study, and the minor components, other than β-carotene, remained unaltered in the package even at the end of 6 mon of storage.

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KEY WORDS: Blended oil, micronutrients, minor components, minor constituents, packaging, storage stability, vegetable oil blends.

India occupies an important place in the world in production of major oilseeds (1). About 60% of the oil extracted from these oilseeds contains 40% or more of unsaturated FA. Edible oil quality is defined mainly by organoleptic parameters such as flavor, odor, and color for expeller-pressed unrefined vegetable oils; and certain other physicochemical characteristics such as FFA value, saponification value, iodine value, Bellier turbidity test, refractive index, unsaponifiable matter, and FA composition are being used for determining the quality of refined vegetable oils. However, more emphasis is placed on the PUFA content and natural antioxidants present as minor components in the oil. The minor constituents, which are uniquely present in certain vegetable oils, are associated with medicinal qualities and hence helpful in preventing diseases and promoting health. These include the oryzanol present in rice bran oil (RBO), which has been shown to have hypocholesterolemic activity (2,3). The β-carotene found in palm oil, which functions as provitamin A and a scavenger of oxygen free radicals, has health benefits of its own (4). Tocopherols and tocotrienols present in unrefined and physically refined oils, such as palm oil and RBO, have antioxidative and hypocholesterolemic properties and are beneficial in preventing cardiovascular diseases (5). Sesame oil (SESO) contains sesamin, which acts as an antioxidant and a hypocholesterolemic agent (6). With the growing awareness of health and fitness among consumers, the health-improving minor components of vegetable oils are being isolated and used as nutritional supplements.

With this background, the present study was undertaken to incorporate health-improving minor components, found in underutilized vegetable oils, into more widely used oils through blending. The major vegetable oils commonly used in different regions of India are groundnut oil (GNO), sunflowerseed oil (SFO), and mustardseed oil (MO). These oils do not contain the health-improving minor components such as oryzanol, tocotrienols, and lignan antioxidants. Indian food laws do not permit external addition of minor components as concentrates/isolates to vegetable oils, but a vegetable oil (unrefined or refined grade) containing minor components can be incorporated at a level of 20 to 80% in any other vegetable oil (7,8). Previous reports on oil blends have focused on component tocopherols (9), FA composition in relation to stability (10), and storage stability of oil blends (11). No data regarding stability during storage under packed conditions of oil blends containing minor components such as β-carotene, tocopherols, oryzanol, and SESO lignan antioxidants are available. In this communication, we report the preparation and storage stability of oil blends enriched with minor components with reference to the starting oils used for the preparation of oil blends.

MATERIALS AND METHODS

Refined vegetable oils, GNO, and SFO and expeller-pressed, unrefined mustard oil (MO) and SESO, were purchased from the local market of Mysore city; RBO (physically refined, from Eastman Agro Mills, Ltd., New Delhi, India) and unrefined palm oil (Palm Tech India, Ltd., Mysore, India) were obtained from the manufacturers. The unrefined palm oil was fractionated into olein and stearin fractions by using a suspended basket centrifuge followed by a mild treatment of olein fraction with alkali to yield deacidified red palm olein

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(PO). The deacidified red PO was used as such without bleaching and deodorization so as to retain naturally present β-carotene, tocopherols and tocotrienols. All reagents used were of analytical grade.

Vegetable oil blend preparation. Base oils (GNO, MO, and SFO) were blended with PO, RBO, and SESO in the following weight ratios: GNO/PO, 80:20; MO/PO, 80:20; SFO/PO, 80:20; GNO/RBO, 80:20; MO/RBO, 80:20; SFO/RBO, 80:20; GNO/SESO, 80:20; MO/SESO, 80:20; SFO/SESO, 80:20; SFO/RBO/SESO/PO, 40:20:20:20; GNO/RBO/SESO/PO, 40:20:20:20; MO/RBO/SESO/PO, 40:30:20:20. The procedure for blending was similar to that used earlier (11). The blending oils (PO, RBO, and SESO) were chosen for their contents of nutritional interest, *viz*., PO (β-carotene, tocopherols and tocotrienols), RBO (oryzanol, tocopherols, tocotrienols, and phytosterols) and SESO (tocopherols and lignan compounds found in unsaponifiable matter).

Packaging of the oil blends and storage studies. Once prepared, the oils and oil blends (200 mL) were packed in 16 × 10 cm pouches (having a water vapor transmission rate in the range of 0.01–0.50 g/m^2/d at 92% RH and 38°C and an oxygen transmission rate in the range of 0.01–10 cm^3/m^2/d/atm at 65% and 27°C). The pouches were stored in two humidity cabinets adjusted to two storage conditions, 27°C/65% RH and 40°C/30–40% RH. The stored samples were then withdrawn once a month in independent duplicates for evaluation of (i) oxidation, (ii) bleaching of color, (iii) any hydrolysis of the oil due to moisture pickup, and (iv) the retention of the minor components, *viz.*, β-carotene. Oryzanol and other minor components including tocopherols were analyzed once at the beginning and at the end of 3 and 6 mon of storage.

Analytical methods. PV (Method Cd 8-53) and FFA content (Method Ca 5a-40) of the oils were measured according to AOCS methods (12) using 5 ± 0.1 g of the oil samples. Color of the oil samples was determined by using a Lovibond tintometer in 1" cell in the transmittance mode and expressed as 5R+Y Lovibond units.

Minor components determination. Oryzanol content in the oil was determined by measuring the optical density at 314 nm in a 1-cm path length cell on the hexane solution of oil in a UV-Vis double beam spectrophotometer (model UV-240; Shimadzu Corporation, Kyoto, Japan) followed by calculation using the specific extinction coefficient of 358.9 (13) and expressed as g/100 g oil.

Tocopherol contents of the initial and stored oils were determined after saponification of the oils and extraction of the unsaponifiable matter followed by colorimetric determination using Emmerie Engel procedure as reported in the vitamin E panel method (14) and expressed as mg/kg oil.

β-Carotene content was determined by reversed-phase HPLC (LC-6A; Shimadzu Corporation) using an instrument equipped with a UV detector (SPD-6A) and fitted with a μ-Bondapack, 10 μm C-18 column (4.6 × 300 mm; Millipore, Milford, MA). The mobile phase was methanol/acetonitrile (1:1) at a flow rate of 1.0 mL/min, and the detector was set at 460 nm. A calibration curve using standard β-carotene was prepared in the range of 10–50 ng and used for the determination of β-carotene content of PO and its blends. All data were generated in quadruplicate from the two independent duplicate stored samples and then averaged.

RESULTS AND DISCUSSION

Physicochemical characteristics of base oils and blending oils. The physicochemical characteristics of the base and blending oils and minor component composition of the base oils, blending oils, and the blended oils are given in Tables 1 and 2; these results are comparable to literature reports (15). PO had high color values due to retention of β-carotene (for providing nutrition) and RBO had deep color (due to color fixation during physical refining of the oil); these increased color values had no relationship to the presence of minor components such as oryzanol. The PV of the starting PO and RBO were also slightly high, at 20.7 and 18.9 meq O_2/kg oil, respectively. However, rancidity was not noticed for these oils. The oryzanol content of the RBO was 2.0 g/100 g oil which was similar to that found in crude RBO. The tocopherol content of the oils used were in the range of 360–1700 ppm/100 g oil for the different oils.

Storage behavior of base oils and blending oils. The PV data and FFA values are presented in Tables 3 and 4, respectively, at temperatures of 27 and 40°C. At both temperatures, red PO showed a regular trend. The initial PV was about 20 meq O_2/kg, and it remained relatively constant over 6 mon of storage. RBO showed an irregular trend from the initial PV to the PV of the second month of storage period. The initial PV was 18 meq O_2/kg oil, and then fell to 2.2 meq O_2/kg oil by the second month; it continued to decline thereafter, indi-

TABLE 1
Physico-chemical Characteristics of Base and Blending Oils[a]

	Base oils			Blending oil		
Property	GNO	SFO	MO	PO	RBO	SESO
Color (5R+Y Lovibond units in 1 cm cell)	0.3	0.2	10.0	42.8	23.6	8.2
FFA (as % oleic acid)	0.08	0.10	0.60	0.10	1.00	2.10
PV (meq O_2/kg oil)	2.8	0.6	1.5	20.7	18.9	1.1
Tocopherols (mg/kg, ppm)	360	540	1070	1700	820	860
Oryzanol (%)	—	—	—	—	2.0	—
β-Carotene (mg/kg, ppm)	—	—	—	27	—	—

[a]GNO, groundnut oil; SFO, sunflowerseed oil; MO, mustardseed oil; PO, palm olein; RBO, rice bran oil; SESO, sesame oil.

TABLE 2
Minor Components Contents of Base Oils, Blending Oils, and Blended Oils Used in the Study[a]

Oil blend	Tocopherols (ppm)	β-Carotene (ppm)	Oryzanol (%)
GNO blends			
GNO	360	—	—
GNO-PO	630	67	—
GNO-RBO	850	—	0.51
GNO- SESO	1030	—	—
GPRS	960	52	0.54
SFO blends			
SFO	540	—	—
SFO-PO	7700	53	—
SFO-RBO	600	—	0.51
SFO-SESO	600	—	—
SPRS	1110	55	0.59
MO blends			
MO	1070	—	—
MO-PO	1200	41	—
MO-RBO	1020	—	0.58
MO-SESO	1030	—	—
MPRS	1530	49	0.46

[a]GPRS, GNO + PO + RBO + SESO; SPRS, SFO + PO + RBO + SESO; MPRS, MO + PO + RBO +SESO; for other abbreviations see Table 1.

cating the decomposition of hydroperoxides. SFO, MO, GNO, and SESO had initial PV < 10 meq O_2/kg oil, and no appreciable change in PV during storage was observed.

Physicochemical characteristics of oil blends. The physicochemical characteristics of oil blends were similar to their corresponding base and blending oils (Tables 3 and 4). Oil blends containing PO and RBO showed higher color and PV, whereas blends containing SESO or MO showed higher initial FFA values.

Storage behavior of oil blends. The PO and RBO blends showed lower PV than their blending oils, *viz*., PO and RBO at 27°C. The PV of SESO, GNO, SFO, and MO were much lower than their oil blends. This indicates that in spite of the higher starting PV of PO and RBO, the PV of their blends with other oils studied did not increase to an appreciable extent (Table 3).

The FFA content of base, blending, and blended oils did not increase appreciably during the 6 mon of storage compared with their initial FFA content (Table 4). This indicates that hydrolytic rancidity was much less in the base, blending, and blended oils during storage. SESO and RBO had higher initial FFA (>1% as oleic acid) compared to the other oils at 27 and 40°C (Table 4), whereas their blends showed lower FFA due to low initial FFA values for the oils used for blending. Color values showed slight or no change on storage up to 6 mon. The red PO, MO, SESO, and their blends were more highly colored than the other oils and their blends both before and after storage at 27 and 40°C (Table 5).

Stability of minor components during storage. The contents of the minor components, *viz*., oryzanol, tocopherols, and β-carotene (Table 6), were assessed periodically at both 27 and 40°C. RBO and its blends showed the same trend in the stability of oryzanol both at 27 and 40°C during storage for 6 mon. The contents of oryzanol and tocopherol (data not shown) did not change during storage. The base oil (RBO) contained 2.00 to 2.10 g/100 g oil; whereas in the blended oils oryzanol content ranged from 0.39 to 0.66 g/100 g oil. The tocopherols content of base oils, blending oils, and their blends, *viz*., GNO (350–370 ppm), SFO (530–551 ppm), MO (1050–1070 ppm); PO (1690–1710 ppm), RBO (800–830 ppm), SESO (855–863 ppm); GNO+PO (1002–1020 ppm), GNO+RBO (850–856 ppm), GNO+SESO (1030–1036 ppm), GPRS (1002–1024 ppm), SFO+PO (1000–1030 ppm), SFO+RBO (590–610 ppm), SFO+SESO (570–602 ppm),

TABLE 3
PV of Base Oils, Blending Oils, and Blended Oils During Storage at Two Different Temperatures[a]

	PV (meq O_2/kg) of samples stored at												
	27°C for months							40°C for months					
Oils	0	1	2	3	4	5	6	1	2	3	4	5	6
PO	2.09	1.67	1.88	1.66	1.76	1.71	1.71	1.75	1.64	1.89	1.78	1.74	1.80
RBO	1.89	2.20	1.82	0.94	0.75	0.72	0.70	2.80	1.84	0.95	0.95	0.91	0.90
SFO	0.60	3.60	4.10	3.83	4.13	3.04	3.10	3.50	3.90	3.62	3.64	3.63	3.60
MO	1.50	0.97	0.85	0.90	0.90	0.91	1.00	0.96	0.97	0.97	0.93	0.92	1.00
GNO	2.80	2.83	3.79	3.62	3.02	2.63	2.60	3.53	3.56	2.98	2.87	2.63	2.70
SESO	1.10	1.99	2.03	2.76	1.81	1.50	1.50	2.05	2.56	1.99	1.58	1.62	1.60
GNO + PO	7.05	7.40	7.40	7.25	5.60	3.70	3.70	5.30	7.00	7.51	6.63	6.38	6.40
GNO + RBO	5.50	3.64	3.11	2.89	3.12	3.16	3.20	3.63	3.32	1.78	0.99	0.98	1.00
GNO + SESO	4.40	3.90	3.62	3.68	3.75	3.32	3.30	3.57	3.62	3.80	3.69	3.38	3.40
SFO + PO	14.40	6.46	6.72	4.50	3.38	2.39	2.40	6.13	1.42	0.92	0.95	0.93	0.90
SFO + RBO	9.00	3.95	3.54	3.24	1.82	1.91	1.99	3.65	1.75	0.95	0.89	0.92	0.90
SFO + SESO	8.60	6.73	5.67	5.45	5.51	5.90	5.92	6.35	5.74	5.97	5.78	5.28	5.30
MO + PO	5.20	3.87	2.10	1.89	1.95	1.81	1.82	3.56	1.93	1.91	0.87	0.81	0.90
MO + RBO	1.20	1.18	1.89	1.91	1.93	0.93	0.90	1.81	0.92	0.81	0.89	0.93	0.90
MO + SESO	3.10	3.13	1.95	1.87	1.69	0.68	0.70	2.77	2.94	1.91	0.90	0.91	1.05
GPRS	11.00	6.86	7.26	5.63	5.75	5.34	5.30	6.64	5.60	5.53	4.40	4.90	4.90
SPRS	11.30	6.65	7.12	7.38	5.85	4.50	4.80	2.25	5.60	5.63	3.50	2.03	2.00
MPRS	8.40	5.37	5.36	5.65	3.90	2.81	2.92	4.74	5.52	5.81	4.94	5.20	5.31

[a]For abbreviations see Tables 1 and 2.

TABLE 4
FFA Values of Base Oils, Blending Oils, and Blended Oils During Storage at Two Different Temperatures[a]

	FFA (as % oleic acid) of samples stored at												
	27°C for months							40°C for months					
Oils	0	1	2	3	4	5	6	1	2	3	4	5	6
PO	0.10	0.10	0.10	0.10	0.11	0.12	0.12	0.15	0.16	0.11	0.12	0.12	0.12
RBO	1.00	1.58	1.27	1.15	1.42	1.4	1.40	1.06	1.23	1.24	1.23	1.24	1.25
SFO	0.09	0.10	0.07	0.06	0.05	0.06	0.06	0.09	0.09	0.09	0.81	0.82	0.85
MO	0.63	0.69	0.65	0.61	0.71	0.70	0.70	0.67	0.69	0.62	0.68	0.69	0.70
GNO	0.08	0.07	0.10	0.05	0.05	0.06	0.06	0.08	0.10	0.09	0.09	0.10	0.10
SESO	2.10	2.40	2.5	2.54	2.56	2.60	2.60	2.54	2.56	2.66	2.64	2.64	2.65
GNO +PO	0.13	0.71	0.18	0.19	0.16	0.17	0.17	0.54	0.59	0.57	0.57	0.57	0.57
GNO + RBO	0.29	0.29	0.39	0.37	0.39	0.40	0.40	0.59	0.46	0.60	0.56	0.60	0.60
GNO + SESO	0.05	0.06	0.06	0.05	0.05	0.05	0.59	0.14	0.17	0.17	0.19	0.19	0.18
SFO + PO	0.10	0.12	0.10	0.09	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.11	0.11
SFO +RBO	0.30	0.33	0.33	0.32	0.26	0.25	0.26	0.30	0.30	0.30	0.35	0.35	0.35
SFO + SESO	0.46	0.51	0.61	0.50	0.54	0.55	0.55	0.31	0.39	0.39	0.32	0.33	0.33
MO+ PO	0.47	0.52	0.53	0.58	0.55	0.55	0.56	0.98	1.05	1.35	0.99	1.00	1.10
MO + RBO	0.67	0.69	0.82	0.73	0.64	0.65	0.65	0.68	0.66	0.79	0.68	0.70	0.72
MO + SESO	0.93	1.0	0.83	1.05	0.96	1.00	1.00	0.33	0.45	0.39	0.38	0.39	0.39
GPRS	0.77	0.69	0.82	0.80	0.82	0.90	0.90	0.79	0.87	0.86	0.85	0.86	0.86
SPRS	0.69	0.78	0.81	0.80	0.78	0.80	0.80	0.80	0.84	0.83	0.86	0.90	0.90
MPRS	0.85	0.96	1.05	1.01	0.94	1.00	1.00	1.00	1.03	1.01	1.05	0.11	0.11

[a]For abbreviations see Tables 1 and 2.

SPRS (880–893 ppm), MO+PO (590–610 ppm), MO+RBO (1010–1020 ppm), MO+SESO (1010–1022 ppm), MPRS (1080–1104 ppm), also did not change appreciably during storage. The results presented on the stability of minor components, *viz.*, oryzanol and tocopherols, show that under the conditions used in the study, packaged oils and their blends may retain appreciable amounts of these natural antioxidants and therefore may provide adequate nutrition.

Various methods are available for the determination of β-carotene in vegetable oils and related products based on the analysis of unsaponifiable matter using reversed phase C-18 columns and methanol/acetonitrile/methylene chloride (16), methylene chloride/acetonitrile (17), and 90% methanol (18) as the mobile phases. In this study, the β-carotene content was determined by injecting the oil sample solution directly into the mobile phase. The PO used in this study contained about 270 ppm of β-carotene. The data in Table 6 indicate that β-carotene is relatively stable in PO and its blends at 27°C for the period of study (8.9–60.2%) under the test conditions. In contrast, a substantial instability of β-carotene was observed

TABLE 5
Color Values of Base Oils, Blending Oils, and Blended Oils During Storage at Two Different Temperatures[a]

	Color in 1-cm cell (5R + Y units) of samples stored at												
	27°C for months							40°C for months					
Oils	0	1	2	3	4	5	6	1	2	3	4	5	6
PO	143.0	143.0	143.0	142.0	142.0	142.0	142.0	142.0	143.0	142.0	142.0	142.0	142.0
RBO	23.6	23.6	23.4	23.4	23.3	23.2	23.2	23.6	23.4	24.2	24.2	23.0	23.0
SFO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
MO	10.0	10.0	10.0	9.0	9.2	9.3	9.3	9.6	9.8	9.8	9.4	9.3	9.3
GNO	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.3	7.6	7.6
SESO	10.0	10.0	9.8	9.6	9.7	9.6	9.6	7.6	7.2	7.1	7.8	7.8	7.8
GNO + PO	17.6	17.6	16.7	16.3	16.2	16.0	16.0	17.6	16.5	16.6	16.3	16.2	16.2
GNO + RBO	9.6	9.6	9.6	9.6	9.5	9.4	9.4	9.6	9.6	9.5	9.5	9.4	9.4
GNO + SESO	3.2	3.2	3.0	3.0	3.0	3.0	3.0	3.2	3.0	3.0	3.0	3.0	3.0
SFO + PO	18.0	18.0	18.0	18.0	18.0	17.0	17.0	16.0	18.0	18.0	18.0	18.0	18.0
SFO + RBO	9.6	9.6	9.6	9.6	9.5	9.0	9.0	9.6	9.6	9.5	9.5	9.4	9.4
SFO + SESO	1.6	1.6	1.5	1.4	1.4	1.4	1.4	1.6	1.5	1.4	1.4	1.4	1.4
MO + PO	17.6	17.6	17.6	17.3	17.2	17.0	17.0	17.0	17.0	17.3	17.2	17.0	17.0
MO + RBO	13.6	13.6	13.6	13.3	13.4	13.0	13.0	13.6	13.6	13.4	13.3	13.0	13.0
MO + SESO	9.6	9.6	9.6	9.5	9.5	9.5	9.5	9.6	9.6	9.5	9.5	9.4	9.4
GPRS	21.6	21.6	20.0	21.0	20.0	20.0	20.0	21.6	21.0	21.0	20.0	20.0	20.0
SPRS	21.6	21.6	21.0	20.0	20.0	20.0	20.0	21.6	20.0	20.0	20.0	20.0	20.0
MPRS	21.6	21.6	21.0	21.0	20.2	20.1	20.1	21.6	21.0	21.0	21.0	21.0	21.0

[a]For abbreviations see Tables 1 and 2.

TABLE 6
β-Carotene Content of RBO and Its Blends During Storage at Different Temperatures[a]

	β-Carotene content (ppm) of samples stored at												
	27°C for months							40°C for months					
Oils	0	1	2	3	4	5	6	1	2	3	4	5	6
PO	269.0	247.0	248.0	244.0	244.0	241.0	240.0	229.0	186.0	165.0	162.0	159.0	152.0
GNO + PO	66.7	47.0	39.2	40.7	41.3	38.3	38.2	49.6	36.2	28.1	25.9	23.5	20.1
SFO + PO	53.1	53.0	52.3	51.6	50.2	42.2	40.2	50.2	49.0	47.5	41.4	32.1	27.8
MO + PO	40.7	36.7	33.2	38.8	35.9	36.9	37.1	39.8	28.4	22.2	23.1	18.2	15.9
GPRS	51.5	22.4	23.7	22.5	22.9	21.4	20.5	21.8	19.5	18.5	18.8	16.3	15.3
SPRS	54.8	38.0	34.2	29.3	28.5	30.9	28.5	27.3	24.3	22.5	19.9	18.0	15.9
MPRS	49.2	48.6	40.3	35.0	36.7	34.5	35.1	41.3	35.8	27.5	23.9	21.5	19.4

[a]For abbreviations see Tables 1 and 2.

in the initial 3 mon of storage at 40°C in the PO and its blends (48–71%) (Table 6). Although there was a reduction in the β-carotene content during storage, it is expected that the levels retained are sufficient to give nutritional benefits in terms of providing provitamin A for the consumer.

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