Plant Archives Vol. 25, Supplement 1, 2025 pp. 1967-1974 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.269

EVALUATING QUALITY OF VARIOUS REFINED VEGETABLE OILS DURING STORAGE

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(Date of Receiving : 29-09-2024; Date of Acceptance : 29-11-2024)

ABSTRACT

Edible vegetable oils are important part of human diet providing several nutrients (antioxidants, essential fatty acids and vitamins). However, they are prone to quality deterioration by oxidation process leading to off-flavour and nutritional loss. Oil deterioration contribute to the formation of primary and secondary oxidation products that may pose health risk. Hence, it's of prime importance to determine the oil quality. This study used several standard methods (peroxide value, acid value, free fatty acids, thiobarbituric acid value, moisture content, fatty acid profiling, p-anisidine value and iodine value) to assess the quality of different refined vegetable oils thereby determining their shelf life. Most of the values fall within the permissible limits as prescribed by WHO. There was significant increase in the PV, p-anisidine value, acid value and total oxidation of oils during 90 days storage. Antioxidants are additives that retard the process of lipid oxidation thereby enhancing the shelf life of edible oils. However, higher concentration of α-tocopherol shows pro-oxidant effect leading to increase in oxidation.
Keywords **:** Antioxidants, Edible oils, Fatty acid profiling, Oxidative stability, Storage

Introduction

Edible oils comprise of important role in human diet, not only because of their taste and flavour but also due to their health benefits (Tian *et al.*, 2023). Edible fats and oils are used for cooking, deep-frying, salad dressing, mayonnaise and in several processed foods (cookies, chocolates, cream, bakery products). They provide essential fatty acids [linoleic (18:2), linolenic acid (18:3)] required for the body, energy and antioxidants (tocopherols, carotenoids, oryzanol) that help in human development and growth and the prevention of several severe illnesses such as neural, inflammatory, and cardiovascular disorders (Qian *et al.*, 2020). India is the second largest consumer of edible oil, commonly used vegetable oils include: coconut, cotton seed, canola, groundnut, mustard, palm, sesame, soybean, and sunflower oil (Zhang *et al.*, 2023).

Edible vegetable oils comprised of mainly triacylglycerides i.e., ester derived from glycerol and three fatty acids. Depending upon the type of fatty acids present vegetables oils differ in their chemical and nutritive characteristics (Vavra *et al.*, 2021). Oils high in saturated fatty acids are solid at room temperature while those having higher content of unsaturated fats are liquid at room temperature (Nduka *et al.*, 2021). Unsaturated fatty acids are significantly higher in vegetable oils compared to animal oil and thereby vegetable oils are considered healthier (Dinh *et al.*, 2021). The other minor compounds present in edible oils includes: vitamins, diacylglycerides, phytosterols, tocopherols, polyphenols, pigments, waxes etc which significantly affects their quality and are also beneficial for health. Due to the high temperature and chemicals used in refining process a major portion of these compounds are removed and added artificially to some of the processed oils as they

are beneficial for health (Ghodsi *et al.*, 2020). Hydrolysis and oxidation are the two common processes for deteriorating oil quality and leads to formation of mono- and diacylglycerols, glycerol, aldehyde, ketones, hyperoxides and carboxylic acid. Due to unsaturated fatty acids these oils are more prone to oxidation and quality deterioration (Lee *et al.*, 2022). The deterioration of oils may be accelerated during refining process or their storage in unsuitable conditions (humidity, microbial growth, exposure to direct sunlight or high temperature). This leads to change in flavour, colour and odour of oil rendering it unfit for consumption and loss in economic value. Therefore, maintaining quality control is of paramount importance to monitor vegetable oils quality for food safety (Ahmed *et al.*, 2023; Zhou *et al.*, 2020).

There have been different physical and chemical parameters in order to assess lipid oxidation. Some of the internationally used standard methods includes: acid value, free fatty acids (FFA), thiobarbituric acid reactive substances (TBARS), p-anisidine value, moisture content, peroxide value, totox value, iodine value, fatty acids profiling, polar compounds, conjugated dienes, phospholipids etc (Ahmed *et al.*, 2021). Free fatty acids are formed due to hydrolysis of lipids leading to increase in acidity of oils. Further the primary (hyperoxides) and secondary oxidations (alkenes, dienes, aldehydes, alkenes) products formed are together used as indication of total oxidation in edible oils. These products are directly linked to the bad odour and turbidity forms in edible oils. Peroxide value is the indication of primary oxidation products while p-anisidine for secondary oxidation products. Some other impurities like proteins, nucleic acid, phospholipids react with thiobarbituric acid (TBA) and measured as TBARS (Abeyrathne *et al.*, 2021). Using single parameter to analyse oil quality can be misleading hence, it is recommended to use these parameters altogether for measuring total oxidation. Considering the importance of edible oils in our diet and its nutritional value, the present study was carried out to analyse the quality of various refined vegetable oils using a set of different analytical methods mentioned above.

Materials and Methods

Sample collection: Various edible oils (canola, rice bran, soybean, sunflower, olive oil and blend A (rice+sunflower oil), blend B (sesame+soybean oil), blend C (rice+canola oil) were collected from the local market of Hisar and stored at room temperature (from November to February). Various parameters for tested for significance ($p<0.05$) using two-way ANOVA.

2.1 Peroxide Value

Ten gram of oil was mixed in acetic-acid/chloroform (3:2 v/v) solvents. 0.5 ml potassium iodide & 30 ml water added after one minute then titrated against 0.1 N sodium thiosulphate using 0.5 ml starch (1%) as indicator. Simultaneously blank was conducted (AOAC, 2000).

$$\text{Peroxide value (mEq of } O_2\text{/kg of oil)} = \frac{(S - B) \times N \times 1000}{W}$$

where,

S = Volume of sodium thiosulphate used (ml);

B = Volume of sodium thiosulphate used for blank (ml); W = Weight of oil sample (g); N = Normality of sodium thiosulphate solution

2.2 Acid Value

Mixture of oil sample and freshly neutralized methanol (50 to 100 ml) was titrated against 0.1 N sodium hydroxide using phenolphthalein (1g in 100 ml ethanol) as indicator (FSSAI, 2015).

$$\text{Acid value}\left(\text{mg of } \frac{\text{KOH}}{\text{g}} \text{ of oil}\right) = \frac{56.1 \times V \times N}{W}$$

where,

V = Volume of sodium hydroxide used (ml); N = Normality of the sodium hydroxide solution; W = Weight of the sample (g)

2.3 Iodine Value

Oil sample was added into carbon tetrachloride (25 ml) and Wij's solution (25 ml). After mixing potassium iodide (15 ml), the solution was kept in dark for an hour, simultaneously blank was carried out. After dilution (100ml) the liberated iodine was titrated against 0.1N sodium thiosulphate, using starch as end point (FSSAI, 2015).

$$\text{Iodine value}\left(\text{g of } \frac{\text{Iodine}}{100\text{g}} \text{ of oil}\right) = \frac{12.69(B - S)N}{W}$$

where,

B = Volume of sodium thiosulphate solution required for the blank (ml); S = Volume of sodium thiosulphate solution required for the sample (ml); N = Normality of the sodium thiosulphate solution; W = Weight of the sample (g)

2.4 p-Anisidine Value

Two grams of oil and 25 ml isooctane were mixed and measured at 350 nm absorbance (A_1) against a blank of isooctane. 5 ml of this mixture was added to 10 ml of anisidine solution and after 10 minutes, the

absorbance (A_2) was measured at 350 nm against blank (Diana *et al.*, 2012).

$$p-AV(mEq/kg)=\frac{25\times1.2\times(A_2-A_1)}{W}$$

where,

A_1 = Absorbance of oil and isooctane mixture; A_2 = Absorbance of sample and anisidine mixture; W = Weight of sample (gm)

2.5 Thiobarbituric acid value

Dissolv100 mg of oil in 25 ml 1-butanol then 5 ml of this soluiton was added to 5 ml of TBA reagent. The mixture was heated (95°C) for about two hours. The absorbance of the sample was taken at 530 nm using distilled water as blank (Pokorny and Dieffenbacher, 1989).

$$\text{TBA value (mg of MDA/kg)}=\frac{50\times(A-B)}{M}$$

where,

A = Absorbance of the sample solution; B = Absorbance of TBA reagent; M = Mass of oil sample (mg)

2.6 Totox Value

Totox value was calculated as below (Diana *et al.*, 2012).

$$\text{Totox value} = (2 \times PV) + p - AV$$

where,

PV = Peroxide value (mEq O_2/kg); p-AV = para-Anisidine value (mEq aldehyde/kg)

2.7 Moisture content and volatile matter

Oil sample (5 gm) was dried in an oven (105°C) for about an hour. The difference in weight was calculated after cooling it in desiccator (15 minutes) (FSSAI, 2015).

$$\text{Moisture content and volatile matter (\%)}=\frac{W_1\times100}{W}$$

where,

W_1 = Loss of the material on drying (gm), W = Weight of the material taken for test (gm)

2.8 Fatty acid composition

Instrumentation

Fatty acids were analysed using GC (Shimadzu Nexis GC 2030) coupled with FAME column. FID detector was used for analysis and the temperature conditioned as: injection port temperature: 240 °C, FAME column temperature: 50-260°C, flame ionization detector temperature: 260°C. Nitrogen gas was used as carrier gas and one ml of sample injected with flow rate of 0.62 ml/min & running time: 24 minutes (Vasudev *et al.*, 2008).

FAME preparation

Mixture of oil sample (1 ml) and methanol (5 ml): sulphuric acid (2-3 drops) was incubated (65°C) for an hour. After cooling the tubes to room temperature, hexane (2 ml) was added till layers were formed. The separated layer of (1-1.5 ml) was isolated into the vials for analysis.

2.9 β-carotene content

Oil sample (1 gm) was dissolved in 5 ml n-butanol (6:2 v/v) and kept in dark for 2 hours. After making up the volume to 10 ml, the absorbance was measured at 440 nm against blank (saturated n-butanol) (AOAC, 2000).

$$\beta\text{-carotene content (ppm)}=\frac{A}{0.00523}$$

where, A is the absorbance of the sample

2.10 α-Tocopherol content

Fifty-six milligram of oil was mixed in acetone and methanol mixture (7:3 v/v) and further 1 ml of 2, 2-bipyridal reagent (0.125 g in 25 ml ethanol) was added. After proper mixing 1ml of ferric chloride reagent (0.29 g in 100 ml ethanol) was added and measured at 522 nm using blank (mixture of 2, 2-bipyridal reagent and ferric chloride) (Verma *et al.*, 2019). The α-tocopherol content was calculated by standard curve from the following regression equation:

$$\alpha\text{-tocopherol content (ppm)}=\frac{A}{0.0016}$$

where,

A is the absorbance of the sample

2.11 Free Fatty Acid

Free fatty acid content is measured as follow (FSSAI, 2015).

$$\text{Free fatty acids (\% oleic acid)}=\frac{\text{Acid Value}}{1.99}$$

Results & Discussion

Antioxidants in edible oils

Antioxidants in edible oils are food additives that prevent the oil from oxidation by scavenging the free radicles thereby extending its shelf life (Fadda *et al.*, 2022). Tocopherol is the most common antioxidant found in vegetable oil. However, the concentration at

which it works effectively vary among different oil as it also acts as pro-oxidant at higher concentration as depicted by Martin *et al*., (2018) in soybean oil. In our study, α-tocopherol was found highest in case of sunflower oil (474.92 ppm) and thereafter decreasing significantly upon 30, 60 and 90 DAS which doesn't seem to correlate with lower oxidation in the oil (Table 6). For rice bran oil the α-tocopherol content varied from 214-175 ppm during the 90 days storage and also related to lowest oxidation (based on Totox value). Grilo *et al*. (2015) also observed decrease in α-tocopherol in soybean, sunflower, canola and corn oil. β-carotene on the other hand, was found highest in olive oil (18.97 ppm) and thereby decreasing (11.77 ppm) with the increase in days of storage. Canola and blend B oil depicted lowest range of β-carotene (1-2 ppm). Teh and Lau, (2023) found carotenoid retention between 51.24% and 83.63% after 12 months of storage in various edible oils, including palm and olive oils, under different conditions. The decline in antioxidants was followed across by all types of edible oils as seen in Table 6. α-tocopherol and β-carotene were significantly influenced by storage period and types of oil ($P \leq 0.01$).

Oxidative stability of edible oils

The oxidative stability of different edible oils was evaluated during 30,60 and 90 DAS using various parameters namely peroxide value, acid value, p-anisidine value; totox value; FFA; TBARS value and moisture content. The analysis of variance showed highly significant ($P \leq 0.01$) effect of types of oil and their storage on the peroxide value, p-anisisdne value & TBA value. Peroxide value of edible oils depicts increase as per storage days (Table 2). The values varied between 1.97-0.27 mEq/kg on DAS and 5.1-2.24 mEq/kg on 90 DAS that were within the acceptable limit of edible oils i.e., 10 mEq/kg (Codex standard). While PV depicts primary oxidation products (hyperoxides) p-anisidine value on the other hand depicts secondary oxidant products (aldehydes, ketones, polymers) in edible oils. The highest anisidine value was found for sunflower oil (19.51 mEq/kg) and for rest of the oils it ranged between 18.57 to 12.52 mEq/kg and thereafter increasing on 90 DAS (Table 3). The increase in the PV and p-anisidine value may be due to oxidation of fatty acids during prolonged storage. Since the primary oxidation products are unstable, they are simultaneously converted to secondary products. Among the secondary oxidation products, malondialdehyde specifically was determined using TBARS assay. The TBA value remarkably increased during 90 days storage for all the oils and it also corresponds to the anisidine value. Lowest TBA value was retained by rice bran oil (0.18-0.45 mg/kg) during the storage (Table 3). Mohammed *et al*., (2024) observed increment in TBA levels from 0.533 mg MDA/kg at the beginning to 1.446 mg MDA/kg after 12 months of storage in soybean oil. As the primary oxidation products readily decomposes into secondary products so it becomes essential to determine the total oxidation (i.e., totox value). The totox value increased as: rice bran oil < Blend C < olive oil < soybean oil < canola oil < Blend B < Blend A < Sunflower oil, thereafter increasing upon 90 days storage (28.87-19.40 mEq/kg) (Table 2). The acid value varied from 0.13-0.65 mg/g and lowest oxidation rate was observed in rice bran oil. The present study revealed that acid value and FFA value were significantly affected by oil types, storage and their interaction at $P \leq 0.01$. Upon oxidation triglycerides break down and form free fatty acids that indicates lower oil quality indicated by increased FFA value (Ejikeme *et al*., 2021). The refined oils with exceeding FFA value (> 2%) are discarded as they give foul odour. The FFA value was between 0.5-1 % for various oils during the entire storage period (Table 4). Our results are in agreement with previous studies reported by Maszewska *et al*., (2018) and Kumar *et al*., (2019). Another important parameter to evaluate oil quality is moisture content. The presence of water may lead to rancidity and thereby leads to microbial growth (Fatlawi and Abbas, 2010). According to WHO (2008), the maximum allowable moisture content of edible oils is 0.2 %. However, soybean (0.26 %) and sunflower oil (0.20 %) showed higher water content. There was no significant difference in moisture content of different edible oils during 90 days storage.

Fatty acid composition of edible oils

Fatty acid profiling was done for eight different samples of vegetable oils (Table 1). Different saturated and unsaturated fatty acids analyzed were: palmitic (C 16:0), stearic (C 18:0), oleic (C 18:1), linoleic (C 18:2; Omega 6), linolenic (C 18:3; Omega 3) and erucic acid (C 22:1). The result of this study showed that saturated fatty acids ranged between 17.34%- 1.47% among which palmitic acid had the major contribution and thereafter increasing upon 90 days storage. Similar study was carried out by Gulla and Waghray (2011) in sesame oil and its blends. Rice bran oil had the maximum palmitic acid content (16.71%), however overall blend A oil had the maximum content of saturated fatty acids (palmitic acid: 17.10% + stearic acid: 2.41%). There is an increasing trend towards consumption of MUFA as they are effective in preventing heart diseases by reducing the LDL and triacylglycerols levels in blood (DiNicolantonio *et al*.,

2022). The content of oleic acid was found lowest in soybean (24.12%) and blend B (28.13%) oil and for the rest oils it ranged from 57.74% to 43.12%. Only canola oil contained erucic acid (1.15%), which decreased after 90 days of storage (0.87%). Among the unsaturated fatty acids, linoleic acid (54.56%-19.10%) was predominant compared to linolenic acid (9.96%-0.95%). Canola oil had the highest linolenic acid content (9.96%) while soybean oil had the highest linoleic acid content (54.56%). The polyunsaturated fatty acids (linoleic and linolenic acid) decreased after 90 days of storage. Krol *et al*., 2021 observed 1.6 % (approx.) decrease in monounsaturated fatty acids thus the percentage of SFA increased by approx. 13.7% during 9 months of storage of hazelnut oil. Among PUFA's omega 6 and omega 3 are essential fatty acids as human body lacks the enzyme to generate them hence, they should be obtained through the diet (Kapoor *et al*., 2021).

As we know the degree of unsaturation greatly influences the oil's behaviour in cooking, such as smoke point, and its impact on health (Mahmud *et al*., 2023). The unsaturation of edible oils is measured through standard titration technique i.e., iodine value. Hence, overall its measurement of oil's stability, flavour, and nutritional properties (Thimmappa *et al*., 2021). The study showed that iodine value was highly significant ($P \leq 0.01$) for oil type and storage. Fatty acid composition changes during 90 days of storage can be explained by variations in the iodine value (82.36-120.73 g/100g) of various oils (Table 5). Olive oil exhibit the highest iodine value (120.73 g/100g) which corresponds to the total unsaturated fatty acids in the oil. The decrease in the iodine value during storage period may be attributed to the oxidation of fatty acids that leads to formation of short chain fatty acids, aldehydes, ketones and free radicles (Omozuwa *et al*., 2023).

Table 1 : Fatty acid composition (%) of different edible oils during 0, 30, 60 and 90 days after storage (DAS)

Fatty acids	DAS	Canola oil	Rice bran oil	Soybean oil	Sunflower oil	Olive oil	Blend A	Blend B	Blend C	CD*
Palmitic acid	0	9.16±0.09	16.71±0.07	12.05±0.10	6.50±0.07	7.93±0.05	17.10±0.09	11.70±0.06	11.86±0.04	0.20
	30	9.20±0.17	16.76±0.15	12.09±0.22	6.54±0.13	7.96±0.19	17.19±0.19	11.74±0.13	11.9±0.19	0.52
	60	9.26±0.18	16.82±0.18	12.16±0.12	6.61±0.15	8.05±0.20	17.23±0.19	11.79±0.18	11.94±0.22	0.51
	90	9.38±0.11	16.90±0.31	12.22±0.15	6.70±0.15	8.14±0.17	17.34±0.22	11.85±0.13	12.00±0.31	0.60
Stearic acid	0	3.38±0.05	1.98±0.08	2.68±0.06	4.01±0.08	1.47±0.07	2.41±0.09	5±0.11	2.03±0.09	0.23
	30	3.42±0.20	2.03±0.15	2.72±0.16	4.08±0.15	1.54±0.18	2.47±0.15	5.09±0.18	2.10±0.20	0.57
	60	3.48±0.17	2.10±0.16	2.77±0.16	4.16±0.28	1.69±0.13	2.53±0.20	5.15±0.20	2.16±0.12	0.52
	90	3.56±0.23	2.17±0.13	2.87±0.22	4.23±0.18	1.77±0.25	2.61±0.16	5.23±0.27	2.21±0.24	0.62
Oleic acid	0	54.23±0.09	43.98±0.14	24.12±0.19	57.74±0.10	57.32±0.06	43.12±0.13	28.13±0.14	52.52±0.10	0.35
	30	54.13±0.16	43.90±0.17	24.06±0.18	57.71±0.19	57.27±0.13	43.09±0.15	28.10±0.14	52.46±0.13	0.45
	60	54.05±0.20	43.85±0.16	23.99±0.17	57.67±0.20	57.23±0.30	43.01±0.25	28.05±0.20	52.41±0.16	0.57
	90	53.96±0.26	43.75±0.30	23.88±0.32	57.56±0.25	57.14±0.31	42.93±0.28	27.91±0.24	52.33±0.15	0.70
Linoleic acid	0	19.10±0.15	34.87±0.07	54.56±0.19	30.25±0.16	32.00±0.15	36.10±0.12	50.72±0.09	26.49±0.12	0.39
	30	19.07±0.20	34.81±0.22	54.51±0.17	30.21±0.20	31.96±0.23	36.03±0.17	50.67±0.18	26.42±0.22	0.55
	60	19.00±0.27	34.77±0.16	54.48±0.15	30.16±0.21	31.90±0.14	35.97±0.27	50.61±0.17	26.37±0.21	0.56
	90	19.73±0.30	33.60±0.22	53.34±0.34	29.15±0.26	31.53±0.17	35.26±0.21	49.33±0.12	25.34±0.26	0.65
Linolenic acid	0	9.96±0.17	1.80±0.09	6.03±0.09	0.95±0.12	1.20±0.15	1.20±0.14	4.35±0.14	6.73±0.13	0.40
	30	9.89±0.19	1.73±0.18	5.96±0.17	0.90±0.15	1.14±0.23	1.16±0.02	4.28±0.24	6.67±0.25	0.46
	60	9.83±0.19	1.66±0.24	5.90±0.12	0.85±0.19	1.10±0.19	1.11±0.14	4.20±0.25	6.61±0.23	0.49
	90	9.71±0.21	1.58±0.20	5.82±0.16	0.78±0.15	1.01±0.12	1.04±0.16	4.10±0.12	6.52±0.22	0.45
Erucic acid	0	1.15±0.29	ND	ND	ND	ND	ND	ND	ND	0.48
	30	1.59±0.21	ND	ND	ND	ND	ND	ND	ND	0.36
	60	1.07±0.24	ND	ND	ND	ND	ND	ND	ND	0.44
	90	0.87±0.24	ND	ND	ND	ND	ND	ND	ND	0.32

*Critical Difference (CD) at 5% level of significance; DAS (Days after storage); ND- not detected.

Table 2 : Peroxide and Totox (total oxidation) value of edible oils of crude and refined edible oils.

		Peroxide value (mEq/kg)				Totox value (mEq/kg)			
		0	**30**	**60**	**90 DAS**	**0**	**30**	**60**	**90 DAS**
1	**Canola oil**	1.56±0.03	1.65±0.03	2.15±0.03	3.73±0.04	18.72±0.48	19.49±0.42	20.95±0.42	26.37±0.43
2	**Rice bran**	0.38±0.01	1.13±0.02	1.76±0.02	2.23±0.03	13.27±0.51	16.09±0.26	17.77±0.55	19.40±0.49
3	**Soybean**	0.37±0.01	1.43±0.02	2.37±0.02	3.57±0.04	14.71±0.56	17.11±0.63	21.27±0.58	25.71±0.50
4	**Sunflower**	0.54±0.01	1.65±0.02	2±0.02	2.4±0.03	20.59±0.64	23.99±1.26	25.45±0.71	27.32±0.58
5	**Olive oil**	0.83±0.01	1.12±0.02	1.87±0.02	2.53±0.03	15.45±0.48	16.43±0.5	19.65±0.54	21.10±0.49
6	**Blend A**	0.7±0.01	1.18±0.02	2.6±0.06	3.3±0.03	19.96±0.51	21.65±0.47	25.77±0.45	27.78±0.62
7	**Blend B**	1.97±0.03	2.03±0.03	4.73±0.04	5.1±0.05	18.03±0.43	20.79±0.55	26.54±0.65	28.87±0.45
8	**Blend C**	0.27±0.01	1.03±0.02	1.87±0.02	2.27±0.02	14.33±0.60	16.18±0.51	19.01±0.49	20.55±0.40

Table 3 : p-Anisidine value (p-AV) and Thiobarbituric Acid reactive substances (TBARS) of crude and refined edible oils.

		p-Anisidine value (mEq/kg)				TBARS value (mg/kg)			
		0	**30**	**60**	**90 DAS**	**0**	**30**	**60**	**90 DAS**
1	**Canola oil**	15.6±0.49	16.2±0.41	16.66±0.38	18.91±0.51	0.26±0.01	0.33±0.01	0.47±0.01	0.5±0.01
2	**Rice bran**	12.52±0.53	13.84±0.3	14.25±0.51	14.94±0.52	0.18±0.01	0.24±0.01	0.31±0.01	0.45±0.01
3	**Soybean**	13.97±0.58	14.25±0.66	16.54±0.62	18.58±0.54	0.66±0.02	0.75±0.01	0.85±0.01	0.98±0.02
4	**Sunflower**	19.51±0.65	20.69±0.67	21.45±0.73	22.52±0.62	0.53±0.01	0.63±0.02	0.77±0.02	0.87±0.02
5	**Olive oil**	13.79±0.60	14.2±0.48	15.92±0.52	16.04±0.42	0.21±0.01	0.36±0.01	0.42±0.01	0.56±0.01
6	**Blend A**	18.57±0.5	19.3±0.45	20.57±0.41	21.18±0.55	0.45±0.01	0.56±0.02	0.69±0.01	0.82±0.02
7	**Blend B**	14.1±0.48	16.73±0.56	17.08±0.60	18.67±0.54	0.22±0.01	0.30±0.01	0.41±0.01	0.55±0.01
8	**Blend C**	13.8±0.6	14.12±049	15.28±0.48	16.02±0.45	0.23±0.01	0.28±0.01	0.34±0.01	0.43±0.01

Table 4 : FFA (Free Fatty Acid) and Acid value of crude and refined edible oils.

		Free fatty acid content (%)				Acid value (mg/g)			
		0	**30**	**60**	**90 DAS**	**0**	**30**	**60**	**90 DAS**
1	**Canola oil**	0.13±0.007	0.14±0.008	0.2±0.009	0.31±0.01	0.26±0.01	0.28±0.02	0.39±0.02	0.62±0.02
2	**Rice bran**	0.09±0.001	0.12±0.002	0.16±0.004	0.18±0.003	0.17±0.01	0.24±0.01	0.31±0.01	0.36±0.01
3	**Soybean**	0.13±0.005	0.42±0.007	0.71±0.009	0.87±0.016	0.25±0.01	0.82±0.02	1.41±0.03	1.73±0.03
4	**Sunflower**	0.33±0.012	0.47±0.024	0.66±0.019	1.1±0.026	0.65±0.02	0.93±0.02	1.32±0.02	2.19±0.03
5	**Olive oil**	0.47±0.005	0.53±0.007	0.61±0.01	0.67±0.012	0.13±0.01	0.27±0.01	0.32±0.02	0.43±0.01
6	**Blend A**	0.15±0.01	0.21±0.016	0.35±0.023	0.48±0.026	0.83±0.02	1.23±0.02	1.43±0.02	1.95±0.03
7	**Blend B**	0.08±0.016	0.12±0.019	0.19±0.021	0.24±0.024	0.92±0.02	1.97±0.03	2.12±0.03	2.24±0.02
8	**Blend C**	0.06±0.003	0.08±0.005	0.17±0.007	0.21±0.006	0.16±0.01	0.23±0.01	0.38±0.01	0.47±0.01

Table 5 : Moisture content and Iodine value of crude and refined edible oils.

		Moisture content (%)				Iodine value (g/100g)			
		0	**30**	**60**	**90 DAS**	**0**	**30**	**60**	**90 DAS**
1	**Canola oil**	0.12±0.003	0.13±0.003	0.13±0.003	0.15±0.003	114.39±1.54	114.1±1.48	113.74±1.49	112.42±1.46
2	**Rice bran**	0.09±0.003	0.1±0.003	0.1±0.003	0.1±0.003	83.03±0.97	82.57±1.05	82.44±0.88	82.36±0.93
3	**Soybean**	0.26±0.003	0.27±0.003	0.27±0.003	0.28±0.003	116.66±1.11	116±0.97	115.89±1.16	115.67±0.91
4	**Sunflower**	0.20±0.003	0.21±0.003	0.21±0.003	0.22±0.003	119.03±1.24	118.98±1.19	118.79±1.3	118.54±1.05
5	**Olive oil**	0.11±0.003	0.12±0.003	0.13±0.003	0.13±0.003	120.73±1.33	120.54±1.26	120.28±1.11	119.97±1.17
6	**Blend A**	0.08±0.003	0.09±0.003	0.09±0.003	0.09±0.003	96.49±0.87	96.46±0.8	96.18±0.73	95.93±0.95
7	**Blend B**	0.07±0.003	0.1±0.003	0.1±0.003	0.1±0.003	102.52±0.93	101.96±1.06	101.67±0.89	101.65±0.96
8	**Blend C**	0.06±0.003	0.07±0.003	0.08±0.003	0.08±0.003	119.09±1.15	118.97±1.24	118.8±1.03	117.26±0.97

Table 6 : β-carotene and Tocopherol content of crude and refined edible oils.

		β-carotene (ppm)				α-tocopherol (ppm)			
		0	**30**	**60**	**90 DAS**	**0**	**30**	**60**	**90 DAS**
1	**Canola oil**	1.92±0.2	1.11±0.16	0.63±0.1	0.54±0.1	257.13±5.6	250.79±4.28	249.61±5.87	224.92±4.99
2	**Rice bran**	7.11±0.35	5.49±0.29	4.21±0.2	3.45±0.17	214.21±6.53	200.73±7.53	199.42±6.23	175.05±7.84
3	**Soybean**	2.73±0.23	1.73±0.18	1.04±0.12	0.79±0.09	424.38±8.94	424.33±7.35	419.04±7.69	331.46±7.22
4	**Sunflower**	2.1±0.35	1.75±0.19	0.71±0.07	0.27±0.05	474.92±7.11	461.81±6.47	460.41±7.45	430.2±6.18
5	**Olive oil**	18.97±0.6	17.72±0.59	12.97±0.43	11.77±0.32	172.53±3.65	171.18±4.44	168.79±5.24	136.86±4.31
6	**Blend A**	5.05±0.29	3.44±0.31	2.33±0.24	2.21±0.20	164.84±3.32	162.54±4.56	161.99±5.14	143.74±4.16
7	**Blend B**	2.34±0.31	2.18±0.21	0.74±0.13	0.45±0.09	184.21±5.43	181.17±6.87	157.4±5.61	152.5±5.17
8	**Blend C**	8.84±0.37	7.64±0.25	6.64±0.3	4.80±0.27	206.47±4.67	205.43±5.46	203.8±4.98	171.71±3.48

Conclusion

The present study was carried out to investigate different physico-chemical and quality parameters of edible oils during 90 days of storage period. Our results indicate increase in the oxidation of all the edible oils, however, rice bran oil depicted least oxidation (in terms of PV, acid value, TBA value, p-anisidine value and totox value). Also, the presence of higher β-carotene content in olive and blend C oil correlate with their lower oxidation. However, higher α-tocopherol content in soybean and sunflower oil doesn't seem to lower oxidation. Hence, it's important to identify the appropriate concentration at which these antioxidants show their activity instead of pro-oxidant effect. Considering the importance of edible oils for health and their susceptibility to oxidation it's important to monitor their storage conditions (moisture level, light, temperature) to preserve the shelf life and thereby maintaining nutritional quality.

Acknowledgements: The funds for the research work were provided by Department of Biochemistry, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India.

Conflict-of-interest statement: The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

Abbreviations

Abbreviation		Definition
ANOVA	:	Analysis of Variance
p-AV	:	p-Anisidine value
DAS	:	Days after storage
FAME	:	Fatty acid methyl esters
FFA	:	Free fatty acids
MDA	:	Malondialdehyde
mEq	:	Milli-Equivalents
MUFA	:	Monounsaturated fatty acids
PV	:	Peroxide value
PUFA	:	Polyunsaturated fatty acids
SFA	:	Saturated fatty acids
TBA	:	Thiobarbituric acid
TBARS	:	Thiobarbituric acid reactive substances

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