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Stabilisation of Some Vegetable Oils by Sugarcane Leaf Extract at Ambient Temperature

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Abstract. The present study was aimed to assess the antioxidant activity of ethanolic sugarcane leaf extract for the stabilisation of sunflower, (SFO), soybean and (SBO) canola oils (CO) at ambient temperature. SFO, SBO and CO were added with 600 ppm sugarcane leaf extract, filled in transparent PET bottles, stored at ambient temperature for 180 days, sampled at 0, 60, 120 and 180 days for the assessment of oxidative stability. Total phenolic content in sugarcane leaf extract (SLE) was 724.3 (mg GAE/100g). 2,2,diphenyl- 2 picrylhydrazyl free radical scavenging activity of SLE was 76% as compared to 88% in butylated hydroxyl toluene. C18:1 and C18:2 in fresh, 6 months stored controls and SLE supplemented SFO were 46.12%, 42.59%, 44.91% and 47.15%, 40.29, 43.13%, respectively. C18:2 and C18:3 in fresh and 180 days stored control and SLE supplemented SBO were 51.19%, 45.61%, 48.97% and 6.19%, 3.37% and 5.67%, respectively. Similar trend was also recorded in canola oil. Induction period of supplemented vegetable oil was higher than the un-supplemented samples ($P<0.05$). Viscosity and specific gravity of supplemented vegetable oils were not different from non-supplemented samples. Sensory characteristics of SLE supplemented vegetable oils were not different from the control. Sugarcane leaf extract can be used for the long term preservation of SFO, SBO and CO at ambient temperature.

Keywords: sunflower oil, soybean oil, canola oil, oxidative stability, sugarcane leaf

Introduction

The auto-oxidation and photo-oxidation susceptibility of vegetable oils is one of the biggest problems of vegetable oil processing industry (Choe and Min, 2006). Health apprehensions of rancid vegetable oils are even worse than bad fats because of the absorption of several oxidation products in the body (Quiles *et al*., 2002). Auto-oxidation of fats and oils leads to the generation of potentially toxic oxidation products which have been connected in a large number of health related disparities such as atherosclerosis, carcinogenesis etc. (Turner *et al*., 2006). The conversion of primary oxidation products into highly reactive and toxigenic secondary oxidation products such as 4-hydroxy-2-alkenals has led to the great deal of concerns regarding the consumption of oxidized fats, the toxicity of oxidation products for L6 muscles has also been scientifically proven (Pillon *et al*., 2010; Zarate *et al*., 2009). Further, the nutritional and sensory characteristics of oxidized fats and oils are on the lower side due to the generation of a wide range of disagreeable flavouring compounds, loss of fats soluble vitamins and essential fatty acids (Kanner, 2007). Degree of unsaturation, processing conditions, metal ions, antioxidants, light and heat greatly influence the oxidation of vegetable oils. The undesirable activities of reactive oxygen species (such as superoxide, hydrogen peroxide and hydroxyl radicals) can cause oxidative damage to the cells, the unrestrained free radicals in body can lead to the damage of DNA, lipids, proteins, lipoproteins, carcinogenesis, cardiovas-cular diseases, diabetes, stroke and accelerated ageing (Adedapo *et al*., 2008;Yazdanparast and Ardestano, 2007). The role of phytochemicals as biologically active compounds in the neutralisation of free radicals, protective against oxidative damage and inhibition of lipid peroxidation has been well established (Valantina *et al*., 2009).

Sugarcane (*Sacchrum officinarum* L.) is one of the most widely cultivated cash crops in the world and recent studies have reported the presence of phenolic acids, flavonoids with diuretic, anti-anaemic, anti-ulcer and live protective properties. Although some work has been previously conducted to assess the antioxidant characteristics of sugarcane leaves, the detailed work is the need of hour to explore its antioxidant potential for the stabilisation of some commercially important vegetable oils. The oxidative stabilisation of vegetable oils through natural antioxidants has been extensively studied (Nadeem *et al.,* 2014) but the antioxidant activity

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of sugarcane leaf extract for the stabilisation of sunflower (SFO), soybean (SBO) and canola (CO) has not been previously investigated. This study aimed to stabilise SFO, SBO and CO through ethanolic sugarcane leaf extract at room temperature by the assessment of oxidative stability through some conventional and advanced analytical techniques.

Materials and Methods

Refined, bleached and deodorized (RBD) sunflower, soybean and canola oils (SFO, SBO and CO) without any additives were obtained from United Industries Ltd. Kashmir Road, Nishatabad, Faisalabad, Pakistan and their chemical camposition was noted (Table 1). Sugarcane leaves were obtained from Ayub Agricultural Research Institute, Faisalabad. All the reagents used in this work were HPLC grade and obtained from Sigma Aldrich, UK.

Preparation of antioxidant extract. Fresh leaves of surgarcane were washed with tap water, dried in the shade and ground to 100 mesh size. The sample (20 g) was mixed with 100 mL ethanol in a Pyrex beaker, mixed at 200 rpm for 8 h at room temperature (20-22 °C), filtered over Whatman filter paper and the residue was again extracted in a similar manner, pooled, evaporated on a rotary evaporator at 45°C (Buchi, Japan) till 10 mL, preserved in amber bottles and stored at 65 °C (Sanyo) till further use in this study.

Experimental plan. SFO, SBO and CO were added with 600 ppm sugarcane leaf extract, filled in transparent PET bottles, stored at ambient temperature for 180 days, sampled at 0, 60, 120 and 180 days for the assessment of oxidative stability.

Total phenolic contents. For the determination of total phenolic contents 5 mL Folin-ciolcalteu and 10 mL distilled water were mixed then 5 mL of this solution was mixed with 1 mL extract and sodium carbonate (7.5%), vortexed at 2200 rpm for 2 min and incubated at room temperature for the development of colour for 1 h and measured on a double beam spectrophotometer at 760 nm (Shimadzu, Japan). The concentration of total phenolic contents were calculated from the calibration curve (R^2=0.994) and expressed in terms of GAE/ 100 g (Wolf *et al*., 2003).

Determination of antioxidant activity in linoleic acid system. To a solution containing 0.13 mL linoleic acid, 10 mL 99.8% ethanol and 7 mL phosphate buffer (0.2 M; pH 7), 5 mg SLE was added, distilled water was added to make the volume of mixture to 25 mL, incubated at 4 °C. The extent of oxidation was determined as per thiocyanate method, 10 mL 75% ethanol, 30% ammonium thiocyante (0.2 mL), 0.2 mL SLE and 0.2 mL ferrous chloride solution (20 mL in 3.5% HCl) were added in a sequence. The absorption was read at 500 nm after 3min of stirring and compared with a control (without SLE). Butytated hydroxyl anisole (BHA) and butylated hydroxyl toluene (BHT) were employed as positive controls. The inhibition of linoleic acid peroxidation was calculated by the following expression to assess the antioxidant activity of extract (Yen and Duh, 1993).

100 – [(Absorbance of sample at 336 h/ absorbance of control at 336 h)]

DPPH free radical scavenging activity. DPPH solution (2,2,diphenyl-2 picrylhydrazyl) 1.95 (6×10^{-5}; 50 µL) was mixed with sugarcane leaf extract at different concentrations, left at room temperature for 60 min and absorbance was measured on double beam spectrophotometer at 515 nm (Mansouri *et al*., 2005). DPPH free radical scavenging activity was calculated by the following expression

% DPPH free radical scavenging activity= (AB-AS)/ AB × 100

where:

AB and AS is the absorbance of blank and sample, respectively.

Experimental plan. Sugarcane leaf extract (SLE) was incorporated into RBD SFO (winterized), SBO and CO at 600 ppm concentration, compared with the controls (SFO, SBO and CO without SLE as positive controls). Filled in PET bottles, stored at ambient temperature and oxidative stability was measured at 0, 60, 120 and 180 days of storage period.

Analysis. Peroxide, anisidine and iodine values were determined by the standard methods (AOCS, 1995). Specific extinctions at 232 and 280 nm were measured on a double beam spectrophotometer (Shimadzu, Japan) as per method (IUPAC, 2006). Two methods were used to assess the antioxidant potential of sugarcane leaf extract in the accelerated oxidation conditions; in the first method Schaal oven test was performed by exposing the vegetable oils added with SLE and controls to 63°C for 5 days, extent of peroxide value was determined as an adequacy of the antioxidant capacity of SLE (AOCS, 1995). Induction period was determined on a Rancimat 679 as per instructions prescribed in the instruction

manual of Metrohm Corporation, Switzerland (Metrohm, 1993). Colour was checked in 5.25″ quartz cell (Lovibond Tintometer Salisbury, England). The fatty acid methyl esters were prepared by sodium methoxide trans esterification technique in iso-octane, the supernatant FAME layer was injected at a 1µL concentration into the GC (Perkin Elmer Instrument, Auto system XL) using SP-2380 fused silica capillary column (30 m × 0.25 mm Supelco Bellefonte, PA) using nitrogen (1.5 mL/min) as a carrier gas (Qian, 2010). Fatty acids were identified and quantified by using FAME Mix GLC-30, Supelco). The results of triplicate treatments and three time analysis of each samples were expressed as Mean±SD and Duncan Multiple Range Test was used to determine the significant difference among the treatments (Steel *et al*., 1997).

Results and Discussion

Total phenolic contents. Total phenolic contents in ethanolic extract of SLE were 724.3 (mg GAE/100 g). Souza-Sartori *et al*. (2013) observed that the concentration of flavonoids in sugarcane leaf extract was 50.98 mg/100 mL. The antioxidant activity of sugarcane leaves is due to luteolin-8-C-(rhamnosyl glucoside) (Fabiana *et al*., 2008). The beneficial effects of polyphenols as antimicrobial, antimutagenic, antiproliferative, and vasodilatory activities has been well established *in vitro* studies (Lazarou *et al*., 2007; Taguri *et al*., 2006). Polyphenols can prevent tooth decay by inhibiting the activities of *Streptococcus mutans*, improve memory and lack of concentration disorders (Magdalini *et al*., 2009; Sasaki *et al*., 2004). The strong antioxidant activity of methanolic extract of sugarcane leaves has also been reported in Chinese sugarcane. In current investigation, the ethanolic extract of sugarcane top leaves also revealed the higher extent of phenolics. The literature suggest the better antioxidant activity of plant based antioxidants, but from the safety view point methanolic extracts for the stabilisation of food substrates could have a high degree of concerns due to its toxicity. Abbas *et al*. (2013) reported a great deal of neutralization of free radicals by the leaves of sugarcane from seven different cultivars of Pakistan.

DPPH free radical scavenging activity. DPPH free radical scavenging activity is a useful assay to determine the antioxidant activity of antioxidants. The scavenging of DPPH is based on the hydrogen donating ability of the antioxidant which leads to the formation of non-radical DPPH-H (Al-Farsi *et al*., 2005). The DPPH free radical scavenging activity of SLE was 76% (1mL) as compared to 88% in BHT (Fig.1). The strong free radical scavenging activity of SLE could be connected to the occurrence of a wide range of phenolic and polyphenolic compounds in SLE. The results of this investigation are corroborated with the earlier finding of Abbas *et al*. (2013) on the antioxidant activity of various sugarcane genotypes. The antioxidant and prophylactic activity of sugarcane has also been reported by Koge *et al*. (2000). Plant based natural antioxidants possess the capability of neutralizing free radicals, can safeguard the body from the damage caused to the cardiovascular system and oxidative stresses by the free radicals. DPPH free radical scavenging activity of sugarcane juice (60%) and detoxification of free radicals has been reported by Zamir *et al*. (2012). Li *et al*. (2010) studied the phenolics in sugarcane tip, stem, peel and leaves, the flavonoid content of the leaves 3700-µg/g was significantly higher over other parts of the plant ($P<0.05$).

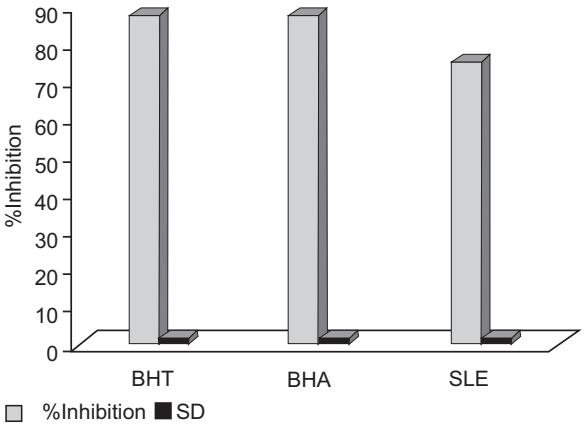

Fig.1. DPPH free radical scavenging activtiy of SLE. SD= standard deviation, BHT= butylated hydroxyl toluene; BHA= butylated hydroxyl anisole; SLE= sugarcane leaf extract.

Antioxidant activity in linoleic acid system. The antioxidant activity of SLE in linoleic peroxidation system is given in Fig. 2. SLE inhibited 82% peroxidation of linoleic acid as compared to 85% and 90% inhibition by BHA and butylated hydroxyl toluene (BHT) after 360 days of incubation. The percentage of inhibition of SLE was almost similar to BHA and comparable to (BHT). The great antioxidant activity of SLE can be connected to the higher concentration of phenolics. The

Table 1. Chemical composition of sunflower (SFO), soybean (SBO) and canola oils (CO)

Parameter	Unit	SFO	SBO	CO
Free fatty acids	%	0.08±0.01[a]	0.08±0.01[a]	0.09±0.02[a]
Colour	Lovibond scale	14±0.54[c]	18±0.92[b]	21±0.74[a]
Rancidity	Kries Test	-ve	-ve	-ve
USM	%	0.72±0.03[a]	0.66±0.04[a]	0.68±0.07[a]
Iodine value	Unit	122.46±1.29[a]	133.19±2.15[b]	110.54±1.42[c]

Within a row means denoted by a common letter are not statistically different; USM = Unsaponifiable matter.

Table 2. Effect of sugarcane leaf extract on peroxide value ($MeqO_2$/kg) of vegetable oils stored at ambient temperature

Treatments	0-Day	60-Days	120-Days	180-Days
SFO	0.25±0.03[n]	1.25±0.08[j]	2.88±0.11[d]	4.47±0.36[a]
SFO+SLE	0.25±0.03[n]	0.84±0.05[k]	1.34±0.07[i]	2.18±0.23[f]
SBO	0.22±0.02[n]	0.95±0.09[k]	2.53±0.15[e]	3.95±0.34[b]
SBO+SLE	0.22±0.02[n]	0.62±0.04[l]	1.74±0.13[h]	1.92±0.35[g]
CO	0.19±0.04[n]	0.81±0.05[k]	1.46±0.09[i]	3.19±0.46[c]
CO+SLE	0.19±0.04[n]	0.45±0.03[m]	1.22±0.07[j]	1.57±0.18

Within rows and columns means denoted by a different letter are statistically different (P<0.05).

antioxidant activity of *Moringa oleifera* leaf, fruits and vegetables for the inhibition of peroxidation of linoleic acid has been described by Anwar *et al*. (2006) and Siddhuraju and Becker (2003).

Peroxide value. The results regarding peroxide value of SFO, SBO and CO supplemented with SLE are given in Table 2. The addition of SLE in substrate oils considerably inhibited the generation of peroxides. Peroxide value of all the experimental samples and their controls increased throughout the storage period of 6 months but to varying extents. The rise of peroxide value during ambient storage period was dependent upon two factors, (i) the kind of oil i.e., degree of unsaturation and (ii) the addition of antioxidant. Polyphenolic compounds of SLE provided a great deal of protection to the oil samples added with SLE. Vegetable oils (controls) which were not added with SLE suffered a high degree of oxidation. The pattern of rise of peroxide value in the supplemented and non-supplemented vegetable oils was in the order of SFO> SBO > CO. The inhibition of lipid peroxidation phenomenon in the supplemented vegetable oils could be connected with the neutralization of free radicals by the antioxidant. The oxidizability of SFO was the highest followed by SBO and CO. The better inhibition of peroxidation could have been achieved by the application of higher dose of SLE however, this aspect needs to be further investigated. Assessment of peroxide value delivers a worthwhile evidence of the oxidative breakdown in fats and oils (Pritchard, 1991). Greater values are frequently interrelated with inferior storage stability (Fereidoon, 2005). The storage stability of vegetable oils through the phenolics of sugarcane leaf has not been previously investigated therefore, little is known regarding its suitability as an antioxidant for the preservation of vegetable oils at ambient temperature. The antioxidant activity of plant based natural antioxidants for the stabilization of vegetable and animal fat has been described by Nadeem *et al*. (2013); Anwar *et al*. (2011) and Mohdaly *et al*. (2011) .

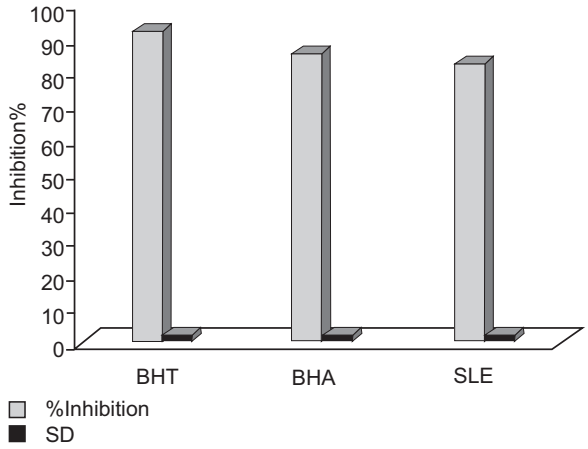

Fig. 2. Antioxidant activty of SLE in linoleic acid system. SD= standard deviation; BHT= butylated hydroxyl toluene; BHA= butylated hydroxyl anisole; SLE= sugarcane leaf extract.

Anisidine value. The results of anisidine value of vegetable oils added with SLE are presented in Table 3. Anisidine value of the experimental samples and their controls increased during the storage period of 180 days. Anisidine value of SFO supplemented with SLE and without SLE was highest at 60, 120 and 180 days of determination followed by SBO and CO and vegetable oils supplemented with SLE exhibited the lower concentration of oxidation products over their controls

(P<0.05). In this study, the effect of antioxidant on vegetable oils with different fatty acid composition was compared and the oxidizability of vegetable oils was in the order of SFO < SBO < CO. The generation of oxidation products also followed the fashion of oxidizability. The oxidation rate of linoleic acid is 12 times greater than oleic acid (Baer *et al*., 2001) that could be the justification of higher extents of oxidation products in SFO over SBO and CO. CO contains considerably higher concentration of monounsaturated fatty acids which are relatively more stable than polyunsaturated fatty acids that could be connected to the lower amount of oxidation products in CO. Determination of anisidine value gives information of the amount of oxidation products generated during the course of oxidative breakdown (Erickson, 1995). Addition of *Moringa oleifera* leaf extract considerably enhanced the storage stability of butter (Nadeem *et al*., 2013). The long term preservation of SFO and CO through barley and rice bran extracts has been reported earlier (Chatha *et al*., 2011; Anwar *et al*., 2010).

Table 3. Effect of sugarcane leaf extract on anisidine value of vegetable oils stored at ambient temperature

Treatments	0-Day	60-Days	120-Days	180-Days
SFO	4.11±0.04^{m}	14.64±0.62^{j}	23.72±1.13^{h}	47.96±1.54^{a}
SFO+SLE	4.11±0.04^{m}	9.62±0.47^{k}	17.68±0.91^{i}	34.67±1.18^{d}
SBO	4.31±0.02^{m}	12.95±0.77^{j}	32.54±1.64^{e}	41.18±1.76^{b}
SBO+SLE	4.31±0.02^{m}	8.29±0.59	13.67±2.16^{j}	29.22±0.86^{f}
CO	3.86±0.01^{m}	10.51±0.92^{k}	25.64±1.43^{g}	39.89±1.32^{c}
CO+SLE	3.86±0.01^{m}	7.62±0.38^{l}	12.38±0.66^{j}	19.35±0.43

Within rows and columns means denoted by a different letter are statistically different (P<0.05).

Conjugated dienes and trienes. The results of conjugated dienes and trienes of oils added with SLE and controls are given in Table 4 and 5. Oxidation products in the form of conjugated dienes and trienes went on increasing throughout the storage period of 180 days at ambient temperature depending upon the addition of natural antioxidant and fatty acid composition of individual oils. The rise of conjugated dienes and trienes at the end of storage period was in the order of SFO > SBO > CO, the determination frequencies of 60 and 120 days revealed the same order. In current investigation vegetable oils were compared with each other and their controls (without antioxidant). SFO, SBO and CO yielded the varying extents of oxidation product, also their extent was considerably lower than their controls (P<0.05) which revealed that the addition of SLE had a pronounced effect on the inhibition of auto-oxidation in these oils during long term storage at ambient temperature. The protective effect of SLE can be seen in all three types of 60, 120 and 180 days stored vegetable oils as compared to their controls. The inhibition of generation of oxidation products by SLE also has health beneficial effects as oxidation products have been implicated with flavour defects and health related disparities. Determination of conjugated dienes and trienes is regarded as one of the useful and convenient methods to quantify the oxidation products.

Table 4. Effect of sugarcane leaf extract on conjugated dienes of vegetable oils stored at ambient temperature

Treatments	0-Day	60-Days	120-Days	180-Days
SFO	0.21±0.030	3.65±0.17^{i}	8.92±0.31^{d}	19.87±0.49^{a}
SFO+SLE	0.21±0.030	1.18±0.11^{l}	3.57±0.21^{i}	7.84±0.33^{e}
SBO	0.15±0.020	2.98±0.24^{j}	7.51±0.17^{e}	16.84±0.71^{b}
SBO+SLE	0.15±0.020	1.02±0.14^{l}	2.94±0.16^{j}	5.63±0.25^{g}
CO	0.19±0.010	0.83±0.09^{m}	6.54±0.24^{f}	14.35±0.34^{c}
CO+SLE	0.19±0.010	0.55±0.07^{n}	2.56±0.12^{k}	4.29±0.10^{h}

Within rows and columns means denoted by a different letter are statistically different (P<0.05).

Table 5. Effect of sugarcane leaf extract on conjugated trienes of vegetable oils stored at ambient temperature

Treatments	0-Day	60-Days	120-Days	180-Days
SFO	0.08±0.021	1.85±0.08^{h}	4.53±0.29^{d}	8.76±0.41^{a}
SFO+SLE	0.08±0.021	1.79±0.05^{h}	2.19±0.18^{g}	3.41±0.10^{e}
SBO	0.08±0.021	1.35±0.13^{i}	3.43±0.14^{e}	7.64±0.22^{b}
SBO+SLE	0.08±0.021	0.59±0.04^{j}	1.42±0.08	2.76±0.16^{f}
CO	0.08±0.021	1.17±0.13^{i}	3.24±0.17^{e}	6.19±0.11^{c}
CO+SLE	0.08±0.021	0.42±0.05^{k}	1.22±0.04^{i}	2.14±0.07^{g}

Within rows and columns means denoted by a different letter are statistically different (P<0.05).

Changes in peroxide value in accelerated oxidation chamber. Schaal oven test is one of the simplest and widely used method to assess the antioxidant activity of antioxidants in the accelerated oxidation chamber at 63 °C for 5 days, the extent of oxidation was measured in terms of peroxide value. In the accelerated oxidation chamber SLE provided a high degree of protection to the supplemented oils (Fig. 3). Among the supplemented oils, the greatest peroxide value was exhibited by the

SFO followed by SBO and CO; similar trend was also seen in the non-supplemented vegetable oils. Enhancement of the oxidative stability of vegetable oils through the supplementation of SLE has not been previously investigated and this is the pioneer study suggesting the suitability of SLE for the long term stabilization of vegetable oils at room temperature. Fatty acid composition had a major effect on the rise of peroxide value in the oxidation chamber, oils rich in monounsaturated fatty acids are usually more stable to auto-oxidation, and therefore, CO yielded the lowest peroxide value as compared to SBO and SFO. Reduction in unsaturated fatty acids of SFO and SBO had a great effect on the enhancement of the oxidative stability of SBO and SFO (Anwar *et al*., 2007).

Induction period. Accelerated oxidation techniques are widely used for the assessment of antioxidant activity of antioxidants. Induction period of fats and oils is usually corroborated with keeping quality; higher values are usually connected with better storage stability and vice versa (Anwar *et al*., 2011). From the results of Fig. 4 it is obvious that SLE significantly improved the induction period of SFO, SBO and CO over their controls. In the absence of SLE, controls suffered from serious consequences of autoxidation during the long term storage and in the accelerated oxidation conditions (120 °C; 22 L air/h). The induction period of SLE supplemented vegetable oils were in the order of CO > SBO > SFO. The remarkable resistance of the supplemented vegetable oils in the accelerated oxidation conditions was due to the antioxidant activity of phenolics contained in SLE.

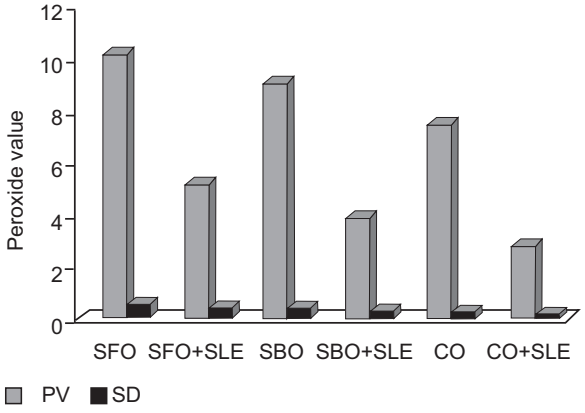

Fig. 3. Peroxide value (PV) of SLE added vegetable oils in Schaal oven test. SFO= sunflower oil; SLE = sugarcane leaf extract.

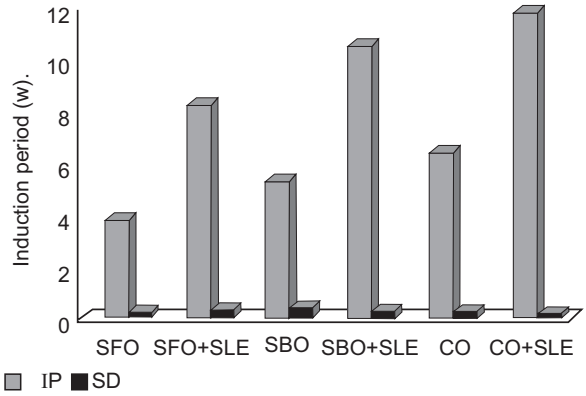

Fig. 4. Induction period (IP) of vegetable oils added with SLE. SFO = sunflower oil; SLE = sugarcane leaf extract.

Table 6. Effect of sugarcane leaf extract on fatty acid composition of sunflower, soybean and canola oils during storage period of 180-days at ambient temperature (mg/g)

Fatty acid	Sunflower oil			Soybean oil			Canola oil		
	Fresh	6M-SFO	6M-SFO+ SLE	Fresh	6M-SBO	6M-SBO+ SLE	Fresh	6M-CO	6M-CO+ SLE
C16:0	6.54±0.22e	10.38±0.39c	7.14±0.56d	10.41±0.21f	14.25±0.12a	12.55±0.12b	4.15±0.03f	7.32±0.09d	5.74±0.23df
C18:0	1.89±0.05e	3.15±0.27c	2.45±0.18d	3.55±0.95b	3.76±0.64b	2.38±0.09d	3.17±0.06c	4.45±0.08a	3.69±0.18b
C18:1	46.12±1.34d	42.59±0.95f	44.91±1.47e	22.95±2.14g	19.35±1.35i	21.13±1.31h	56.32±1.79a	53.67±2.16c	54.91±1.92b
C18:2	47.15±0.89c	40.29±1.38f	43.13±0.76e	51.19±0.12a	45.61±0.26d	48.97±0.23b	25.73±0.62g	22.47±1.13i	24.12±0.10h
C18:3	0.11±0.01f	0.03±0.01f	0.07±0.02f	6.19±0.64d	3.37±0.45e	5.67±0.14	10.35±0.49a	7.62±0.49c	9.24±0.17b

Within a row means denoted by a different letter are statistically different (P<0.05); Fresh=freshly deodorized vegetable oils; 6-M=six months stored oils at ambient temperature; 6M-SFO+SLE=sunflower oil supplemented with 600 ppm sugarcane leaf extract; 6M-SBO+SLE=Soybean oil supplemented with 600 ppm sugarcane leaf extract; 6M-CO+SLE=canola oil supplemented with 600 ppm sugarcane leaf extract.

Changes in fatty acid composition. The changes in fatty acid composition of vegetable oils as a function of addition of SLE and ambient storage are presented in Table 6. Major changes were observed in the fatty acid composition of controls, while, the change in fatty acid composition from the original value was not drastic in the SLE supplemented vegetable oils. Addition of SLE and degree of unsaturation were the two major factors responsible for the changes in fatty acid composition. The concentration of unsaturated fatty acids in 6 months stored controls and supplemented samples were less than the initial value due to their breakdown into oxidation products and increase in saturates was on percentage basis. C18:1 and C18:2 in fresh, 6 months stored controls and SLE supplemented SFO were 46.12%, 42.59%, 44.91% and 47.15%, 40.29, 43.13%, respectively. C18:2 and C18:3 in fresh and 180 days stored control and SLE supplemented SBO were 51.19%, 45.61%, 48.97% and 6.19%, 3.37,% 5.67%, respectively. C18:2 and C18:3 in fresh and 6 months stored CO were 25.73%, 22.47%, 24.12% and 10.35%, 7.62%, 9.24%, respectively. The phenolics of SLE provided a high degree of protection to the unsaturated fatty acids towards their breakdown into oxidation products which is evident from the lower generation of concentration of oxidation products in SLE supplemented vegetable oils. The strong correlation between degree of unsaturation and the generation of oxidation products during storage of oils rich in unsaturated fatty acids has been suggested by Gulla and Wagahary (2011). Addition of *Moringa oleifera* leaf extract in butter oil with higher extent of unsaturated fatty acids significantly inhibited the auto-oxidation phenomenon (Nadeem *et al*., 2013).

Conclusion

Supplementation of SFO, SBO and CO with sugarcane leaf extract at 600 ppm concentration significantly (<0.05) inhibited the auto-oxidation. Supplemented vegetable oils yield the lower extents of primary and secondary oxidation products with minimum changes in the fatty acid composition during storage period and improved resistance in the accelerated oxidation conditions, with no effect on viscosity and sensory characteristics. Sugarcane leaf extract therefore, can be used to prolong the shelf life of vegetable oils.

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