

Evaluation of Commercial and Laboratory Refined Sunflower Oils for Different Food Frying

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Abstract

This project was designed to evaluate the performance of commercially and laboratory refined sunflower oils during frying of samosas and potato chips with and without the addition of antioxidant (butylated hydroxyl toluene, BHT). The specific gravity, colour index, peroxide value and total polar compounds of the laboratory refined sunflower oil were lower than the commercially refined sunflower oil, and a gradual increase in these parameters was noticed with the increments in number of fryings. There was a less decrease in iodine value of the laboratory refined sunflower oil than the commercially refined sunflower oil during the course of frying. Samosas produced more degradative changes than potato chips in both oils in the process of frying. It was observed that BHT added oils experienced less deteriorative changes at elevated temperature.

Key Words: Sunflower oil, Refining, Antioxidant, Frying, Potato chips

Introduction

Sunflower oil is good quality edible oil. It contains traces of linolenic fatty acids, and thus is fairly stable oil. It is commonly used in cooking as well as frying of snack foods due to high smoke point. Traditional polyunsaturated linoleic acid sunflower oil has been a popular vegetable oil for many years and currently ranks fourth in the world production among all vegetable oils. Recently efforts are being made to develop high oleic sunflower oil which is comparatively of better shelf life with hydrogenation (Xu *et al.*, 1999).

Deep fat frying is one of the oldest processes of food preparation. The deep fat fried foods have gained worldwide popularity because of their unique flavour-texture combination. Fats and oils play important functional and sensory role in the food products. They are responsible for carrying, enhancing and releasing the flavour of the fried food (Giese, 1996).

The refining produces an edible oil with characteristics that consumers desire such as bland flavour and odour, clear appearance, light colour, stability to oxidation and stability to frying. But a lot of controversy is going among the masses regarding the nutritional losses during the commercial refining; hence the present study was designed to compare the frying performance of laboratory and commercially refined sunflower oils of similar fatty acid composition and impact of antioxidant on the frying performance of these oils.

Materials and Methods

Oil Extraction and Refining: The sunflower seeds were procured from Oilseeds Research Institute, Faisalabad. The sunflower oil (Kissan) was purchased from the local market. The oil was extracted from sunflower seeds through hydraulic press. The oil was refined through degumming, alkali refining and bleaching (using 5% gray earth) after settling the higher density impurities. Deodorization process was avoided during laboratory refining of the sunflower oil.

Use of Antioxidant: Butylated hydroxytoluene (BHT) was added @0.01% to compare the impact of antioxidant.

Frying Food Preparation: Samosas and potato chips were used as frying food. The potatoes were sliced after proper washing and cleaning into 0.1 cm thick slices. The samosas, a traditional fried food in Indo-Pak, were prepared by using the formula given as: boiled potatoes 6Kg; cabbage 2Kg; onion 2Kg; fresh peas 1Kg; lentils 1Kg; common salt 100G; black pepper 100G; green chilies 100G; dried coriander 50G and cumin 50G. The mixture was wrapped in a

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sheath of wheat flour dough (0.1cm thickness). The average weight of each samosa was kept 60-65G.

Frying process: In each treatment 7.5L oil was taken in an open voke of 12L capacity where 1:6 ratio of food to oil (Thorner, 1973) was maintained during the whole process of frying which was carried out at a temperature of 185-190°C. The oil was first heated at frying temperature and freshly prepared samosas and potato chips were pored and allowed to fry till proper light brown colour was developed (Sanchez-Muniz *et al.*, 1993). The frying time was set for seven minutes for potato chips and eight minutes for samosas, as determined in a pretest.

Oil Sampling: The potato chips were fried in oils till a light brown color appeared, up to 70th number of fryings. After every 5th frying, the oil sample (100 mL) was drawn for oil characterization and stored at -14°C. The same procedure was adopted for drawing of oil samples during the frying of samosas.

Fatty Acid Analysis: The fatty acids were converted to their respective methyl esters prior to analysis by Gas Chromatograph (GC) model 3900 Varian USA. The oil samples (50 µL) were methylated in 4 mL KOH (1 M) for one hour at room temperature (Xu *et al.*, 1999). The resultant fatty acids methyl esters (FAME) were extracted with High Performance Liquid Chromatography grade hexane and analyzed by GC immediately using a fused capillary column (WCOT fused Silica 30mX0.25mm coating CPWAX52CBDF = 0.25 µm, CP8713), a flame ionization detector (FID) and nitrogen gas as carrier (3.5 mL/Min). GC split ratio was 100%. Injector and Detector temperatures were 260°C and column oven temperature was 222°C for 7.5 minutes. Fames were injected manually. The fatty acids were identified by chromatographic retention time by comparison with standards (Supelco, USA).

Oil Characterization: The laboratory extracted and commercially available sunflower oils were characterized for specific gravity, peroxide value, iodine value and total polar compounds by following the methods outlined in AOAC, 2000. The colour index of the oil for each treatment was determined by taking absorbance at 490nm through spectrophotometer by following the method of Przybylski *et al.* (1997).

Statistical Analysis: Data from physico-chemical analysis were analyzed statistically using analysis of variance and Duncan's Multiple Range Test by following the methods described by Steel *et al.* (1997).

Results and Discussion

The major fatty acid profiles of the laboratory and commercially refined sunflower oils have been presented in Table I. The percentage of palmitic acid for laboratory and commercially refined sunflower oils was 5.36 and 4.44, stearic acid 2.15 and 1.76, oleic acid 29.69 and 30.60, linoleic acid 57.01 and 55.48, and linolenic acid 0.00 and 0.84, respectively. The laboratory refined sunflower oil used during the present studies did not contain any linolenic acid in its composition, which is also indicated by Xu *et al.* (1999). But commercially refined sunflower oil, used in the present studies, has 0.84% linolenic acid in its composition, which is in agreement with the report published by Codex Alimentarius Commission (1993) according to which sunflower had been described to contain linolenic acid up to 0.7%. The fatty acid profile results of the sunflower oils used during the present study are in agreement with the findings of Gustafsson *et al.* (1993) who determined the composition of sunflower oils and their products. The physico-chemical parameters of the sunflower oils studied during the present project before frying are mentioned in Table II.

The specific gravity (SG) of crude sunflower oil decreased from 0.9294 to 0.9168 after refining while commercially refined sunflower showed SG value of 0.9162. A decrease in colour index (CI) of crude sunflower oil was observed from 1.0243 to 0.0121 after refining when commercially refined sunflower oil was used as reference. A decrease in peroxide values from 4.15 to 3.06 meq/Kg for crude sunflower oil was observed after refining. The Peroxide value of commercially refined sunflower oil was recorded as 3.09 meq/Kg. The iodine value (IV) decreased in case of crude sunflower oil from 127 to 124 cgI₂/g after refining. The iodine value of commercially refined sunflower oil was noted to be 131 cgI₂/g. The value of total polar compounds decreased from 4.91 to 2.32 for crude sunflower oil after refining. The percentage of total polar compounds was observed to be 2.45 for commercially refined sunflower oil. Biswas *et al.* (2001), reported similar range of specific gravity 0.917 for sunflower oil and attributed the higher values for specific gravity of sunflower oils to the higher content of linoleic acid contents. Xu *et al.* (1999) found similar results for sunflower oil while performing the physico-chemical analysis of six different types of oils. Rudan-Tasic and Kolfutar (1999) studied the characteristics of commercial sunflower oils of different brands and the results substantiated the range of specific gravity and peroxide value recorded during the present studies.

The different physico-chemical parameters of the sunflower oils during samosas and potato chips frying have been presented in the Table III. The

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specific gravity was found to be lower in laboratory refined sunflower oil than commercially refined sunflower oil, when data for frying objects, antioxidants and number of fryings were combined. The specific gravity of sunflower oil used in samosa frying was observed to be higher than the sunflower oil used in potato chips frying, when results for sunflower oils, antioxidants, and number of fryings were pooled. The use of antioxidants in sunflower oils showed lower specific gravity as compared to sunflower oil without antioxidant on pooling the data of all other variables i. e., sunflower oils, frying objects and number of fryings. There was a slight increase in specific gravity with the increments in number of fryings. The specific gravity ranged from 0.9143 ± 0.0089 to 0.9240 ± 0.0087 .

The results revealed that laboratory refined sunflower oil yielded significantly lower colour index than commercially refined sunflower oil, when data for frying objects, antioxidant and number of fryings were combined. The colour index of sunflower oil used for frying samosas was observed to be significantly higher than the sunflower oil used for potato chips frying, when results for sunflower oils, antioxidant, and number of fryings were pooled. The use of antioxidants in sunflower oils showed significantly lower values for colour index as compared to sunflower oils used without antioxidant on pooling the data of all other variables i. e., sunflower oils, frying objects and number of fryings. Colour index ranged from 0.0158 ± 0.0060 to 2.6237 ± 0.0964 . Xu *et al.* (1999) reported that the colour of the sunflower oil changed from clear and pale yellow to dark brown during deep frying which is in line with the present results and this significant change in colour linearly increased with the increments in number of fryings. It is substantiated from the results of the present studies that butylated hydroxytoluene (BHT) added sunflower oils experienced a less change in colour than sunflower oils used without the addition of BHT. Takeoka *et al.* (1997) and Che *et al.* (1999) reported that antioxidants such as BHT and BHA do provide protection to oils during frying/heating.

The peroxide value was recorded to be significantly lower in laboratory refined sunflower oils than commercial sunflower oils, when data for frying objects, antioxidants and number of fryings were combined. The peroxide values of sunflower oils used in frying of samosas were observed to be significantly higher than the sunflower oils used in frying of potato chips, when results for sunflower oils, antioxidants, and number of fryings were combined. The use of antioxidants in sunflower oils gave significantly lower peroxide values as compared to sunflower oils when no antioxidant was used,

pooling the data of all other factors i. e., sunflower oils, frying objects and number of fryings.

The peroxide value ranged from 3.06 ± 0.06 to 34.70 ± 2.76 meq/Kg during frying process. The increasing trend of peroxide formation with the frying time during current studies is well supported by many researchers. Yamaguchi *et al.* (1986) concluded that peroxide value was increased with the frying time. Tan and Che (1999) reported an increase in peroxide value of oil during heating and frying. Jaswir *et al.* (2000) observed an increase in peroxide value of the frying oil from 0.91 to 11.70 meq/Kg during frying of potato chips. Nasirullah (2001), reported peroxide value change from 3.6 to 6.0 and from 5.7 to 11.2 meq/Kg on refined soybean and rice bran oils, respectively during frying. It is interesting to note that peroxide limit 10 meq O₂/Kg set by Codex Alimentarius Commission (1993) was crossed after a minimum of 25th and maximum 60th number of fryings in different sunflower oils. One can tentatively assume that the oil was past the peroxides formation stage and was not fit for consumption. Therefore peroxide value alone can not used to assess the edibility and quality of the oil. A similar conclusion was drawn by Goburdhun *et al.* (2000), who reported an increase in peroxide value from 6.6 to 12.6 meq/Kg when potato chips were deep-fried for 300 minutes.

Lolos *et al.* (1999) studied the oxidative stability of different oils and potato chips at varying temperature and with antioxidants. They found that oxidation rate increase with frying time and type of oil. Antioxidant proved significantly more effective during storage and processing of oil. These findings support the results of the present studies in which the presence of antioxidant gave better stability to the oils against peroxide formation. Che *et al.* (1999) and Takeoka *et al.* (1997) reported that antioxidants like butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tertiary butyl hydroquinone (TBHQ) provide protection to the oil at elevated temperatures during frying. The results of these studies are in quite favour of the findings of the present study.

From the results mentioned in Table III, it could be inferred that the iodine value was significantly higher in laboratory refined sunflower oils than the commercial sunflower oils, when data for frying objects, antioxidants and number of fryings were combined. The sunflower oils used for frying of samosas showed relatively lower iodine values than the iodine values of sunflower oils used in frying of potato chips, when results for sunflower oils, antioxidants, and number of fryings were pooled. The use of antioxidants in sunflower oils gave significantly higher iodine value as compared to sunflower oils in which no antioxidant was used on

combining the data of all other variables i.e., sunflower oils, frying objects and number of fryings.

The results further indicated that the iodine value decreased significantly with the increase in number of fryings from 127.50 ± 1.94 to 63.75 ± 1.76 (cg of iodine/g of fat) among different number of fryings. Augustine *et al.* (1989) evaluated the frying performance of sunflower oil and found reduction in iodine value with the frying time. Xu *et al.* (1999) strongly correlated the decrease in iodine value with the hours of frying. Takeoka *et al.* (1997) and Cuesta *et al.* (1991) attributed the decrease in iodine value to the destruction of double bonds by oxidation and polymerization during frying. They stated that oils with less polyunsaturation had the lowest rate of loss of unsaturation. These results are also in well agreement with the results of the study under report. Tyagi and Vasishta (1996) reported a decrease in iodine value from 129.8 to 96.2 and 74.4 to 60.2 cgI₂/g in soybean oil and blend of some partially hydrogenated oils. Less decrease was observed in case of less unsaturation. These results are corroborating the present findings as sunflower oils showed more decrease in iodine value because of more unsaturation.

The total polar compounds (TPC) were found to be significantly lower in laboratory refined sunflower oils than the commercial sunflower oils, when data for frying objects, antioxidants and number of fryings were combined. TPC of sunflower oils used in frying of samosas were observed to be significantly higher than the sunflower oils used in frying of potato chips, when results for sunflower oils, antioxidants, and number of fryings were pooled. The use of antioxidants in sunflower oils gave significantly lower values for TPC as compared to sunflower oils used without antioxidant, on pooling the data of all other variable i. e., sunflower oils, frying objects and number of fryings.

There was a significant increase in total polar compounds with the increments in number of fryings which ranged from 2.47 ± 0.05 to $47.38 \pm 1.23\%$. The total polar compounds value increased progressively with increase in number of fryings irrespective of changes in variables like sunflower oils, frying objects or use of antioxidants. In many European countries, as a basis for the assessment of the end point of frying oil, 25% TPC, a regulatory limit (Blumenthal, 1996) is used. Whereas, during present studies, a limit of 27% TPC described by HACCP (Truong, 2000) was followed. The TPC remained under this limit for samosas frying in commercially refined sunflower oil used without antioxidant up till 40th number of frying, and after 50th number of frying when antioxidant was used. During potato chips frying in commercially refined sunflower oil;

with and without antioxidant TPC remained under legal limit up to 45th number of fryings. Similarly, in laboratory refined sunflower oil used without antioxidant, TPC remained under limit up to 45th and 50th number of frying for samosa and potato chips, respectively. In case of laboratory refined sunflower oil used with antioxidant TPC remained acceptable up to 50th and 55th number of frying for samosa and potato chips, respectively.

The results of the present studies are in line with the results of Warner *et al.* (1994) who reported that due to polymerization and hydrolysis of frying oils, TPC level increased after 18h of frying. Sanchez-Muniz *et al.* (1993) reported a significant increase in total polar compounds ($6.2 \pm 0.3\%$ to $18.7 \pm 0.8\%$) in sunflower oil during fifteen times repeated and discontinuous frying. The findings of the present study are quite in line with these results in which the TPC increased from 2.06 ± 0.03 to $37.98 \pm 1.41\%$ cup to 70th number of frying. Schwarz, (2000) also reported that TPC levels increased with the increasing frying time. Warner *et al.* (1997) studied the effect of fatty acid composition of oils on flavour and stability of fried food and concluded that TPC levels increased with the increasing linoleic acid content and time of frying. This conclusion strongly supports the findings of the study under discussion that higher level of TPC was recorded for sunflower oils, as linoleic acid contents were 55-57% in sunflower oils, and similarly, TPC level increased with number of frying. A trend towards higher polar compounds as unsaturation increases was also reported by Warner and Mounts (1993). They reported that palm oil with 56% unsaturates, after heating for 100h at 195°C produced up to 58% polar compounds as compared to olive oil with 86% unsaturation resulted a polar contents of 66%. Results of the present study are concordant with the above findings. The present results are also corroborated by the findings of Takeoka *et al.* (1997) who stated that the oils deteriorate after frying temperature through the formation of polar compounds and generally, oils with a higher level of unsaturated fatty acids produced more polar compounds compared to more saturated ones. Mid-oleic acid sunflower oil and hydrogenated canola oil showed slow rate of TPC production during the frying process than regular canola and low linolenic canola concluded by Przybylski *et al.* (1999). The sunflower oil used in the present study was of low oleic acid (30-31%) and degraded rapidly due to low oleic acid contents and higher linoleic acid contents.

During the present studies laboratory refined sunflower oils experienced less deterioration in terms of all physico-chemical parameters than commercially refined sunflower oils. The laboratory

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refined sunflower oils may have ample amount natural antioxidants whose concentration may be remained unchanged because of not using deodorization step in refining process. This view is supported by Karabulut *et al.* (2005) who reported that deodorization process during oil refining caused a reduction in natural antioxidants like phytosterols. This observation is also supported by the findings of Przybylski *et al.* (1999) and Gertz *et al.* (2000), who observed that oils carrying natural antioxidants performed better at elevated temperature. O'Donnell and Claudia, (1995) narrated that oils having natural antioxidants showed increase in ambient shelf life of oils and during frying at elevated temperature.

It was observed during present studies that samosas produced more degradation in terms of all studied physico-chemical parameters than potato chips in both sunflower oils. It may be due to the difference in composition of samosas and potato chips. This observation is supported by Truong (2000) who stated that different foods with different composition produce different amount of polar material during frying. Goburdhun *et al.* (2000) also stated that foods with different composition contribute different level of oil deterioration.

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Table I. Major Fatty Acid Profiles of Different Sunflower Oils before Deep Frying

Fatty Acids	Laboratory Refined Sunflower Oil	Commercially Refined Sunflower Oil
Palmitic Acid (%)	5.36	4.44
Stearic Acid (%)	2.15	1.76
Oleic Acid (%)	29.69	30.60
Linoleic Acid (%)	57.01	55.48
Linolenic Acid (%)	0.00	0.84

Table II. Physico-Chemical Changes in Sunflower Oil during Refining

Parameters	Sunflower Oils		
	Crude	Laboratory Refined	Commercially Refined
Specific Gravity	0.9294	0.9168	0.9162
Colour Index (Abs at 490Nm)	1.0243	0.0121	0.000
Peroxide Value (meq/Kg)	4.15	3.06	3.09
Iodine Value (cgI ₂ /g)	127	124	131
Total Polar Compounds (%)	4.91	232	2.45

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Table III. Physico-chemical Changes in Sunflower Oils during Frying

Parameters	Sunflower Oils		Fried Objects		Antioxidant	
	Laboratory Refined	Commercial ly Refined	Samosas	Potato Chips	Without	With
Specific Gravity	0.9218 ±0.0012 a	0.9205 ±0.0012 a	0.9228 ±0.0012 a	0.9195 ±0.0011 a	0.9218 ±0.0012 a	0.9204 ±0.0011 a
Colour Index (Abs at 490Nm)	1.0616 ±0.0687 a	0.9945 ±0.0704 b	1.1558 ±0.0755 a	0.9012 ±0.0616 b	1.1037 ±0.0746 a	0.9534 ±0.0637 b
Peroxide Value (meq/Kg)	13.92 ±0.90 a	11.57 ±0.79 b	13.34 ±12.09 a	12.16 ±0.79 b	15.38 ±1.03 a	10.12 ±0.54 b
Iodine Value (cgI₂/g)	99.38 ±1.48 b	103.20 ±1.62 a	100.66 ±1.64 a	101.92 ±1.46 a	99.11 ±1.66 b	103.47 ±1.43 a
Total Polar Compounds (%)	21.94 ±1.13 a	19.39 ±1.02 b	21.83 ±1.14 a	19.49 ±1.01 b	22.02 ±1.17 a	19.30 ±0.97 b

*same letters in a row indicate non-significant means values