

Effect of frying on chemical properties of commonly used edible oils: A comparative study



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KEYWORDS : sunflower oil, soybean oil, groundnut oil, mustard oil, oxidation degradation, UV spectra, hydroperoxide, frying.

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ABSTRACT

The oxidative degradation of refined sunflower, soybean, groundnut oil and pure mustard oil during deep frying at 180°C of 'poories' were studied. The oxidative degradation of the oils was evaluated by monitoring their chemical changes in IV, PV and UV spectra at 234 nm and 268 nm during frying process for four consecutive days. The result indicated that IV of sunflower oil decreased more. PV increased for first two days and then decreased for last two days of frying process for all oil samples. The highest evolution of absorptivity at 234 nm during frying was noticed in sunflower and soybean oil followed by groundnut oil then mustard oil. It is observed that, the formation of hydroperoxide and their decomposition to conjugated triene was faster in soybean and sunflower oil than groundnut and mustard oil. Result indicate that as comparing the selected four edible oils, mustard oil shows better oxidative stability during deep frying process and soybean oil shows least oxidative stability.

INTRODUCTION

Deep frying is one of the oldest processes of preparation of food in India. Fried foods have a desirable flavor, colour and crunchy texture, which make fried food very popular. Deep frying is normally carried out at high temperature (180°C) and in presence of air and moisture; frying oils will undergo physical and chemical deterioration. Lipid oxidation can occur during deep frying process, resulting in the formation of lipid hydro peroxides. Lipid hydro peroxides have no flavour or odour but break down rapidly to form secondary products, many of which have a strong flavour and odour. The lipid hydro peroxide concentration in oils is generally expressed as peroxide value (PV) (Nawar, 1996). Iodometric titration assay, which is based on the oxidation of the iodide ion by hydroperoxides (ROOH), is the basis of current standard methods for determination of hydroperoxide (9). The primary oxidation products (hydroperoxides) are unstable and susceptible to decomposition. A complex mixture of volatile, nonvolatile, and polymeric secondary oxidation products is formed through decomposition reactions, providing various indices of lipid oxidation (5). Secondary oxidation products include aldehydes, ketones, alcohols, hydrocarbons, volatile organic acids, and epoxy compounds, among others.

The formation of peroxides is coexisting with conjugation of double bonds in polyunsaturated fatty acids, which can be measured using the specific absorptivity of CDs and CTs at 234 and 268 nm in the UV spectrum (Wanasundara et al., 1995). Almost immediately after peroxides are formed, the non-conjugated double bonds (C=C-C-C=C) that are present in natural unsaturated lipids are rearranged to conjugated double bonds (C=C-C=C). Conjugated dienes absorb ultraviolet radiation strongly at 234 nm, whereas conjugated trienes absorb at 268 nm. Thus oxidation can be followed by dissolving the lipid in an isooctane solvent and measuring the change in its absorbance with frying time using a UV-visible spectrophotometer. Good correlations between conjugated dienes and peroxide value have been found (4, 5).

The aim of this study is to compare the chemical changes of sunflower, groundnut, soybean and mustard oil that occurs after exposure to prolonged deep frying for four consecutive days. The oxidative degradation of the oils was evaluated by monitoring Iodine value (IV), Peroxide Value (PV) and UV spectra at 234 nm (CD) and 268 nm (CT) during frying process for four consecutive days.

2. MATERIALS AND METHODS

2.1 Sampling

Deep frying experiments on the vegetable oil of sunflower,

Groundnut, Soybean and Mustard oil were carried out simultaneously using stainless steel frying pot of 2 lit. capacity placed in electric stove. About 1 kg of each oil was introduced into fryer. Each day, the oil was heated at higher temperature (180°C) and allows equilibrating at this temperature for 30 min. In total ten batches of Puri, 100 gm per batch intermittently fried for 5 min., at interval of 5 min. for period of 2 hr. per day for 4 days. The fryer was turned off at the end of the frying experiment each day and oil was allowed to cool to room temperature. The oil in the fryer was filtered to remove debris using separate filter. The oils were stored in the uncovered glass bottle for analysis.

2.2 Determination of Peroxide value (PV)

The Peroxide values were determined according to ISO 3960-2007. A known weight of the oil sample (5 g) was dissolved in a mixture of glacial acetic acid: chloroform (3:2, v/v, 30 ml), then freshly prepared saturated potassium iodide solution (1 ml) was added. Distilled water (30 ml) was added then titrated slowly with a sodium thiosulphate solution (0.01ml) in the presence of starch solution (1%) as an indicator. Each sample was analyzed twice.

2.3 Determination of Iodine Value (IV)

The iodine value (IV) of oil samples was measured by Wijs reagent (ISO/CD 3961, 2011) method. Weigh accurately 0.22-0.25 g of dry oil sample into a 250 ml Erlenmeyer flask, and add 20 ml of carbon tetrachloride. Add 20 ml of carbon tetrachloride to each of two additional flasks to serve as blanks. Pipet 25 ml of Wijs reagent into each flask. Stopper the flasks, mix contents by swirling and store in a dark place at 25 ± 5°C. At the end of 30 mins., add 10 ml of 30% potassium iodide solution and 100 ml of purified water to the sample solution. Titrate immediately with standard 0.01 N thiosulfate solution until the yellow color almost disappears. Add 1 ml of starch indicator solution and titrate dropwise with vigorous swirling to disappearance of the blue starch-iodine color. Titrate the blanks in the same manner.

2.4 Determination of di- and tri-unsaturated fatty acids by ultraviolet spectrophotometry

AOCS(1991) method was used to determine the conjugated compounds. The determination of conjugated dienes (CD) and conjugated trienes (CT), estimated by UV spectrophotometer (Ballabio, et al 2006). The absorption at 234 nm and 268 nm are expressed as specific extinction was recorded. The content of conjugated dienes and trienes were expressed as absorptivity of the 1% oil in isooctane. The absorption of 1% of oil in isooctane solution placed in quartz cuvette was measured against a blank of isooctane over the range of 200 nm to 400 nm of refined sunflower, soybean, groundnut oil and pure mustard oil during deep

frying at 180°C, for four consecutive days. The absorptivity at 234 nm and at 268 nm of different oil samples are plotted against number of frying.

Table 1 – Changes in chemical properties of oils during four consecutive days of frying

Type of Oil	No. of frying	Peroxide Value (PV)	K-234	K-268	Iodine Value (IV)
Sunflower	0	0.59	1.985	1.145	125.65
	1	1.82	2.689	1.22	122.42
	2	5.83	2.798	1.227	120.43
	3	5.52	3.01	1.326	117.24
	4	1.98	3.14	1.359	115.68
Soybean	0	0.74	1.99	1.271	124.18
	1	1.6	2.764	1.325	123.08
	2	6.2	2.932	1.381	122.02
	3	4.19	3.142	1.424	119.21
	4	2.19	3.374	1.467	116.89
Groundnut	0	0.78	0.997	1.064	112.05
	1	2.11	1.999	1.119	110.43
	2	5.16	2.287	1.148	109.5
	3	4.98	2.343	1.188	107.32
	4	3.96	2.465	1.227	105.2
Mustard	0	0.21	0.875	0.978	109.94
	1	2.66	1.525	1.054	108.6
	2	5.35	1.532	1.114	105.61
	3	3.96	1.586	1.127	103.32
	4	2.38	1.621	1.138	102.76

3. RESULT AND DISCUSSION

3.1 Iodine Value (IV)

Figure no. 1 shows sunflower and soybean oil have a high initial iodine value and groundnut and mustard oil have low initial iodine value which decreases sharply with deep frying at 180°C for four consecutive days of deep frying which indicated a general loss of unsaturation and lipid oxidation in agreement with Naz et al. (2004), C and .Cuesta et al (1991). This observation suggest that sunflower oil are richer in unsaturated fatty acids than soybean, groundnut and mustard oil. Iodine value of sunflower oil was decreases more than other and iodine value of mustard oil was decreases less than other oils.

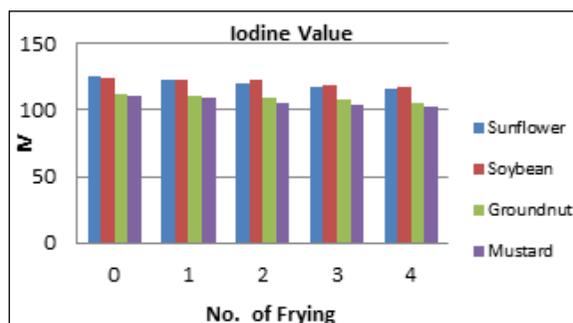


Figure No. 1- Evaluation of the Iodine Value depending on the numbers of frying at 180°C

3.2 Peroxide Value (PV)

Peroxide value is useful as an indicator of oxidation at the initial stages of reaction between oxygen and unsaturated fatty acids, however, it not related to the frying duration, but to the formation and breakdown of oxidation products. Peroxides are unstable and decomposed at frying temperature. The oil with peroxide value between 1 and 5 mEq/Kg are at low oxidation state and between 5 and 10 mEq/Kg are at average oxidation stage (O'Brien, 2004) The changes in peroxide value of different oils during frying are shown in Fig. 2 The result showed that there was an initial sharp increase in PV from day 1 to day 2 in all frying oils. While, the PV decrease after second day of frying in all frying oils. The results indicate that PV value of sunflower oil was increase from first day to the end of second day of frying (1.82 to 5.53), while it decreased slightly from the second day to

third day (5.53 to 5.52) and decreases sharply from third day to fourth day (5.52 to 1.98). Initially, a sharp increase in the PV of Soybean was observed from first day to second day (1.6 to 5.82) and it sharply decreases from second day to fourth day (5.82 to 2.19) of the frying process. The result showed that a sharp increase in PV of groundnut oil during the first two days of frying (2.11 to 7.16), while it decrease slowly after second day of frying to fourth day of frying (7.16 to 3.96). The result also show that the PV of mustard oil increased sharply from first day to second day (2.66 to 5.96), while it decrease from second day to fourth day (5.96 to 2.38) of frying process. It is observed that, after third frying, PV of all oils decreased due to alteration of hydroperoxide into secondary oxidative products. The results indicated that after third frying PV of soybean oil decreased maximum than other oils and PV of groundnut oil decreased minimum than other oils. This may be due to presence of natural antioxidant such as tocopherols in oil and fatty acid composition.

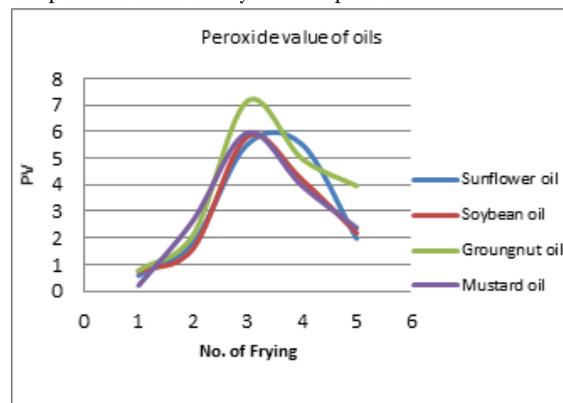


Figure No. 2 Evaluation of the Peroxide Value depending on the numbers of frying at 180°C

3.3 Absorption spectra of oils – K 234 and K 268

The changes in absorptivity at K234 and K268 of sunflower, soybean, groundnut and mustard oil during four consecutive days of frying are shown in table no.1. When linoleic acid is oxidized to form hydroperoxides, a shift in one of the double bond occurs producing a conjugated diene that can measure by UV absorption at 234 nm. The sharp changes in the absorptivity at 234nm (Figure no. 3) during the first two days of frying indicates the formation of a large amount of conjugated dienes, while gradually increase in content of conjugated dienes was observed during the last two days of frying process. The highest evolution of absorptivity at 234 nm during frying was noticed in sunflower and soybean oil followed by groundnut oil then mustard oil. The high absorbance of soybean and sunflower oil could be attributed to its higher PV which led to greater degree of primary oxidation.

Carbonyl compounds, aldehyde and ketons are the most abundant secondary oxidation products produced during deep frying process of oils. Their formation is known to be accelerated by elevated temperature and metal traces (E.Choe and D.B.Min(2006) . UV absorption at K268 is one of the markers used to follow secondary oxidation formation (S. Garby,et al, 2013).The increment of absorptivity at 268 nm, which is an indicator for the formation of conjugated trienes, increased significantly during the four consecutive days of frying of all four oil. From the figure no.4, it is observed that, the formation of hydroperoxide and their decomposition to conjugated triene was faster in soybean and sunflower oil then groundnut and mustard oil. This observation is in agreement with the general opinion that the oxidative stability of an oil was dependant to a large extent on its initial oxidation state (Blumenthal 1991; Ramadan and Moersel, 2004) The increase in absorptivity at 268 nm in soybean and sunflower oil may be contributed to the high content of polyunsaturated

fatty acids. The small changes in absorbance may be contributed to the low concentration of polyunsaturated fatty acids (linoleic acid) in groundnut and mustard oil and subsequently low relative rates of formation of aldehyde and ketones oxidative products as well as low formation of conjugated trienes.

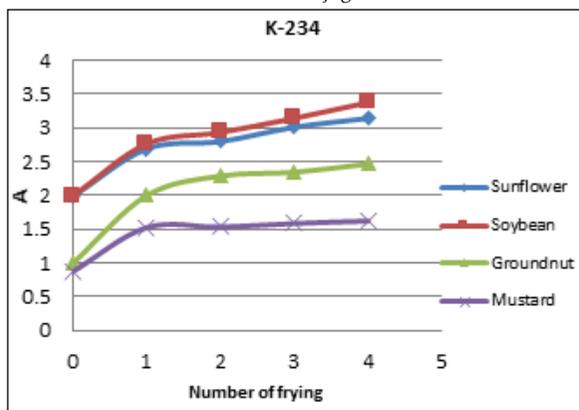


Fig.No. 3- Evaluation of the K234 depending on the numbers of frying at 180°C

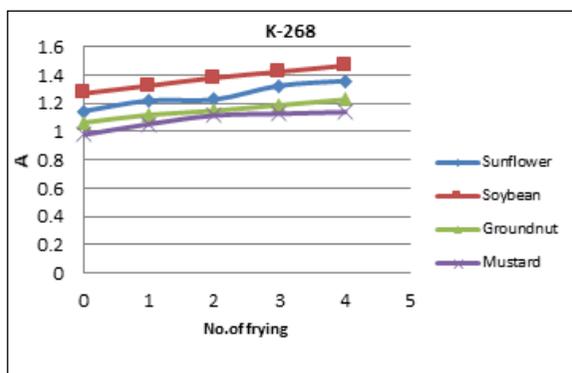


Figure No. 4 Evaluation of the K268 depending on the numbers of frying at 180°C

4. CONCLUSION

The present study predicted that, groundnut and mustard oil was found to be suitable for subsequently four days of deep frying process as these has lowest degree of oxidative deterioration while sunflower and soybean oil was unstable as these has endure more physiochemical changes during deep frying process. The frying quality of oil with high polyunsaturated fatty acids is not as good as oil with low polyunsaturated fatty acids.

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