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Oxidative stability of sunflower oil on high temperature cooking

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Abstract
The main objective of the present study was to investigate the effects of the frying temperature and duration on oxidative stability of sunflower oil. The oil was subjected to two types of heating trials. The first trial consisted of gradual heating a sample oil up to 300ºC and drawing samples at 50ºC interval. In the second trial same quantity of oil was heated at 180ºC for 6 hours and samples were drawn at 1-hour interval. All the samples were analyzed for Acid value, Peroxide value and TBA value. Both the experiments showed an increased peroxide and TBA value which confirms high thermal oxidation during heating. The results showed that effect of time on thermal oxidation of sunflower oil was more pronounced than effect of temperature. Highest Acid value, Peroxide value and TBA values were observed for sample heated at 180 ºC for 6 hours and the values are as follows: 0.6708±0.0005(AV), 0.4161±0.001 (PV), 0.3837±0.004 (TBA value).

Keywords: Sunflower oil, acid value (AV), peroxide value (PV), TBA value, oxidative stability

1. Introduction
Vegetable oils account for about 80% of edible oil consumption worldwide. They have many important functional as well as sensory roles in food. They acted as reserved energy sources and carriers for fat soluble vitamins (A, D, E, and K). They also provide essential fatty acids like linoleic and linolenic acids. Vegetable oils are very sensitive to oxygen, heat and light. The quality of cooking oils depends on their smoke point, chemical composition particularly, degree of unsaturation and stability during heating (Kaleem *et al*., 2015) [12]. The oil undergoes thermal oxidation upon cooking as it reacts with the oxygen. The mechanism of thermal oxidation is same as that of autoxidation but, the rate of thermal oxidation is faster compared to autoxidation.
Foreign oils like palm oil, soybean oil, sunflower oil and safflower oil have been introduced in India since few years. These oils are commonly extracted with heat or solvents. Nowadays these oils have become much popular because of the high content of polyunsaturated fatty acids (PUFAs) and are commonly used for cooking purposes. Among these, Sunflower oil is considered to be the most preferred one. But it is highly susceptible to thermal oxidation as it is rich in polyunsaturated fatty acids (PUFA), particularly linoleic acid (48.3–74.0%) (Rashmi Sharma and Arun Kumar Sharma, 2017) [16]. It causes an array of complex reactions with the formation of lipid peroxides and other compounds with recognized deleterious effects to human health. (Boukandoul *et al*., 2019) [4].
Oxidative stability of oils is defined as the resistance towards oxidation. Oxidation of oils produce low molecular-weight compounds which may contribute towards off-flavours and also destroys essential fatty acids and produces toxic compounds and oxidized polymers. Oxidation of oil is very important in terms nutritional and sensory quality of edible oils. Our study shows the behaviour of sunflower oil towards high temperature cooking and prolonged time frying by analysing AV, PV and TBA values.

2. Materials and Methods
2.1 Materials
Sunflower oil: Fortune SUN lite refined sunflower oil purchased from local market.
Chemicals: Analytical grade chemicals obtained from various reputed companies were used for chemical analysis.
Glassware: Glasswares of Borosil was used throughout the chemical analysis. They were thoroughly cleaned using detergent solution, rinsed under running water and dried in hot air oven before use.

2.2 Heating Protocol

For studying oxidative stability, sunflower oil was subjected to two different heating trials.

The first trial consisted of gradual heating of 150 mL of sunflower oil in a pan fryer up to 300 ºC, collecting samples as the oils reached 50 ºC (122 ºF), 100 ºC (212ºF), 150ºC (302ºF), 200 ºC (392ºF), 250 ºC (482ºF) and 300 ºC (572ºF). The overall time to reach the highest temperature was approximately 20 minutes.

In the second trial, a sample of 150 mL of sunflower oil was heated in a pan fryer at 180 ºC (356ºF), which is the highest recommended temperature for deep frying, for continuously 6 hours collecting samples at 60, 120, 180, 240, 300 and 360 minutes.

All heated samples were cooled at room temperature (31 ± 1°C, 87.8 ± 1ºF) and then stored for chemical analysis. Acid value, Peroxide value and TBA value were analysed as follows.

2.3 Acid value

The acid value of sunflower oil was determined by directly titrating the oil/fat in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution as per FSSAI Lab Manual 2, (2015) [5].

2.4 Peroxide value

Peroxide Value of samples were determined based on iodometric titration described in IS: SP: 18 [Part XI], (1981)

2.5 TBA value

TBA value of samples were recorded as per the IS: SP:18[Part XI], (1981)

3. Results and Discussions

3.1 Heating up to 300 ^{0}C: Acid value is defined as the weight of potassium hydroxide (KOH) in mg required for the complete neutralization of free fatty acids obtained from 1 g of the oil. This means that bound fatty acids in triglycerides are not counted for acid value calculations (Kapila & Nimanthi, 2016) [15]. Despite the increasing temperature of treatment, Free Fatty acid (FFA) percentage did not change significantly for sunflower oil. The temperature reached was higher than the oil's smoke point. It is assumed that the time of exposure at selected temperatures may not be sufficient to produce the expected hydrolytic breakdown (Guillaume C *et al*., 2018) [7, 8]. Here sunflower oil showed zero acid value even at 300ºc. Sunflower oil is rich in polyunsaturated fatty acids (PUFA), particularly linoleic acid (48.3–74.0%). This reduces its oxidative stability, with a fast formation of lipid peroxides (Boukandoul *et al*., 2019) [4]. The experiment results showed an increase in peroxide value on heating.

Oxidative stability, secondary products of oxidation, and total level of PUFAs are said to be reasonable predictors of how an oil will perform when heated at high temperature. (Guillaume C *et al*., 2018) [7, 8]. The TBA test was perhaps the most widely used method for detecting lipid oxidation in foods. In our study increased TBA values indicates increased lipid oxidation at high temperatures. The effect of high temperature heating is illustrated in Table 1 and Figure 1.

Table 1: Effect of High temperature on Oxidative stability of sunflower oil

Tempe Rature (˚c)	Acid Value	Peroxide Value	Tba Value
0	0^{ns}	0.0037±0.0007*	0.0342±0.002*
50	0 ^{ns}	0.08±0.003 ^{ns}	0.03875±0.002*
100	0 ^{ns}	0.0823±0.003 ^{ns}	0.05725±0.003*
150	0 ^{ns}	0.088±0.001 ^{ns}	0.077±0.018 ^{ns}
200	0 ^{ns}	0.0918±0.002*	0.0787±0.023 ^{ns}
250	0 ^{ns}	0.1033±0.008*	0.16575±0.010*
300	0 ^{ns}	0.118±0.009*	0.3512±0.001*

Figures are Mean± standard error of four replicates

*- Treatments are significant at 5% Level of significance, ns- Non significant

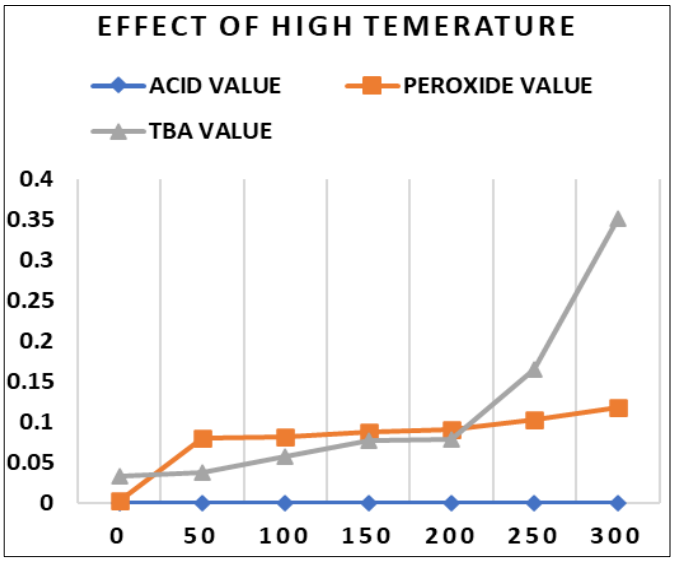

Fig 1: Effect of High temperature on Oxidative stability of sunflower oil

3.2 Heating at 180 ^{0}C for 6 hours

As per the results shown in the Table 2, Acid value has increased from zero to 0.6708±0.0005. This shows effect of time of heating on hydrolysis of oil. The peroxide value (PV), which depends on temperature, time and light, measures the extent of primary oxidation of oils (rancidification). So here we can see an increase in peroxide value throughout the heating period. These results were supported by the obtained TBA values which confirms increased lipid oxidation on heating (Figure 2).

Table 2: Effect of Time on oxidative stability of Sunflower oil

Sample	Acid Value	Peroxide Value	Tba Value
unheated	0±0*	0.0037±0.0007*	0.0342±0.002*
1st hour	0.2245±0.001 ^{ns}	0.0545±0.002*	0.097±0.0004 ^{ns}
2nd hour	0.2248±0.001 ^{ns}	0.0988±0.0008*	0.098±0.0004 ^{ns}
3rd hour	0.2251±0.001 ^{ns}	0.1188±0.001*	0.1027±0.003 ^{ns}
4th hour	0.2261±0.0005 ^{ns}	0.1946±0.001*	0.1692±0.003*
5th hour	0.228±0.001 ^{ns}	0.2943±0.002*	0.266±0.008*
6th hour	0.6708±0.0005*	0.4161±0.001*	0.3837±0.004*

Figures are Mean± standard error of four replicates

*- Treatments are significant at 5% Level of significance, ns- Non significant

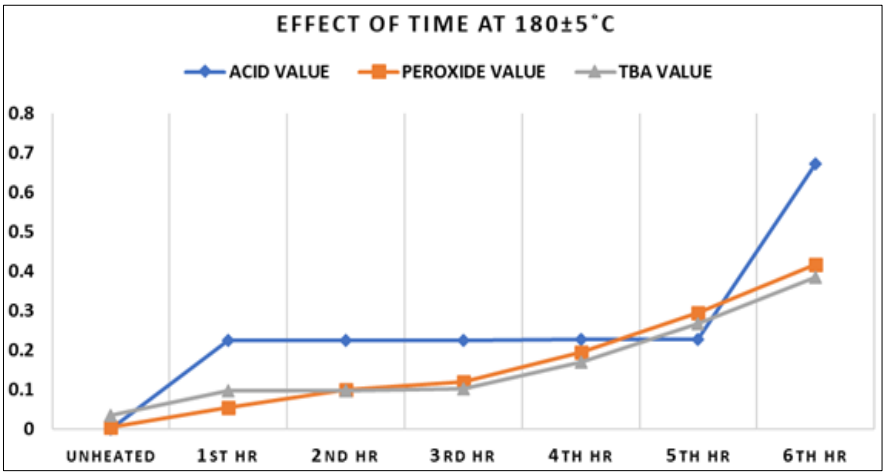

Fig 2: Effect of Time on oxidative stability of Sunflower oil

4. Conclusion

Oils with a higher degree of unsaturation are highly prone to autoxidation. The simplest test for autoxidation (oxidative rancidity) is determination of the peroxide value (PV). Peroxides are intermediary products in the autoxidation reaction. Oxidation of lipids is one of the serious problems occurring while cooking, especially when reusing oils. This may influence not only flavour & aroma but also nutritional quality and, in some cases, even the fineness of the product. The tertiary oxidation products such as dimers and polymers are formed as a result of polymerization reactions of secondary oxidation products. These products cause darkening of oil colour, formation of foam on the oil surface and an increase in viscosity of oil.

As per our research, it was found that longer exposure at frying temperature caused more oil deterioration compared to high temperature heating.

Since sunflower oil is one among the highly consumed edible oils worldwide, the study conducted on its oxidative stability is having much relevance. The fast formation of lipid peroxides in sunflower oil have recognized deleterious effects to human health. Several suggestions targeting to enhance its resistance to oxidation, such as hydrogenation, interesterification, the addition of natural or synthetic antioxidants, have been attempted.

5. Acknowledgment

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