
**EVALUATION OF EFFECT OF DIFFERENT STORAGE TEMP AND HEATING
AT 185⁰C ON THE DIFFERENT EDIBLE COOKING OIL SOLD IN LOCAL
MARKET OF INDIA
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ABSTRACT- Oil and fats are valuable necessary nutrients that play an important role in human life and health. Temperature affects the quality of edible oils. When edible oils are not properly stored and exposed to high temperatures in addition to moisture, It may go rancid and develop an unpleasant odor and flavor and results in changes in the physicochemical properties of edible oils. The purpose of this research, to study the changes in the physicochemical properties of edible oils at different storage conditions such as air, dark and refrigerator increases from 0 to 6 weeks and heating at 185⁰C for different hours. In this research work, different brands of commonly used different cooking oil samples were used. During the different storage conditions and heating, the changes in Physicochemical properties of edible oils were assessed using standard analytical procedures. From the results obtained showed that as time increases as 0 to 6 weeks, the values of AV,PV, SV,EV,P-AV and Totox values increases while IV decreases in all oil samples studied, The samples stored on the ambient temperature exhibited the highest AV, PV, SV,EV values throughout the period of storage followed by those stored in air , dark and in refrigerator and the lowest Iodine values recorded. Results of Acid, Peroxide and Iodine values, the samples stored in the refrigerator provided the best protection to the oil. In case of frying temperature, all the parameters are higher side except IV.

KEYWORDS-Different storage method, cooking oils, Temperature, physicochemical properties

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1. INTRODUCTION

Vegetable oils are important in human nutrition as they provide energy, essential fatty acids and facilitate the absorption of fat-soluble vitamins [1]. Oil quality and its stability are therefore very important for the consumer's desirable use usually as cooking ingredient

[2]. The quality of any oil is indicated by some physicochemical properties which provide an indication of both the nutritive and physical quality of the oil. These properties include iodine value, peroxide value, saponification value, free fatty acid, colour appearance etc. To retain oil quality, care must be taken when storing vegetable oils for a period of time to prevent their deformation as they easily undergo oxidative deterioration, hence shortening their shelf-life[3].

Different physical and chemical parameters of edible oil were used to monitor the compositional quality of oils [4,5]. These physico-chemical parameters include iodine value (IV), saponification value (SV), viscosity, density and peroxide value (PV). Edible oils are one of the main constituents of the diet used for cooking purposes. Several researchers studied the impact of temperature on the stability; viscosity, peroxide value, and iodine value to assess the quality and functionality of the oil [6-8]. Atmospheric oxygen reacts instantly with lipid and other organic compounds of the oil to cause structural degradation in the oil which leads to loss of quality off odour and is harmful to human health [9]. Therefore, it is essential to monitor the quality of oil to avoid the use of abused oil due to the health consequences of consuming foods fried in degraded oil, to maintain the quality of fried foods and to minimize the production costs associated with early disposal of the frying medium [10].

Oil is an excellent heating medium, because it allows high rates of heat transfer into foods being cooked. However, the frying process also causes a number of chemical and physical changes in the oil. These changes not only influence the heating characteristics, but also bring about changes in the sensory and nutritional characteristics of foods [11]. Physicochemical changes in the oil are due to Oxidative stability is very important factor in oil quality especially for frying therefore the frying oil must have high oxidative stability during use [12].Hydrolytic changes due to water vapours from the product undergoing frying [13].Thermal changes due to oil being maintained at high temperatures.

1.1 Literature review

The oxidative and chemical changes in oils during storage are characterized by an increase in free fatty acid contents and a decrease in the total unsaturation of oils [14]. All these physicochemical parameters such as viscosity, density, peroxide value, iodine value, and

saponification values are qualitative properties of oils and do not indicate the position of the double bonds or the amount of olefinic carbon but rather it provides an overall status of unsaturation of the oils so it is not possible to point out the position of double bond(s) which are more susceptible to oxidation [15].

Deep-fat frying is the process of cooking by completely immersing foods in hot oil. It is a simultaneous heat and mass transfer process. Frying oils are usually maintained at elevated temperatures ranging from 150 to 200 oC. The hot oil serves as a medium of heat transfer into the food, while the moisture migrates out and the oil is absorbed [16]. Frying causes complex physicochemical reactions such as starch gelatinization, protein denaturation, browning, crust formation, textural and flavor changes. These depend on either the frying process itself or the nature of the food or type of frying oil[17]. Atmospheric deep-fat frying is usually practiced. At high frying temperatures and in the presence of oxygen, thermo-oxidation and breakdown occur especially if the oil is polyunsaturated. These reactions lead to the formation of volatile and non-volatile oxidative compounds that affect the quality of frying oil and fried products. Foaming also occurs when products with high initial moisture content are fried. Repeated and continuous use of frying oils produces undesirable compounds that may compromise the quality of the food and pose a potential risk to human health and nutrition [18]. The popularity of fried foods has at no time been reported to decrease. This is certainly due to the smooth mouth feel, distinct flavor, palatability, and aesthetic appeal of fried foods.

Josphine and coworkers studied that the evaluation of iodine value and storage conditions of selected vegetable oils after deep frying different types of food in Kenya. Deep frying is one method which involves submerging the food in hot oil. Five types of food were deep-fried in five types of oil for 6 hrs. The oils were then divided into two portions; one portion was stored at room temperature and the other portion under refrigeration (40°C) for 5 days. Frying was repeated using these oils after 5 days for another 6 hours making the total frying time to be 12 hours. Iodine value was determined according to Wijs method. Fresh palm oil had relatively lower iodine value of 45.58 g of iodine/100g of oil while corn and soybean showed higher values of 131.98 g of iodine/100g of oil and 129.44 g of iodine/100g of oil respectively This study concluded that soybean oil is susceptible to oxidation [19]. Physicochemical properties of oils are determined to know the quality, purity and identification. Characteristic properties are properties that depend on the nature

of the oil. These are used to characterize oil, irrespective of location or sources of origin [20].

Increase in FFA could be attributed to moisture content of the fried product that accelerates the hydrolysis of oil. It is known that water can promote the hydrolysis of triacylglycerols to form a combination of mono and diacylglycerols, glycerol and free fatty acids [21]. Moreover, the FFA content is a dynamic value because at the same time that the acids are being produced, they have sufficient vapor pressure at frying temperatures to evaporate from the surface [22]. However, FFA is not a very reliable parameter for the assessment of the degradation of frying oil, because it is difficult to differentiate FFA formed by oxidation or by hydrolysis. Moreover, low molecular weight FFA may be lost through volatilization during frying [23].

Iodine value is a measure of the degree of unsaturation or double bonds among the fatty acid present in the oil therefore it does not tell precisely the fatty acids composition of any oil. Iodine value or number is useful as a guide to check adulteration of oil and also as a process control of oil. Iodine value is of major interest in regard to oxidative stability of oils after deep frying food. From this study, it was established that soybean oil recorded a large decrease in iodine value based on the food fried and storage conditions. This shows relatively higher oxidation in soybean oil. Palm and peanut oils proved to be relatively stable since they recorded small decrease in iodine values. In terms of storage conditions, it was observed that storage conditions had significant effects on the oil. This finding demonstrates that there is need to refrigerate oils after use. This is because oils refrigerated were more stable than the ones stored at room temperature.

Peroxide value is used in determining the degree of spoilage. The standard peroxide value for edible oils which have not undergone rancidity must be well below 10 meq/kg [19]. Free fatty acid value is often used as general indication of the condition and edibility of oils [24].

Poly-unsaturated oils have reduced stability at elevated temperatures; unsaturated fatty acids easily react with oxygen to form peroxides [26]. Peroxide value is useful as an indicator of oxidation at the initial stages; however, it is not related to the frying duration, but to the formation and breakdown of oxidation products. Peroxides are unstable and decompose at frying temperature. They may even increase after the sample is taken from the fryer. Hence, it is generally not a very reliable parameter to determine deterioration of frying oil quality [25, 27].

Saponification value is a rough index of the molecular weight of the fat or oil. The smaller the saponification value the higher the molecular weight. It also indicates the quantity of alkali required for conservation of a definite amount of fat or oil into soap. It is used to check the adulteration of fat and oils [28]. Esterification value is the difference between the saponification value and the free fatty acid value of the fats and oils. Other variable properties of oil include solubility, freezing point, colour, odour and boiling point. Oil spoilage can be prevented through exclusion of air, addition of antioxidants, addition of chelation agents and hydrogenation [31].

Jorge et al(2003) studied the degree of frying of frying oil degradation in commercial restaurants in the Brazilian city of Chapecó, SC. Laws and regulations to control the quality of frying oil were adopted by some countries, including Belgium, France, Germany, Switzerland, the Netherlands, the United States and Chile. In Brazil, discontinuous frying processes are widely used both in home preparations as in restaurants and cafeterias. The oil is used in a large number of times with minimum replacement, which may result in high levels of change. However, Brazil does not yet have rules for monitoring and disposal of frying oils. These facts demonstrate the importance of studies to get to know the behavior of oil in discontinuous frying processes and their degree of change [32].

The aim of the present study was to investigate the high temperature performance of some vegetable oils as a function of heating duration at simulated frying temperature of 180⁰C and at the different storage conditions with regards to variation in temperature on the stability of vegetable oil commonly consumed in Jalgaon city of Maharashtra, India. The oxidative degradation of the oils was evaluated by monitoring AV,PV, **IV,SV,EV, P-AV** and TV values of collected edible vegetable oils.

2. MATERIAL AND METHODS

The oil samples of vegetable oil such as refined Sunflower(Sf) refined Soyabean(Sb), Groundnut(Gn),Mustard(Mu), refined Canola(Cn) and Palmolein (Pm) oil samples were randomly obtained from local market of Jalgaon, Maharashtra India. The samples were collected using cleaned and dried half a liter containers and were divided each into four (4) portions. Each portion was stored in a cupboard, shelf or a refrigerator for the period of effect storage conditions for 9 weeks and The samples were taken randomly and each one

was heated in three aluminum containers, for study the effect of heating at 185°C for 30 minutes and the analysis were carried out and these edible oils are stored at different storage conditions such as air, dark and refrigerator increases from 0 to 6 weeks. The physicochemical properties were performed for Acid, Peroxide, iodine, saponification, ester, P-anisidine and totox values were determined at two weeks interval by standard method of AOCS [5]. For study the effect of heating, All reagents are of analytical grade unless otherwise stated. Deionized water was used for preparation and dilutions of standard solutions. Nitric acid (HNO₃) and sulfuric acid (H₂SO₄) reagents were used for cleaning of glassware and for digestion of the samples. Representative edible oil samples were used for analysis. Chloroform, potassium iodide (KI), glacial acetic acid, and sodium thiosulphate were used for estimation of peroxide value. Hydrochloric acid (HCl), sodium hydroxide (NaOH), ethanol, and phenolphthalein indicators were used for estimation of acid value and saponification value, respectively; carbon tetra chloride, potassium iodide, and Wijs reagent were used for estimation of iodine value.

2.1 Experimental procedure[31-40]

2.1.1 Determination of Chemical properties

2.1.1.1 Determination of Acid value : Acid value was measured by titration with sodium hydroxide according to the American Oil Chemists' Society (AOCS) method Cd 8-53 (AOCS, 1989b).

2.1.1.2 Determination of Iodine value: The iodine value (IV) of the sample was measured using IS 548 (IS 548, 2015c).

2.1.1.3 Determination of Peroxide value: The acetic acid-chloroform method of the AOCS (Method Ca 5a-40) was used for determination of the peroxide value (PV) (AOCS, 1989c).

2.1.1.4 Saponification value: The saponification value (SV) of the sample was obtained by following IS 548 method (IS 548, 2015b).

2.1.1.5 Method for determination of ester value

The ester value is the 'mg' of KOH required to react with glycerol/ glycerin after saponify 1 g of oil sample. Ester value is calculated by the following relation

$$\text{Ester Value} = \text{Saponification Value} - \text{Acid Value}$$

2.1.1.6 Determination of p-anisidine Value: The p-anisidine value was obtained using a double beam spectrophotometer (UV 2300, LabIndia) according to the AOCS method Cd 18-90 (AOCS, 1989d).

2.1.1.7 Determination of Totox value

The totox (i.e. total oxidation products) value was calculated by AOCS Ccl3e-92 method.

The Totox value was calculated as: **Totox value=TV = (2 x PV) +AV**

3.0 Experimental results of physicochemical characteristics of different brands of different edible vegetable oils at different storage conditions.

Table 1.1 Initial Characterisation and heating at 185⁰C of vegetable oils

Sr.n o	Oil Cod e	At room temperature							Heating at 185 ⁰ C						
		AV*, mg KOH / g oil	PV, Meq/Kg	IV	SV, mg KOH / g oil	EV, mg KOH /g oil	P- AV	TV	AV, mg KOH / g oil	IV	PV, Meq /Kg	SV, mg KOH / g oil	EV, mg KOH /g oil	P-AV	TV
1	Sf	0.36	1.78	127. 24	190.1 2	166.1	3.2	6.76	0.98	120.3 8	7.2	197.24	196.2 6	5.12	19.52
2	Sb	0.23	1.46	124. 58	192.8 7	167.4 1	2.47	5.39	0.85	117.8 2	6.88	198.68	197.8 3	3.14	16.9
3	Gn	3.25	4.2	91.6 8	191.1 4	164.7 7	4.84	13.24	7.85	84.68	5.85	196.92	189.0 7	5.12	16.82
4	Mu	3.77	5.80	103. 32	170.9 8	163.2 3	5.92	17.52	8.30	96.92	7.96	178.98	170.6 8	6.13	22.05
5	Cn	0.33	1.68	106. 24	171.3 7	167.7 6	2.90	6.26	0.65	98.28	2.42	179.48	178.8 3	4.10	8.94
6	Pm	4.26	6.8	57.2 8	199.8 2	165.3	9.21	22.8	8.97	51.26	9.9	205.56	196.5 9	11.0	30.8
7	Tota l	12.2	21.72	610. 34	1116. 3	994.5 7	28.5 4	71.97	27.6	569.3 4	40.2 1	1158.86	1156. 86	34.61	115.03
8	Mea n	2.033	3.62	101. 72	186.0 5	165.7 617	4.76	11.99	4.6	94.89	6.70	192.81	192.8 1	5.77	19.17
9	SD	0.95	0.73	0.78	0.48	0.23	0.3	0.07	0.17	0.53	0.08	0.36	0.31	0.21	0.17
10	CV	46.94	20.3	0.76	0.26	0.14	6.23	0.56	3.77	0.56	1.24	0.18	0.16	3.7	0.89
11	SE M	0.55	0.42	0.45	0.28	0.13	0.17	0.04	0.1	0.31	0.05	0.21	0.18	0.12	0.1

(*AV-acid value, IV-Iodine value, PV-peroxide value, SV-Saponification value, EV-Ester value, SD-standard deviation, CV-coefficient of variation, SEM- standard mean error , P-AV-P-anisidine value, TV-Totox value)

Table 1.2 Characterisation of vegetable oils on different storage conditions

S C	Sunflower			Soyabean			Groundnut			Mustard			Canola			Palmolein		
	A	D	R	A	D	R	A	D	R	A	D	R	A	D	R	A	D	R
T	3w k	6w k	9wk	3 wk	6w k	9w k	3 wk	6w k	9w k	3 wk	6w k	9w k	3 wk	6w k	9w k	3 wk	6w k	9w k
A V	1.2 1	0.9 7	0.6 5	0.9 7	0.6 5	0.4 4	5.2 4	4.2 6	3.7 7	6.7 3	5.3 9	4.4 8	0.8 5	0.6 5	0.4 5	7.8 5	6.7 3	5.2 4
P V	4.0	3.2	2.4	3.8 2	3.2	2.1	8.8 8	6.8 5	6.2 1	8.2	7.8 2	7.2	3.8 2	3.2	2.1	11. 6	10. 0	9.9
S V	20 2.6 8	20 0.1 2	197 .88	20 1.4 6	19 9.9 8	19 6.7 8	19 9.4 2	19 7.5 8	19 5.2 4	17 6.4 2	17 4.7 4	17 2.8 8	17 7.8 4	17 5.6 8	17 3.9 8	20 7.3 4	20 5.7 8	20 2.1 2
I V	88. 56	10 1.8 8	110 .12	10 9.2 8	10 1.2 4	91, 36	68. 48	74. 24	82. 38	79. 62	84. 34	91. 18	78. 34	85. 98	92. 88	54. 27	49. 48	45. 12
E V	20 1.4 7	19 9.1 5	197 .23	20 0.4 9	19 9.3 3	19 6.3 4	19 4.1 8	19 3.3 2	19 1.4 7	16 9.6 9	16 9.3 5	16 8.4	17 6.9 9	17 5.0 3	17 3.5 3	19 9.4 9	19 9.0 5	19 6.8 8
P- A V	6.7 8	5.1 2	4.2 1	6.1 4	5.0 2	3.8 7	8.9 8	7.2 4	6.9 8	9.4 8	7.9 8	6.0 2	5.0 2	4.1 2	3.2 0	12. 6	11. 5	10. 0
T V	14. 78	11. 52	9.0 1	13. 78	11. 42	8.0 7	26. 74	20. 94	19. 4	25. 88	23. 62	20. 42	12. 66	10. 52	7.4	35. 8	31. 5	29. 8

(SC-Storage condition , A-air, D-dark, R-refrigerator, T-Time duration, AV-acid value, PV-peroxide value, SV-saponification value, EV-ester value, P-AV-p-anisidine value, SD-standard deviation, CV-coefficient variation, SEM-standard error, wk-week, P-AV-P-anisidine value, TV-Totox value)

Table 3. Test results of frying oils and codex standards

Sr. no	Test	Before frying	Air	Dark	Refrigerator	After frying	Codex Alimentarius commission standard	FSSAI
1	AV	0.33-4.26	0.97-7.85	0.65-6.73	0.44-5.39	0.85-8.97	0.6 mg KOH/g	0.5-6.0mg KOH/g
2	IV	57.28-127.24	54.3-109.3 gI ₂ /100 g	49.5-101.9	45.12-110.12	51.26-120.38	--	--
3	PV	1.46-6.8	3.82-11.6	3.2-11.6	2.1-9.9	2.42-9.9	10.0 MeqO ₂ /Kg	1-10 MeqO ₂ /Kg
4	SV	170.98-199.82	176.42-207.34 mg KOH/g	174.7-205.7 8	172.88-202.12	178.98-205.56	--	--
5	EV	163.23-167.76	169.69-201.5 mg KOH/g	169.3-199.1 5	168.4-197.23	170.68-196.59	--	---
6	P- AV	2.47-9.21	5.02-12.6	4.12-11.5	3.2-10	3.14-11.0	20 MeqO ₂ /Kg	--
7	TV	5.39-22.8	12.66-35.8	10.5-31.5	7.4-29.8	8.94-30.8	26 MeqO ₂ /Kg	--

4. Statistical Analysis

The data obtained from the experimental measurements and accuracy of different parameters for different vegetable oils have been analysed and the Statistical parameter like standard deviation, coefficient of variance and standard mean error were calculated for AV, IV, SV, EV, P-AV and TV for different brands of different edible vegetable oils before and after frying. All the experiment was carried out in triplicate and the results are

presented as the mean \pm SD, CV, \pm SEM. Accuracy and descriptive Statistics of different oils from different parts of India as shown in figure1to3.

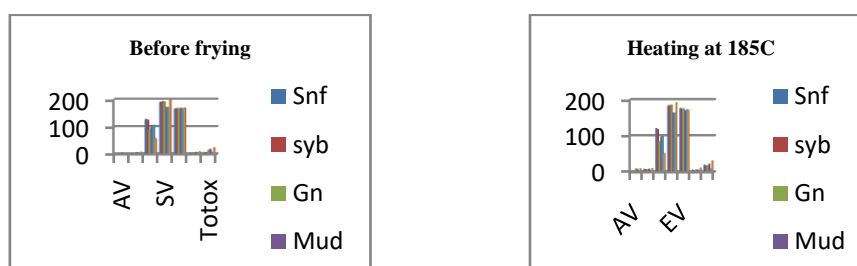


Fig 1-2 shows that plot of obtained results of different parameter of different Mustard edible vegetable oils before and frying.

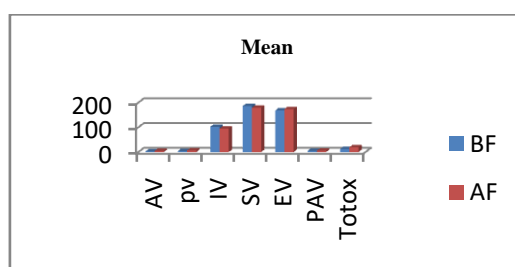


Fig.3 Accuracy and descriptive Statistics of different Mustard oils from different parts of India as shown in figure3.

5. Results and discussion

In the present study, chemical parameters were used as an indicator for assessment of quality of thermally oxidized oil samples. The most common change in the oil or fat during use is the darkening. Food compounds (as carbohydrates, phosphates, sulfur compounds, and trace metals) react with the oil or their breakdown products, which contributes to the formation of color. Vegetable oils are a popular cooking medium in many parts of the world.

The oxidative characteristics of different edible vegetable oils before, after frying and store the oil samples in air ,dark and refrigerator have been extensively investigated. The experimental results of AV,PV,IV,P-AV and Totox values were illustrated in Tables 1-2 and figures 1-3. It can be seen from the tables and figure that,the acid value of all edible oils are in the range of 0.33-4.26 in before,0.97-7.85 in air, in dark 0.65-6.73,in refrigerator 0.44-5.39,in after frying 0.85-8.97 mg/KOH/g in 0 to 9 week storage had slightly higher

value after frying as compared with that before frying, and then decreases with refrigerator storage. Generally, the slight increase of the acid value of the investigated samples may attribute to the complete inhibition of enzymes activity. In case of Iodine value it is in between the range of 57.28-127.24 in fresh oils, 54.3-109.3 in air, 49.5-101.9 in dark, 45.12-110.12 in refrigerator and 51.26-120.38 in after frying. All the oil samples are stored in air, dark and refrigerator for 0 to 9 weeks. The IV which are gradually decreased as the result of destruction of double bonds in after frying, the result was not in this expectation. In case of SV It is 170.98-199.82 in fresh oils, 176.42-207.34 in air, 174.74-205.78 in dark, 172.88-202.12 in refrigerator and 178.98-205.56 in after frying while in case of EV, It is 163.23-167.76 in fresh oils, 169.69-201.5 in air, 169.35-199.15 in dark, 168.4-197.23 in refrigerator and 170.68-196.59 in after frying. The obtained results of PV in the range of 1.46-6.8 in fresh oils, 3.82-11.6 in air, 3.2-11.6 in dark, 2.1-9.9 in refrigerator and 2.4-9.9 in after frying which are exceeded in air and dark than the permitted codex limit and deviated from the Codex standard value of 10 meq O₂/kg, this may be explained by splitting of hydro peroxides which form during the first stage of the oxidation. It is clear from the obtained results (Tables 1, 2 and Figure 1-3) that, P-anisidine value in the range of 2.47-9.21 in fresh oils, 5.02-12.6 in air, 4.12-11.5 in dark, 3.2-10 in refrigerator and 3.14-11 in after frying oil which are lower than the limit of 20 meq/kg and in case of TOTOX value it is 5.39-22.8 in fresh oils, 12.66-35.8 in air, 10.5-31.5 in dark, 7.4-29.8 in refrigerator and 8.94-30.8 in after frying oils which are exceeded the codex limit of 26 meq/kg respectively, causing undesirable odor of oil sample after frying. These results might be due to the effect of high frying temperature causing destruction of some glycerides. It can be noticed that, after frying, AV, PV, SV, EV, P-anisidine and TOTOX values were found higher and Iodine values are decreases. In case of storage in air, dark, refrigerator and after frying, all the parameters are initially increases in after frying and then gradually decreases in air, dark and in refrigerator. The results showed degradation in the physico-chemical properties of the vegetable cooking oil after frying. **A.V. measures the content of free fatty acids formed upon the hydrolytic degradation of lipid molecules, thus contributing the reduction of shelf life of oil. According to Codex Alimentarius Commission standard acid value up to 5 mg KOH/gm of oil is safe for consumption. Here the acid value (table 1-2) is above 5 mg KOH/gm of oil so it deviates codex standard.** In all the selected oils, palm oil samples has the highest peroxide values in comparison to other oil samples, palm oil has the highest increase in peroxide value. At the end of the six weeks storage period as expected, oil samples stored at room temperature has higher peroxide values than the samples kept in the

refrigerator because of the negative effect of temperature to oxidation of oil. Higher P-anisidine and Totox values are the secondary oxidation product. All these vegetable oils can exist as liquid at room temperature. Oil stored in refrigerator has a greater nutritional quality than that of in air and dark storage. This study evaluated the effect of different storage time of different vegetable oils on the physicochemical properties for a period of six (6) weeks. During the storage period, changes took place in the values of quality parameters. From the results obtained it can be deduced that all the oils have similar properties which have much change in variation.

7. CONCLUSION

The different edible oils of home kitchen use as samples before and after frying and storage at in air, dark and refrigerator for 0 to 6 weeks are investigated for the oxidative status. In this study, It is clear from the obtained results that, the acid, peroxide, P-anisidine and Totox values of edible oil are gradually increased after frying compared with that before frying and Iodine value decreases as compared with before frying. Higher p-anisidine and Totox value which indicates the extent of secondary oxidation occurred in oil sample, indicating that it might be due to the effect of high frying temperature causing destruction of some glycerides. During storage 0 to 6 weeks in air, dark and refrigerator, changes took place in the properties of the oils. **The experimental result shows** relatively higher oxidation in soybean oil. Palmolein and groundnut oils proved to be relatively stable since they recorded small decrease in iodine values. In terms of storage conditions, it was observed that storage conditions had significant effects on the oil. This finding demonstrates that there is need to refrigerate oils after use. This is because oils refrigerated were more stable than the ones stored at room temperature.

7. REFERENCES

- [1] PROTA Foundation, (2008). Vegetable oils of tropical Africa. Conclusions and recommendations based on PROTA 14: Vegetable oils. Plant resources Tropical Africa. Pp.84.
- [2] Jambunathan, C., and Reddy, P.S.,(1991). Storage and Determination of Oils (3rd ed.). Canon Press, pp. 85-98.
- [3]. Akin et al (2015), Akin-Osanaiye Catherine Bukola¹, Gabriel Adeyemi Francis, Alaje

Patience and Omoniyi Ahmed Olalekan, Effects of Different Storage Temperature on the Physicochemical Properties of Cooking Oils Available in Nigeria Markets, *European Journal of Academic Essays* 2(10): 7-14.

[4] Ceriani, R., Paiva, F. R., Alves, C. B. G., Batista, E. A. C., Meirelles, A. J. A., 2008. Densities and viscosities of vegetable oils of nutritional value. *J. Chem. Eng. Data* 53 (8),1846–1853.

[5] Mousavi, K., Shoeibi, S., Ameri, M., 2012. Effects of storage conditions and PET packaging on quality of edible oils in Iran. *Adv. Environ. Biol.* 6 (2), 694–701.

[6] Farhoosh, R., Moosai, S. M. R., Sharif, A., 2008. Investigation on frying oils quality in terms of color index, refractive index and viscosity during frying process. *J. Food Sci. Tech.* 5(1):13–19.

[7] Li, H., Zhou, G., Zhang, H., He, Y., 2010. Chemical constituents and biological activities of saponin from the seed of *Camellia oleifera*. *Sci. Res. Essays* 5 (25), 4088–4092.

[8].Susan et al (2018),Susan Okparanta, Victoria Daminabo, Leera Solomon. Assessment of Rancidity and Other Physicochemical Properties of Edible Oils (Mustard and Corn Oils) Stored at Room Temperature. *Journal of Food and Nutrition Sciences*. Vol. 6, No. 3, pp. 70-75.

[9] Bhattacharya, A. B., Sajilata, M. G., Tiwari, S. R., Singhal, R., 2008. Regeneration of thermally polymerized frying oils with adsorbents. *Food Chem.* 110, 562–570.

[10] Vijayan, J., Slaughter, D. C., Paul, S. R., 1996. Optical properties of corn oil during frying. *Int. J. Food Sci. Technol.* 31, 353–358.

[11].Farkas BE, Singh RP, Rumsey TR. Modeling heat and mass transfer in immersion frying. II. Model solution and verification. *Journal of Food Engineering.* 1996; 29:227-248. [A study involving modeling and experimental validation of the frying process].

[12].Tabee ES, Azadmardm S, Dimirchi M, Jagerstad PC, Dulla JA. *Oil Chem.Soc.* 2008; 85:857.

[13].Gertz C, Klosterman, S. Analyziz of acrylamide and mechanism of its formation in deep fried products.*European Journal of Lipid science technology.* 2002; 104:762-771.

[14].Perkin, E.G., 1992. Effect of lipid oxidation on oil and food quality in deep frying. In: Angels, A.J.S. (Ed.), *Lipid Oxidation in Food*, Chapter 18, ACS Symposium Series no. 500 ACS, American Chemical Society, Washington DC, pp. 310–321.

- [15].Knothe, G., Dunn, R., 2003. Dependence of oil stability index of fatty compounds on their structure and concentration and presence of metals. *J. Am. Oil Chem. Soc.* 80, 1021–1026.
- [16].Moreira RG (2014) Vacuum frying versus conventional frying – An overview*. *European Journal of Lipid Science and Technology.* 116(6), 723-734.
- [17].Marrikar JMN, Ghazali HM, Long K & Lai OM (2003) Lard uptake and its detection in selected food products deep-fried in lard. *Food Resource International.* 36, 1047 - 1060.
- [18].Andrikopoulos NK, Boskou G, Dedoussis GVZ, Chiou A, Tzamtzis VA & Papathanasiou A (2003) Quality assessment of frying oils and fats from 63 restaurants in Athens, Greece. *Food Service Technology.* 3(2), 49-59.
- [19].Josphine et al(2016) Josphine Chebet, Thomas Kinyanjui, Peter K. Cheplogoi, Impact of frying on iodine value of vegetable oils before and after deep frying in different types of food in Kenya, *Journal of Scientific and Innovative Research*, vol ; 5(5): 193-196.
- [20]. Amira P, Olaniyi OO, Babalola, Oyediran AM. Physicochemical Properties of Palm Kernel Oil: Current Research *Journal of Biological Sciences.* 2014; 6(5):205-207.
- [21].**Velasco J, Marmesat S and MC Dobarganes** Chemistry of Frying. In: Sahin S, Sumnu G., Taylor and Francis. Deep fat frying of foods. USA, 2008, 33-56.
- [22].**Abd El-Rahman MS, El-Makhzangy A and MF Ramadan** Antiradical performance & physicochemical characteristics of vegetable oils upon frying of French fries: a preliminary comparative study. *Journal of Food Lipids*, 2006; **13**: 259–276.
- [23].**Hau LB, Young PK and LS Hwang** Quality assessment of oils during heating and frying. *Journal of Chinese Agricultural Chemical Society*, 1986; **24**: 397–405.
- [24].Pearson DM. The Chemical Analysis of Foods. 6th Edn. AVI Publishers, West Port, 1976.
- [25].**Hau LB, Young PK and LS Hwang** Quality assessment of oils during heating and frying. *Journal of Chinese Agricultural Chemical Society*, 1986; **24**: 397–405.
- [26].**Che-Man YB and WR Wan-Hussin** Comparison of the frying performance of refined, bleached and deodorized palm olein and coconut oil. *Journal of Food Lipids*, 1998; **5**: 197–210.
- [27].**Warner K and M Gupta** Frying quality and stability of low and ultra low linoleic acid soybean oils. *Journal of American Oil Chemists Society*, 2003; **80**: 275–280.
- [28].Theodore AG. Food Science. 3rd Edn. AVI Publishers, West Port, 1983.

- [29].Furniss BS. Vogel's Textbook of Practical Organic Chemistry Including Qualitative Organic Analysis. 4th Edn. ELBS/Longman, London, 1978, 137-138.
- [30].Jorge N, Lopes MRV. Avaliação de óleos e gorduras de frituras coletados no comércio de São José do Rio Preto – SP. Alim. Nutr 2003; 14(2):149-156.
- [31].AOCS, Official Method Cd 8-53: Peroxide Value Acetic Acid-Chloroform Method. American Oil Chemists Society Sampling and Analysis of Commercial Fats and oils (1997b).
- [32].AOCS, Official Method Cd 18-90: p-Anisidine Value. American Oil Chemists Society Sampling and Analysis of Commercial Fats and oils (1997c).
- [33].ISI Hand book of food Analysis (part III) 1984 page 67/ IUPAC2.201 (1979) I.S, 548 (Part-1)-1964 method of sampling and test for oils and fats/ISO 6601 1996 Determination of acid value and acidity.
- [34].A.O.A.C, Official Method 965.33 Peroxide value in oils and fats/Pearson's composition and analysis of food, 17th edition, pp. 641, 2000.
- [35].DGHS,(2012)., Directorate General of Health Services, Manual of Methods of Analysis of Foods Oils and Fats), Food Safety standards authority of India (FSSAI), Ministry of Health and Family Welfare, Government of India, New Delhi.
- [36].ISI Hand book of food Analysis (part III) 1984 page 67/ IUPAC2.201 (1979) I.S, 548 (Part-1)-1964 method of sampling and test for oils and fats/ISO 6601 1996 Determination of acid value and acidity.
- [37].A.O.A.C, Official Method 920.160-Saponification Number of Oils and Fats/IUPAC 2.202 I.S.I Hand Book of Food Analysis (Part XIII 1984), A.O.A.C, 17th edition, 2000.
- [38]IS 548 (Part I). (2015a) Determination of refractive index, Method. No.10:pp 35
- [39]IS 548 (Part I). (2015b) Determination of saponification value. Method. No.15: pp 50.
- [40]IS 548 (Part I). (2015c) Determination of iodine value. Method. No.14: pp 47.
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