International Journal of Science Technology and Management
Vol. No.4, Special Issue No. 01, September 2015
www.ijstm.com
ISSN 2394 - 1537

OXIDATION OF COOKING OILS DUE TO REPEATED FRYING AND HUMAN HEALTH

GarimaGoswami[1], Rajni Bora[2], Mahipat Singh Rathore[3]

[1]Assistant Professor (Chemistry), [2]Assistant Professor (HSS), [3] ECE Department, Department of Applied Sciences, JIET Universe, NH-62,Mogra, Pali Road, JODHPUR, Rajasthan, (INDIA)

ABSTRACT

Food becomes tastier on deep frying, and some of food items can only be eaten, once are deep fried. Reusing this deep fried oil repeatedly for frying purposes is responsible for many health hazards in human population. Increased viscosity and darkening in colour are some of the physical changes which can alter the fatty acid composition of the cooking oil on repeated frying.Oxidation, hydrolysis and thermal polymerization are the chemical reactions occurring as a result of repeated heating of cooking oil for low and cheap food production. In this paper the degradation of the quality of cooking oil on repeated frying, its effects on human health and some ways to treat this cooking oil so as to make it more cost effective and less dangerous for human consumption are undertaken with special reference to Rajasthan.

Keywords: Adsorbents, Deep Fried, Eatable Oil, Oxidation, Reheating

I. INTRODUCTION

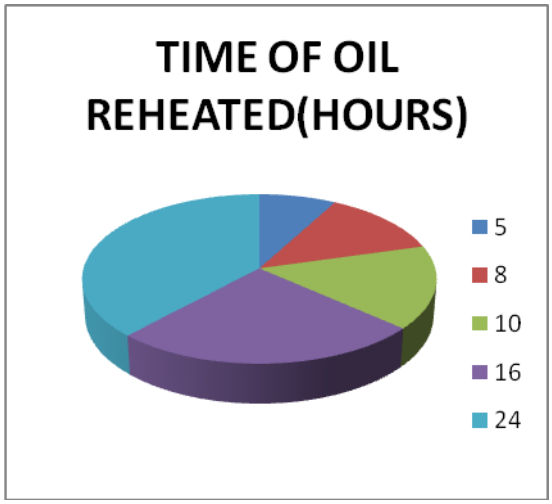
The biggest state of India called Rajasthan is dry and sandy area. Thardesertcovers a large portion of this region Scarcity of water and fresh green vegetables have their effect on the Rajasthan cuisine. People are in a habit of eating all sort of non-green food including much of fried food. Frying means cooking the stuff at app. 180°C by dipping it fully in the heated oil. Various food products such as potato chips, pakodas, namkeens, chicken patties,etc. are prepared at large scale by this frying process. Fried food is considered to be tastier than non-fried.Beingunpropitious area cooking oil used for frying is heated repeatedly.Anytimeone cook food, it runs the risk of creating heat-induced damage. The vegetable oils one choose to cook with, must be stable enough to resist chemical changes when heated to high temperatures, otherwise one hasthe risk of damaging one'sownhealth as well as the health of the person consuming the cooked food. One of the ways vegetable oils can inflict damage is by converting our good cholesterol into bad cholesterol—by oxidizing it.

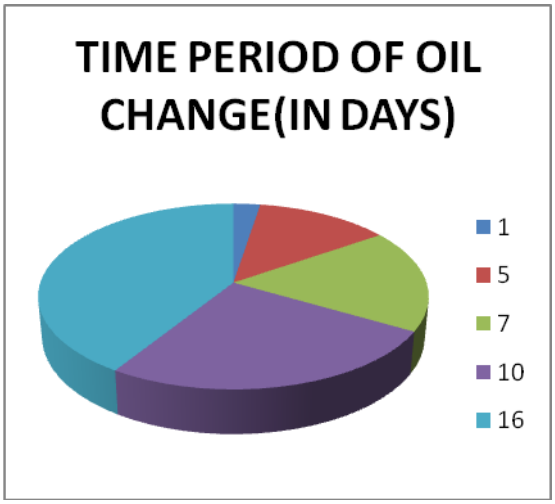
II. CAUSE OF REPEATED HEATING OF THE COOKING OIL

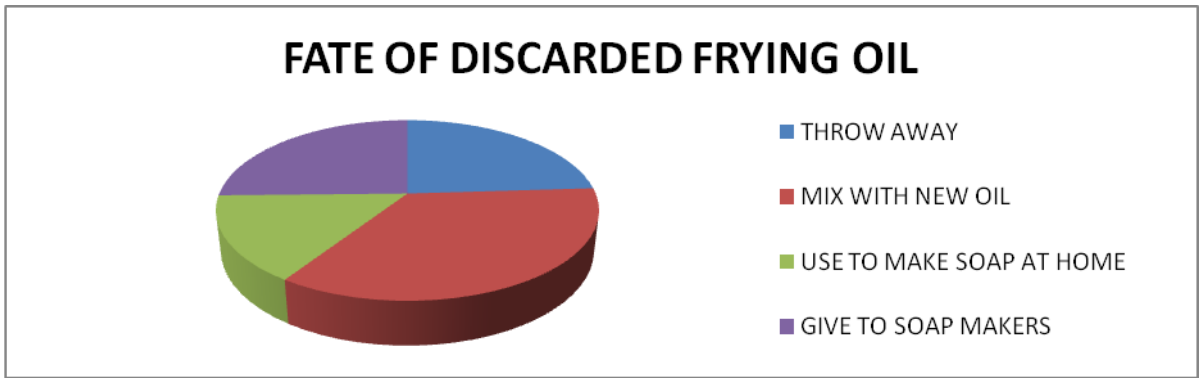
In this fast-paced society, frying remains as one of the popular and tastier methods in food preparation. In developing countries consumption of ready-made food is in much demand. And if it is deep-fried then its demand becomes even higher.Frying improves the sensory quality of food by formation of compounds rich in aroma, attractive colour, crust and texture, all highly appreciated by the consumers.Edible vegetable oil is the major ingredient in these fried food products. Therefore, the cost of the oil becomes the most important factor to

ISSN 2394 - 1537

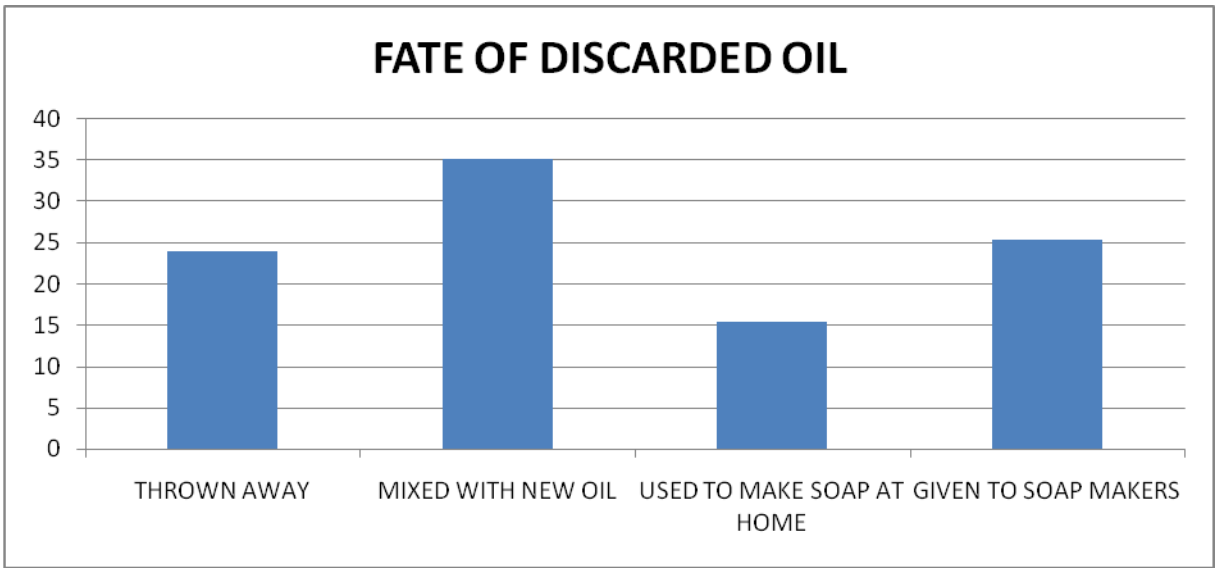
be considered in terms of economy. As a result, vegetable oil is often heated repeatedly to ensure cost effectiveness. Rajasthan is not only famous for sweets but also is well known for friednamkeen items. For cutting down the cost of fried food items and to save money, many of the household ladies and maximum of the Namkeen makers in Rajasthan use the same cooking oil repeatedly for frying different items. The oil is reused repeatedly and it is discarded and replaced with fresh oil, only when it becomes foamy, highly viscous, emits bad odour and become dark coloured [1] and many a times it is never replaced at all, instead fresh oil is added to already heated ,thick and highly viscous oil[2]. A survey was conducted in this regard clearly supports the above statement.100 different people including household ladies and namkeen makers in the study area were surveyed about the oil used in frying , number of times it is reheated and ultimately its fate . The results of the survey were represented in the form of GRAPHS as given below:







ISSN 2394 - 1537



III. CHANGES DURING THE REHEATING OF THE OIL

Although eating limited quantity of fried food items does not cause any kind of health problem in normal human being. The problem begins when the same oil is used again and again by repeated heating. During deep-frying of food at temperatures between 170° – 200°C, the oil used undergo following changes: 1. Hydrolysis – Moisture from the food being fried vaporizes and hydrolyses triglycerides (TGs) in the frying oil to glycerol, free fatty acids (FFA s) , monoglycerides (MGs) and diglycerides (DGs); 2. Oxidation – Triglyceride molecules in the frying oil undergo primary oxidation to unstable lipid species called “hydro peroxides” which cleave to form secondary oxidation products which comprise non-volatile and volatile compounds. Some of these secondary products polymerize (t e r t i a r y o x i d a t i o n), increasing the oil viscosity, cause browning on the surface, and darken the oil[3]; and3. Thermal Polymerization– High temperatures of the frying operation produce high molecular cyclic fatty acid (FA) monomers, and TG dimers and oligomers[4,5,6]. Fried food may absorb many oxidative products such as hydro peroxide and aldehydes, which are produced during this process [7] thus affecting the quality of oil. The quality of oil deteriorates with increased length of frying time due to the accelerated formation of oxidized and polymerized lipid species in the frying medium. If the physico-chemical properties of cooking oil deteriorate, the oil must be discarded because it can prove to be harmful for human consumption. The rate of formation of cooking oil decomposition products depends on the type of food being fried, the type of oil used and the design of the fryer ,etc. The reactions in oil rich frying depend on factors such as replenishment of fresh oil, frying conditions, original quality of frying oil, food materials, type of fryer, antioxidants, and oxygen concentration. Antioxidant decreases the frying oil oxidation, but the effectiveness of antioxidant decreases with high frying temperature.

IV. MATERIALSANDMETHODS

Olive oil, Coconut Oil, Sunflower Oil, Groundnut Oil, SoybeanOil, MustardOil and Palm Oil were purchased from the local Grocery Store. Potatoes were purchased from thehawkers in the local market.

V. PROCEDURE

One- fourthkg of potato were taken , sliced, air dried for4-5 hours and then fried in app. 3 litre of each of the above mentionedcooking oils separately, which were heated to 170-180^0 C. Frying was carried out in a stainless steel pan. After the frying was completed,once heated oil was obtained. This sample was then cooled overnight and again fresh potatoes were taken, sliced, air dried and then fried.The leftover oil was again cooled overnight. The same process was repeated for 4 times to get5 times reheated oil.Small amount of oil each time was taken for analysis (viscosity and peroxide determination). The sample quantity was proportionately adjusted with the amount of cooking oil left. No fresh oil was added in between the frying processes to make up for the loss due to uptake by the frying materials. A comparative study of the physiochemical changes of the different oils including viscosity change and peroxide value was studied. Viscosity is a fluid's resistance to flow. Fluids resist the motion of layers with differing velocities within them. Viscosity can be measured by using Redwood viscometer 1 and 2.Redwood viscometer 1 is used to findout the viscosity of light oil, whereas viscometer is used to measure the viscosity of heavy oils. In this analysis, Redwood viscometer no.1(Aditya make) is used. An oil of different frying was taken and their viscosities were measured at 30°C. Results are listed in Table1.

VI. THE PEROXIDE VALUE

Peroxide values of the heated oils were determined according to American Oil Chemists' Society (AOCS) Official Methods Cd 8–53 [8].In this 5 g of the oil samplewas taken into a 250 mL conical flask then 30 mL of acetic acid-chloroform (3:2)was added in it. The flask was swirled and then 0.5 mL of saturated potassium iodide was added. Then, the solution was mixed again for 1 minute and few drops of starch solution (10%) were added. The solution was titrated against previously standardized 0.01 N sodium thiosulphate solution ($Na_2S_2O_3$), until the blue colour disappeared. The peroxide value was expressed in miliequivalents of peroxide per kg of the sample calculated as:

$$\textbf{Peroxide value (meq/kg)} = \textbf{[(Va-Vb) N} \times \textbf{1000]/W}$$

Where;

Va = volume of sodium thiosulphate solution (mL)

Vb = volume of sodium thiosulphate solution (mL) used for the blank

N = normality of sodium thiosulphate

W = weight of the test portion (g)

VII. RESULTS AND DISCUSSION

Several chemical and physical processes took place ,when the oil was used for frying, namely: i) the fried food being absorbs oil as well as releases some of its own lipid content (sometimes colored) into the frying medium, ii) food particles were charred and due to lipid browning the oil darkens[9]. During frying the potentially hazardous non-volatile polar compounds which are formed as secondary oxidation products- like epoxides, polar dimmers, oxidized polymers, ketones and aldehydes ,and hydrolysis products of triglycerides such as free fatty acids, monoglycerides and diglycerides.[4].

The results are summarized in the table1given below:

Table 1 : Viscosities and peroxide values of different oils with different no. of frying

No. of fryings	Sunflower Oil		Coconut Oil		Groundnut Oil		Mustard Oil		Palm Oil		Soyabean Oil	
	Viscosity (redwood	Peroxide Value (meq.	Viscosity (redwood	Peroxide Value (meq.	Viscosity (redwood	Peroxide Value (meq.	Viscosity (redwood	Peroxide Value (meq.	Viscosity (redwood	Peroxide Value (meq.	Viscosity (redwood	Peroxide Value (meq.
1 frying	182	0.40	175	0.34	245	0.58	295	0.83	426	1.4	274	0.70
2 frying	232	1.05	236	2.10	333	1.21	359	2.12	545	2.45	321	1.15
3 frying	261	4.90	258	3.98	467	1.98	422	3.01	656	3.54	412	5.01
4 frying	371	7.56	352	5.01	584	3.06	556	5.12	732	4.78	424	7.65
5 frying	465	8.42	368	6.89	764	5.00	663	6.50	901	6.01	592	10.88

According to the compiled studies, in order to preserve bioactive components of the edible oils,heating time should be reduced to the minimum. It was shown in the present study that the peroxide values were increased with the increasing frequency of heating in all types of oil. Increased values indicate increased lipid peroxidation by-products content, mainly the peroxides that were formed in the oil during heating process[10]. The extent of oxidation in the oils was affected by the number of frying. Also the viscosity of the oil increased with the increasing number of fryings.

VIII. EFFECT ON HUMAN HEALTH

Frying makes the eatables tasty. Frying of edible items includes the usage of large amount of oil. Increased oil consumption is not considered to be good for human health[4]. Even though a certain amount of potentially toxic products are produced during frying (such as polar compounds or polymers), fried foods are generally considered safe [11,12,13]. It is only when frying oil is used repeatedly that it becomes toxic for human consumption [14]. Repeated heating of the oil accelerates oxidative degradation of lipids, forming hazardous reactive oxygen species and depleting the natural antioxidant contents of the cooking oil. Long-term ingestion of food prepared using reheated oil could severely compromise one's antioxidant defence network, leading to pathologies such as hypertension, diabetes and vascular inflammation[15,16,17]. Lipid oxidation causes a high risk for the development of coronary heart diseases. The human body is constantly subjected to a significant oxidative stress as a result of the misbalance between ant oxidative protective systems and the formation of strong oxidizing substances, including free radicals. This stress can damage DNA, proteins, lipids and carbohydrates and could cause negative effect to intracellular signal transmission.

IX. METHODS SUGGESTED TO REDUCE THE HARMFUL EFFECTS

The oil can be made safe for human consumption and the harm caused by the use of repeated heated oil can be minimised by a number of ways.Theuse of natural antioxidants [18]in cooking oil as adsorbents can make the oil safe by retarding the formation of oildeterioration products .Antioxidants adds Tocopherols,

butylatedhydroxyanisole (BHA), butylatedhydroxytoluene(BHT), propyl gallate(PG), and tert-butylhydroquinone (TBHQ) which slowdown the oxidation of oil at room temperature. However, they become less effective at frying temperature due to losses through volatilization or decomposition (Boskou 1988; Choe and Lee 1998).Addition of different antioxidantslike sugarcane bagasse, rosemary extract,turmeric extract,etc during frying have been found to reduce the harmful effect of the deterioration products . Also this rancidity of the oil can be reduced by taking blended oil or an oil mixture of different types with varying concentration of the different oils mixed.

Turmeric Extract As An Antioxidant: Addition of Curcumin, a natural antioxidant present in Turmeric olantof zingiberaceae family can reduce the harmful effects of oil deterioration products . There was a decrease in trans fatty acid content in the fried food with addition of turmeric extract at the concentrations of 0.03%. This was related to curcumin that inhibit the auto-oxidation rate by modifying the lipid radical into more stable form, that commonly inhibit the fat oxidationreaction[9]. The presence of antioxidant added into the repeatedly used cooking oil can decelerate the oil oxidation rate during frying and contribute to sensory acceptance of fried foods. The findings of this study are supported by the statement of [19] that the addition of antioxidant in cooking oil determine the stability of oxidation during frying; and according to Tuba and [20], curcumin is effective to be used as antioxidant because it can scavenge free radical by donating H atom from phenolic as its active group.

Apart from this many adsorbents such as sugarcane bagasse ash ,magnesol XL, etc. can also be used to reduce the formation of deterioration products produced by repeated frying.

X. CONCLUSION

Above studies clearly indicate that edible oil becomes highly viscous and presence of harmful products increases when oil is heated repeatedly. This oil now becomes dangerous for human consumption. Therefore oil should not be heated again and again and the formation of harmful products can be minimised by discarding it (for making soap at small scale) or using it with certain antioxidants .

XI. ACKNOWLEDGMENT

Authors are acknowledged to Ms. Renu Awasthi, Kapil Shivlani,Umaid Solanki, Vivek Chamoli, Kailash Parihar, Govind Singh for their kind support during the working of this project.

REFERENCES

[1] Rani AKS, Reddy SY, Chetana R (2010) Quality changes in trans and trans free fats/oils and products during frying. Eur. Food Res. Technol. 230(6): 803–811.

[2] Choe E, Min DB (2007) Chemistry of deep-fat frying oils. J. Food Sci. 72(5):R77-R86.

[3] Dana D, Saguy IS. Frying of nutritious foods: obstacles and feasibility.FoodSciTechnol Res 2001; 7: 265-279.

[4] Billek G. Lipid stability and deterioration In: Perkins EG, Visek WJ, eds. Dietary Fats and Health, AOCS Monograph 10, 1983: 70-89.

[5] Henry CJK, Chapman C, eds. The nutrition handbook for foodprocessors. United Kingdom: Woodland Publishing Limited, 2002.

]6] Sikorski ZE, Kolakowska A, eds. Chemical and Functional Propertiesof Food Lipids. United Kingdom: CRC Press, 2002.

[7] Choe, E. & Min, D. B (2006) Chemistry and reactions of reactive oxygen species in foods.Crit. Rev. Food Sci. Nutr. 46(1): 1-22.

[8] AOCS. Official methods and recommended practices of the American Oil Chemists' Society. 4th ed. Champaign: AOCS Press; 2003.

[9] Nor, F. M., Suhaila Mohamed, NorAiniIdris and Razali Ismail. 2009. Antioxidative Properties of Curcuma longa Leaf Extract in Accelerated Oxidation and Deep Frying Studies. Journal American Oil Society (86) 141-147.

[10] Miyagawa K, Hirai K, Takezoe R. 1991.Tocopherol and fluorescence levels in deepfryingoil and their measurement for oil assessment. J Am Oil ChemSoc 68:163–6.

[11] Artman NR. Adv Lipid Res. 1969; 7: 245–330.

[12] Chao PM, Hsu SC, Lin FJ, Li YJ, Huang C. Lipids 2004; 39: 233–238.

[13] Tony Ng KockWai,Local Repeatedly-Used Deep Frying Oils Are Generally Safe,IeJSME 2007: 1 (2): 55-60

[14] Soriguer F, Rojo-Martinez G, DobarganesMC, Garcia-Almeida JM, Esteva I, Beltran M, Ruiz De Adana MS, Tinahones F, Gomez-Zumaquero JM, Garcia-Fuentes E, Gonzalez-Romero S. Am J ClinNutr 2003; 78: 1092-1097.

[15] Y. Kamisah, A. Adam, Ngah. W. Z. Wan, M. T. Gapor, O. Azizah, A. Marzuki, 2005Chronic intake of red palm olein and palm olein produce beneficial effects on plasma lipid profile in rats. Pakistan J. Nutr. 428996

[16] Clemente TE, Cahoon EB2009Soybean oil: genetic approaches for modification of functionality and total content. Plant Physiol. 151310301040

[17] Edem DO2002Palm oil: biochemical, physiological, nutritional, hematological, and toxicological aspects: a review. Plant Foods Hum.Nutr. 57(3-4): 319-341.

[18] Jaswir, I., YaakobB.Che Man and David D. Kitts. 2000. Use of Natural Antioxidants in Refined Palm OleinDuring Repeated Deep-Fat Frying. Food Research International Journal (33): 501-508. Elsevier Science Ltd.

[19] Tuba Ak and IlhamiGulcin. 2008. Antioxidant and Radical Scavenging Properties of Curcumin. Chemico –Biological Interactions Journal (174) 27-37. Elsevier Ireland Ltd

[20] AndiAbriana, Eva Johannes, Turmeric Extract As An Antioxidant In Repeatedly Used Cooking Oil, INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 3, ISSUE 12, December 2014