Plant Archives Vol. 19, Supplement 2, 2019 pp. 810- 812 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

TYPE OF FRYING VESSEL VIZ. OXIDATIVE INDICES OF GROUNDNUT OIL USED FOR PREPARING FRENCH FRIES

Akanksha Jain[1,2], Santosh Jain Passi[3,4]*, William Selvamurthy[5,6] and Archna Singh[7]

[1]Amity Institute of Food Technology, Amity University, Sector 125, Noida – 201303, Uttar Pradesh, India
[2]Bhagini Nivedita College, University of Delhi, Delhi-110043
[3]Institute of Home Economics, University of Delhi, Hauz Khas, New Delhi – 110016, India
[4]Amity Institute of Public Health, Amity University, Sector 125, Noida – 201303, Uttar Pradesh, India
[5]Amity Science, Technology and Innovation Foundation, Amity University, Sector 125, Noida–201303, Noida, Uttar Pradesh, India
[6]Defence Research and Development Organisation, Ministry of Defence, Government of India
[7]Department of Biochemistry, All India Institute of Medical Science, Ansari Nagar, New Delhi – 110029, India
*Corresponding Author: E-mail: sjpassi@gmail.com

Abstract

Frying leads to oxidative degradation of the fat/oil. The study assessed the effect of oil-type, frying temperatures, frying-cycles and type of frying-vessel on oxidative parameters of groundnut oil used for frying potato strips. Compared to Teflon-coated non-stick frying-vessel, free-fatty acid and p-anisidine values were consistently higher in iron frying-vessel ($p<0.05$) while peroxide (PV) and TOTOX values depicted inconsistency. There is a dire need to follow appropriate frying practices and avoid reuse/reheating of oils; if reused, incorporating in dishes by absorption method (curry preparation etc). Reuse of oils for frying adversely affects oxidative stability. Therefore, used oils should be utilized as early as possible since their degradation rate is much higher than the fresh oil. India is yet to formulate quantitative limits/food-safety guidelines relating to oxidative indices of the oils which have been subjected to frying. It is envisaged that the comprehensive data generated in this study would be of great help in the preparation of Indian fried-food standards as well as in curbing oxidative markers of the oils used for frying.

***Keywords*: Frying, frying-vessel, frying temperature, oxidative stability**

Introduction

Deep-fat frying involves concomitant heat/mass transfer, where the food product is entirely immersed in frying fat/oil at high temperatures. During the frying process, both frying oil constituents including triacylglycerols and other minor components as well as the food constituents (being fried) like proteins, carbohydrates, lipids and water are intricately involved in the on-going complex reactions (Shahidi and Wanasundara, 2002). While some of the degradation products may be beneficial, others because of their adverse effects on the frying oil quality and/or the ultimate fried product are detrimental.

During deep-fat frying, since fat/oil is subjected to high temperatures (~160ºC-180ºC or more) for relatively longer periods; frying fat or oil undergo thermal/oxidative degradation. Due to economic factors, multiple use of the same fat/oil during continuous/intermittent repeat frying is a common practice; with increasing number of frying cycles, the deleterious health effects also increase. In commercial enterprises, it is frequently observed that frying is carried out in the same batch of oil for long periods, sometimes for several days; and even at household level, sometimes the same frying oil/fat is used for refrying for several days/weeks. Under these circumstances, numerous chemical changes like hydrolytic, oxidative and cracking reactions can occur resulting in the deterioration of fat quality.

In the Indian scenario, studies are rather scarce highlighting the effect of varying frying conditions, particularly type of frying vessel on primary and secondary oxidative parameters. The present study was, thus, carried out to assess the effect of type of oil, frying temperature, number of frying cycles and type of frying-vessel under standardized laboratory settings.

Materials and Methods

The study was aimed to precisely estimate the oxidative indices in groundnut oil subjected to frying under standardized laboratory conditions. In view of high thermal stability, groundnut oil was chosen for the study. Freshly-cut potato strips (100g) were fried in groundnut oil (750 mL) at 180ºC (common frying temperature in Indian culinary practices) in iron vs. Teflon-coated non-stick frying vessel/*karahi*; and the oil samples (30 mL) were drawn at 1st, 4th, 8th, 16th, 24th and 32nd frying cycles but there was no replenishment of oil till the last frying cycle. The oil samples drawn were cooled to room temperature and filtered (Whatman No. 4 for removing the suspended food particles) and stored in sterilised air-tight glass bottles at –20ºC till analysed. The samples were analysed for their oxidative parameters. Chemicals/reagents procured were of analytical grade and were obtained from Merck and Sigma. Primary/secondary oxidative parameters including free fatty acid value (AOCS Ca 5a-40 1989), peroxide value (Cd 8-53 1998), p-anisidine value (AOCS 1995) and TOTOX value of the samples were analysed independently in duplicates.

Statistical Analysis

For the above parameters, data have been reported as mean ± SD. ANOVA analyses and Tukey's Honestly Significant Difference Test was done using SPSS version 21.0 and Microsoft Excel. Graphs were prepared using Origin Pro9 64-bit software.

Results and Discussion

Transition metals including iron increase the oil oxidation rate due to lowered activation energy of the autoxidation process (Jadhav and others 1996). There is a possibility that these metals react with the lipids leading to production of lipid alkyl radicals and escalate the oxidation process. Our findings demonstrated a consistently higher free fatty acid and p-anisidine values in iron frying-vessel as compared to the Teflon coated non-stick container ($p<0.05$). However, peroxide levels depict an inconsistent behaviour; it increased up till the 8th frying cycle followed by a sudden decline till the 24th frying cycle and again it increased by the 32nd frying cycle (Figure 1).

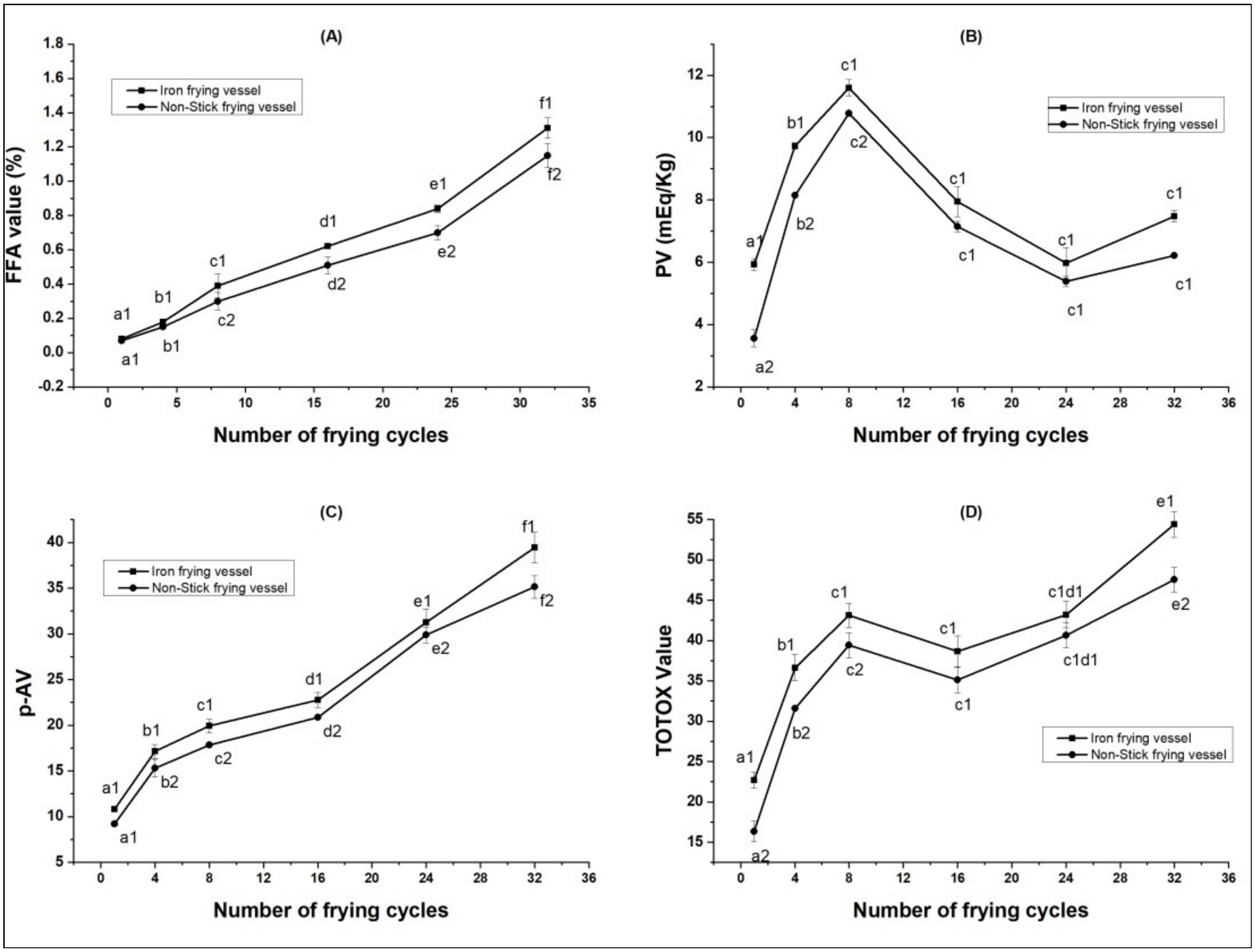

Fig. 1: FFA (free fatty acid value; A), PV (peroxide value; B), p-AV (p-anisidine value; C), TOTOX (total oxidation value; D) and type of frying-vessel

†The values are denoted as mean of two independent experiments and errors bars are indicating standard deviation. The values at varying frying cycles not sharing a common letter are significantly different ($p<0.05$).

Shahidi and Wanasundara (2002) have ascribed this erratic trend of PV due to thermal decomposition of hydrogen-peroxides to carbonyl/aldehydic components resulting in lowered PV which, however, increases with prolonged oxidation period owing to the formation of secondary oxidation products. FSSAI has proposed to avoid using iron vessels as these hasten oxidation, and thus, rancidity (FSSAI, 2017). A Chinese study (Liu *et al*., 1990) reported leaching of iron into the food cooked in iron vessel. Akhabue, Iworah and Aisien (2014) reported that with raised concentration of iron contaminants, hydroperoxide decomposition rate supersedes the hydrogen peroxide formation rate. As a result, in the presence of large amounts of metal contaminants, primary oxidative parameter – peroxide value goes down while the secondary oxidation products like aldehydes, carboxylic acids etc., are formed which adversely affect the oil stability. Transient metals like iron form complexes and catalyse the thermal oxidation processes through homolytic cleavage of hydroperoxides resulting in the formation of free-radicals (Lu *et al*., 2016) which perhaps cannot take place in the case of non-stick frying-vessels since these are coated with layers of Teflon/polytetrafluoroethylene on the base metal, usually aluminium. In another investigation when canola oil was continuously heated for 8 hours at 180ºC in the presence of varying concentrations of metal ions such as iron, copper, aluminium, there was a virtual increase in the production of acrolein, formaldehydes, acetaldehydes and propanal/heptenal; copper being the most efficient catalyst followed by iron and aluminium (Bastos and Pereira, 2010).

In Indian settings, in case the fried products are obtained from some standard food-outlets, the consumer can trust product quality to some extent since these standard food-joints are expected to abide the governmental food-laws/regulations and the quality of their product is under regular surveillance. However, in case of local *halwais,* particularly those selling their products to the urban slum dwellers (economically weaker sections of the society with poor awareness/literacy levels), food quality is rather poor owing to several factors like lower cost, poor/sub-standard quality raw-material, poor hygiene/sanitary conditions, lack of governmental surveillance/monitoring and absence of food labels etc. Further, for generating more profits, these local *halwais* often resort to unhealthy practices jeopardising the consumer's wellbeing; and in the case of fried foods, profound use of poor quality oils and excessive abuse of fat/oil worsen the situation.

Food Safety and Standards Authority of India (FSSAI) has also limited the Total Polar Compounds to not more than 25% after which the oil will be considered unfit for human consumption (FSSAI, 2017). As per the guidelines listed in Operationalization of Food Safety and Standards (Licensing and Registration of Food Business), Amendment Regulations (2018) for the catering/food service enterprises, following provisions have been made:

- Avoid reheating/reusing the edible oil.
- To prevent TFA formation, it should not be reheated/reused more than three times; ideally only once, if possible
- Avoid using leftover oil for frying, if possible
- Fat/oil quality should be periodically monitored for the texture suspended particles and rancidity

Necessary quantitative limits/standards and regulations coupled with effective monitoring of the fried street foods are yet to be laid for the fats/oils used in frying procedures.

Repeat frying at elevated temperatures leads to various thermo-oxidative reactions adversely affecting the physicochemical, nutritional and sensory attributes of the oil. The toxicity of the harmful by-products generated during these reactions is ascribed to the high reactivity with proteins, nucleic acids, DNA and RNA. These adverse health affecting reactions are reported to cause several chronic symptoms/ diseases/disorders including hypertension, heart disease, Alzheimer's and liver disorders. It is well evidenced that when the food product comprising starch like potato strips are fried above 180°C, acrylamide (a carcinogenic compound) is formed due to maillard reaction between amino-acids and reducing sugars. Thus, it is imperative to monitor the frying temperatures and the oil quality which in turn affect the wholesomeness of the ultimate fried products (Chauhan, 2017).

Thus, there is a dire need to follow correct frying practices including suitable frying temperature; right kind of frying-vessel (avoiding iron containers); minimising reuse/reheating of used oil, and if at all, using it in dishes by absorption method; and that too keeping for short periods at low temperatures after straining the oil. Oxidative stability is greatly affected by the frying conditions including frying temperatures, number of frying cycles, type of frying-vessel etc; and it is a matter of grave concern affecting safety of frying oils. Nutrition education – particularly addressing appropriate frying practices, needs to be imparted to the masses to avoid heating/frying at elevated temperatures for prolonged durations and unwarranted reuse of fats/oils. For heating/frying purposes, iron containers should be avoided as these accelerate the formation of primary/secondary oxidation products. Reuse/reheating of oils should be avoided and if used, the oil should be strained and utilized for dishes prepared by absorption method (for making curries, *pulav* etc). Used oil should be consumed at the earliest possible since its deterioration rate is much higher than the fresh oil. India is yet to formulate quantitative limits/food-safety guidelines relating to the oxidative indices of the oils that have been used for frying. It is envisaged that the inclusive data generated in this study would be of help in the preparation of Indian fried-food standards as well as in curtailing oxidative markers of such oils.

Acknowledgement

The authors gratefully appreciate support by Ms Himani Thakkar during the laboratory analysis of the study.

References

Akhabue, C.E.; Iworah, J.C. and Aisien, F.A. (2014). Effect of Selected Metal Contaminants on the Stability of Castor Oil Methyl Ester. *J. Fuels*, Article ID 641849, 6.

AOCS (1989). Firestone, D. (Ed). Official Methods and Recommended Practices of the American Oil Chemists' Society Ca 5a-40 (4^{th} ed.). American Oil Chemists' Society, Champaign, USA.

AOCS (1995). Official Methods and Recommended practices of the American Oil Chemists' Society (4^{th} ed.). AOCS, Champaign, USA.

AOCS (1998). Firestone, D. (Ed). American Oil Chemists' Society Official Method Cd 8-53. Peroxide Value," In Official Methods and Recommended Practices of the American Oil Chemists' Society (5^{th} ed.). AOCS, Champaign, USA.

Bastos, L.C.S. and P.A.D.P. Pereira (2010). Influence of Heating Time and Metal Ions on the Amount of Free Fatty Acids and Formation Rates of Selected Carbonyl Compounds during the Thermal Oxidation of Canola Oil. *J Agri Food Chem*, 58: 12777–12783.

Chauhan, R. (2017). Acrylamide in Crisps (Reducing Acrylamide in Crisps). J Cell Sci Apoptosis, 1(1), 104:1–5.

Food Safety and Standards Authority of India (FSSAI, 2017). Food Smart consumer – Your complete guide to food safety. Can we re-use cooking oil, once it is utilized for frying foods? Retrieved from http://foodsmart.fssai.gov.in/reusingoil.html.

Jadhav, SJ.; Nimbalkar, S.S.; Kulkami, A.D. and Madhavi, D.L. (1996). Lipid oxidation in biological and food systems. In Food antioxidants Madhavi, D. L., S.S. Deshpande and D.K. Salunkhe (eds), Marcel Dekker, Inc., New York, 5-64.

Liu, D.Y.; Chen, Z.G.; Lei, H.Q.; Lu, M.Q.; Li and L.X. Li. (1990). Investigation of the amount of dissolved iron in food cooked in Chinese iron pots and estimation of daily iron intake. Biomed. Environ. Sci, 3: 276–280.

Lu, B.; Hu, Y.; Huang, W.; Wang, M.; Jiang, Y. and Lou, T.. (2016). Effect of Transition Metal Ions on the B Ring Oxidation of Sterols and their Kinetics in Oil-in-Water Emulsions. Sci Rep, 6, 27240.

Operationalization of Food Safety and Standards (Licensing and Registration of Food Business) Amendment Regulations, 2018 Retrieved from https://www.fssai.gov.in/.../Direction_FSS_Licensing_ Registration_16_02_2018.pdf

Shahidi, F. and Wanasundara, U.N. (2002). Methods for measuring oxidative rancidity in fats and oils. In Akoh, C.C. and D.B. Min (eds). Food lipids: Chemistry, nutrition and biotechnology 2^{nd} ed. Marcel Dekker, Inc., New York, 465-482.