

Investigation of Cooking Oil Quality at Fast Food Restaurants in Mashhad City

Seyed Ali Sajjadi, Asiyeh Moteallemi¹, Zohre Rahnama Bargard², Monavvar Afzal Aghae Naeen³, Fatemeh Kariminezhad⁴, Mahnaz Kharghani⁵

Department of Environmental Health Engineering, Social Determinants of Health Research Centre, School of Health, Gonabad University of Medical Sciences, Gonabad, Iran, ¹Department of Environmental Health Engineering, School of Health, Torbat Jam Faculty of Medical Sciences, Torbat Jam, Iran, ²Department of Environmental Health Engineering, Student Research Committee, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran, ³Department of Social Medicine, Social Determinants of Health Research Centre, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran, ⁴Department of Environmental Health Engineering, Faculty of Health, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran, ⁵Department of Environmental Health Engineering, Student Research Committee, School of Health, Gonabad University of Medical Sciences, Gonabad, Iran

Abstract

Aims: Deep frying of foods at high temperatures results in an increase in the unique sensorial properties of fried food including fried flavor, golden brown color, and crispy texture, which ultimately leads to changes in the physical and chemical properties of the oil. This study was conducted to evaluate the quality of oils used in 60 centers of fast food distribution in Mashhad city. **Materials and Methods:** A validated questionnaire based on the instruction from the Ministry of Health and Medical Sciences was used to collect the data and to investigate the health status of the places and foods. Total polar material (TPM), temperature, and acidity of the oil were measured using oil test portable device (DOM-24 model) while the peroxide value (PV) was measured by iodometry method. The data were analyzed by SPSS software V.16 via statistical tests including *t*-test, ANOVA, and Chi-squared tests. **Results:** The mean values of TPM, acidity and PV in the studied oils were 31.8 ± 7.2 %, 3.7 ± 0.8 , 4.7 ± 6.7 meq/kg, respectively. There was a significant relationship between TPM value with acidity, temperature and duration of oil use based on Pearson correlation test ($P > 0.005$). Furthermore, there was a significant relationship between the PV and area, the type of oil, and sanitation of instruments. **Conclusion:** The levels of hydrogen peroxide, polarity, and acidity of oils in fast food shops were higher than the guideline values. We recommend that health inspectors systematically monitor the oils fried in these centers.

Keywords: Fast foods, food handling, oxidants, toxicity

INTRODUCTION

Nutrition is one of the most important factors that affect the people's health. The pattern of food consumption has also an important role in causing or preventing diseases.^[1] Oils are the main components of a diet whose proper use can be helpful in preventing certain diseases. Edible oil is a source of energy and essential fatty acids (FAs) and a carrier of fat-soluble vitamins.^[2,3] Fried foods are very popular for consumers because of the speed of their preparation and the fascination in color, flavor, texture, and taste.^[4] One of the most popular and sophisticated food preparation methods is the deep-frying process, which is usually practiced by fast food centers.^[5,6] The quality of fried food depends on the quality of the oil or fats.^[7] During the frying process, oil or fat is often used several times. In this way, humidity and air are mixed with hot oil

and cause chemical reactions in the oil used for frying. As a result, these fats and oils are affected by the autoxidation, thermo-oxidation, pyrolysis, and thermal polymerization as well as oxidative decomposition, which alter and degrade the composition of the oil. All these lead to production of by-products such as dimeric and polymeric materials which can be harmful to health.^[8]

Address for correspondence: Ms. Mahnaz Kharghani, Department of Environmental Health Engineering, Student Research Committee, School of Health, Gonabad University of Medical Sciences, Gonabad, Iran.
E-mail: m.kharghani.21@gmail.com

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The type, formation, and amount of these harmful products are different based on the parameters of the frying process.^[9-11] The most important parameters in the frying process include the nature of frying oil, temperature, frying time, the frying pan, and the moisture of food. Among these parameters, the nature of frying oil acts as a heat transfer medium and affects the quality of fried foods.^[12,13] This quality is also influenced by the properties of the oil.^[9,10]

In the long-term use of oils, their oxidation occurs with more production of hydroxides and volatile compounds such as aldehydes, ketones, carboxylic acids, and other undesirable chemicals.^[12,14] The consumption of fried foods with repeatedly used oils is unhealthy and increases the chance of cardiovascular disease.^[14] Oil oxidative degradation results in undesirable flavor and partial or whole destruction of vitamins and other nutrients at different stages of oxidation. Oxidized fat reacts with proteins and carbohydrates, causing important chemical changes in food.^[15] Hydrogen peroxide is a polar covalent compound. Studies have shown that peroxides can cause various diseases, including atherosclerosis, cancer, premature aging, allergic inflammation, cardiac and cerebral ischemia, and various liver disorders.^[8,10]

In some countries of the world, to ensure the quality of oil, some provisions have been made for degraded compounds of the oil that are unsuitable for human consumption.^[16] Peroxide value (PV) is one of the most common parameters to determine the oil quality in production, storage, and marketing processes specifically determining the oxidation degree of oil.^[17] This index is one of the quality control methods of edible oils, which measures the concentration of unstable hydroxides that easily decompose to secondary oxidation products.^[18] The standard of polar compounds and free FA (FFA) in Iran is 25% and 1%, respectively.^[19] Accordingly, different studies have been conducted to determine the quality of fried oil in Iran and other countries of the world. For example, the results of a study conducted in Gorgan, Iran showed that the oil PVs were higher than the standard levels in 44% of confectioneries, 60% of restaurants and kitchens, and 82% of fast food stores. In a study conducted in Toronto on the health of the oils used in restaurants, it was observed that the PV was higher than the allowable level in all used oils.^[16] In a study conducted in Toronto on the health of the oils used in restaurants, it was observed that the PV was higher than the allowable level in all used oils.^[14]

Mashhad is located in Razavi Khorasan province, Iran. Because of the existence of the shrine of Imam Reza, Mashhad annually welcomes over 32 million pilgrims. Thus, due to the importance of edible oils as well as its effects and risks to the human health, this study was performed to determine the quality of edible cooking oil at fast foods of Mashhad city in 2017.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted on 60 fast food stands in Mashhad, Iran in 2017. The sample size was calculated using the following formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where n is sample size, Z is confidence interval and p is standard deviation

In this study, the quality of oil consumed was studied based on PV, acidity, and the total amount of polar compounds (TPCs). A validated checklist based on an instruction from the Ministry of Health and Medical Sciences was used for data collection.^[20] The most important questions of the checklist were as follows: demographic characteristics of individuals (sex, age, education, work experience, card and health certificate), type of food, hygiene status of fast food center and oil specifications including type of oil, duration of oil used, oil temperature.

The number and frequency preparation of studied fast food centers are presented in Table 1.

Oil sampling was carried out according to Iranian national standard (No. 493).^[19] A total of 60 oil samples were collected from the fast food stores at peak times (18–23 pm) given the greater activity of these centers at these times, from Wednesday to Friday. The samples were collected by clean and unbreakable glass containers. Sampling containers did not chemically affect the oils. The samples were then transferred to the approved laboratory of the province's health center as quickly as possible and under the temperatures of 5°C–15°C. The PV of samples was measured by iodometry method and based on standard of Iran No. 4179. Finally, the results were reported in meq of peroxide/1000 g.^[21]

To measure total polar material (TPM), temperature, and FFA, the DOM-24 portable test device, manufactured by Japan ATAGO Corporation, was used based on the device guidelines. Data were analyzed by SPSS (version 16, IBM, IL, USA) and ANOVA, t -test, and Chi-squared tests.

RESULTS

This study was conducted on 60 fast food shops in Mashhad. The frequency of preparation and distribution of fast foods has been presented in Table 1. Among the studied fast food managers, 59 of them were male and 1 was female. The maximum age range of the individuals was 26–40 years. The level of education of most people studied was diploma. Further, 60% of the providers had a work experience under 5 years. Notably, 25% of the providers of fast foods did not have any health cards and 46.7% lacked health certificates; this health problem threatens the people's health in the community.

In addition, the environmental health status of 13.3% of the studied shops was unsuitable. Specifically, 16 cases (26.7%) of the studied shops had self-control certificate and 7 cases (11.7%) had health counseling. On the other hand, 37 cases (61.7%) of the studied centers did not have any health counseling, which can be the reason for the inappropriate health status of some centers. Furthermore, the

preparation area of shops in 40% cases was <25 m² [Table 2]. In this study, 90% of the fast food distribution centers used a special frying oil, 5% used solid oil, and 5% cooked through liquid oil for frying.

The TPM value in terms of the number and temperature of utilized oils is presented in Figures 1 and 2. The highest value of measured TPM was related to oils with seven times of use and within the temperature range of 180°C–160°C, while the lowest TPM was associated to oils with one time of use within the temperature range of 60°–40°C.

Figures 3 and 4 display the amounts of FFAs in terms of the number and temperature of oils used. The maximum level of FFA was related to temperature range of 160°–180°C of used oils while the minimum value was associated to temperature range of 40°C–60°C. The maximum magnitude of measured FFA was related to oils with seven times of use, while their lowest was related to oils with one time of use.

The PVs in terms of the number and temperature of oils used are presented in Figures 5 and 6. Table 2 reports the values of oil chemical parameters in fast food restaurants. According to Table 2, the values of TPM, acidity, peroxide, and oil temperature were 31.9 ± 7.2 %, 3.7 ± 0.8 , 4.7 ± 6.7 meq/kg, respectively.

DISCUSSION

Total polar material

TPM refers to the extent of oxidative thermal degradation

Table 1: The frequency of preparation and distribution of fast food centers

The type of food	n (%)
Sandwich	19 (31.7)
Potato	2 (3.3)
Samosa	1 (1.7)
Sandwich and pizza	11 (18.3)
Potato and mushroom	5 (8.3)
Pizza, sandwich, and potato	11 (18.3)
Potato and kentucky	1 (1.7)
Sandwich, pizza, and kentucky	5 (8.3)
Pizza and kentucky	1 (1.7)
Sandwich and Donuts	1 (1.7)
Sandwich, pizza, potato, and kentucky	2 (3.3)
Sandwich, pizza, and mushroom	1 (1.7)

Table 2: The scores of indicators in the checklist of regulation of 13 Act of Iran

Indicator	Mean±SD
Food health	92.2±6.52
Personal health	79.94±16.57
Instrument and equipment health	92.25±12.93
Build health	87.92±11.23

SD: Standard deviation

of frying oil and is one of the objective criteria for assessing the deterioration of cooking oil.^[22] During frying processes, peroxides and hydroxides are degraded to short chain acids and aldehydes, ketones, alcohol, and nonvolatile products which will cause polarization.^[23,24]

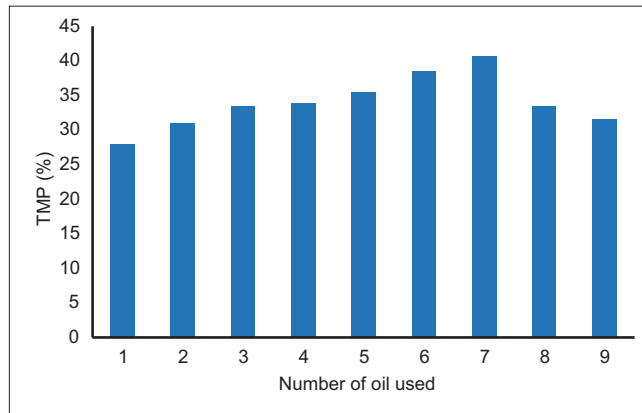


Figure 1: Determination of the total polar material value in terms of number of oil used

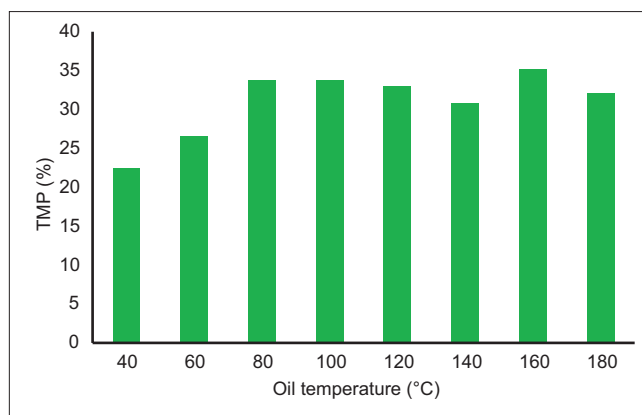


Figure 2: Determination of the total polar material value in terms of the oil temperature used

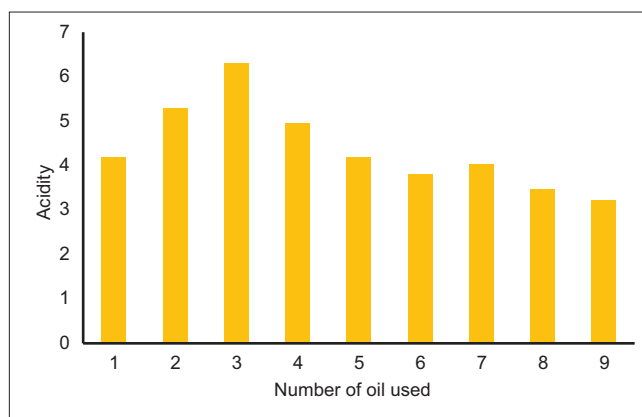


Figure 3: Determination of the free fatty acids used in terms of the number of oil used

Table 3: The mean of oil used indicators in studied fast food centers

Indicator	Mean	Minimum	Maximum	Standard values	unit
TPM	31.85±7.17	5	40.5	25	%
Acidity	3.73±1.82	0	9.8	1	-
Peroxide	4.67±4.68	0.38	31.35	5	meq/kg
Oil temperature	103.65±30.38	42	176	-	°C

TPM: Total polar material

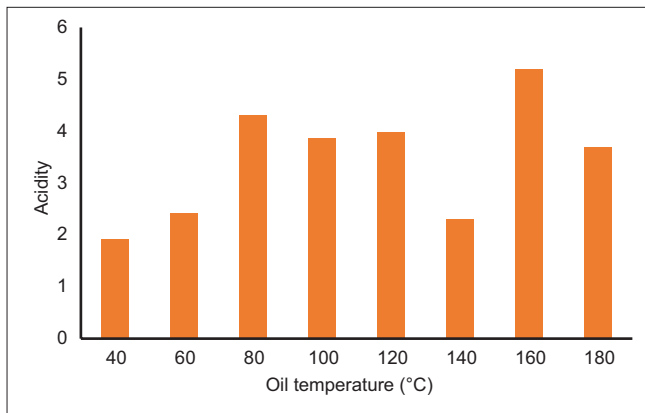


Figure 4: Determination of free fatty acid in terms of the temperature of used oils

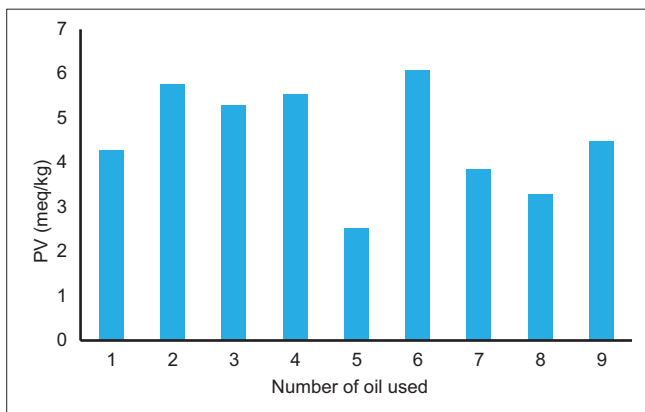


Figure 5: Determination of peroxide value in terms of oil used

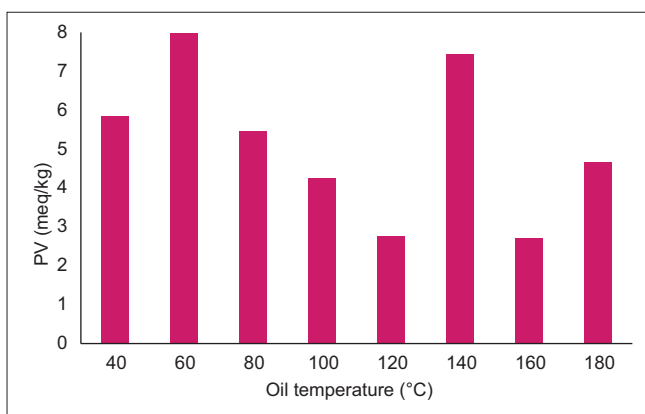


Figure 6: Determination of peroxide value in terms of the oil temperature used

TPM involves the polymer products and nonvolatile aromatic materials (resulting from the oxidation and hydrolysis of oil) and soluble compounds generated from the fried product.^[22] In Spain, Austria, Switzerland, France, and Belgium, TPM is used as a tool to determine the usage time of frying oil.^[24]

According to Table 3, the mean of TPM in this study was 31.85 ± 7.17 % in the studied centers which has been higher than the standard values. The highest value of measured TPM was related to oils with seven times of use and within the temperature range of 180°C–160°C, while the lowest TPM was associated to oils with one time of use within the temperature range of 60°C–40°C [Figures 1 and 2]. With elevation of temperature and frequency of oils used, the TPM increased. Nevertheless, the results indicated that the type of oil used did not affect the TPM value.

Park and Kim revealed that the extent of laboratory polarization increased during the frying process and was strongly correlated with frying time.^[3] The results of a study conducted by Hassanien and Sharoba showed that the polarity in 7% of the samples was higher than the standard values. In this study, the magnitudes of laboratory polarity in 17% of rapeseed oil and 2.2% of sunflower oil were higher than the acceptable limit.^[25] Sebastian *et al.* investigated the quality of oil used in fast food restaurants in Toronto, Canada. They found considerably high PVs (ranging from 3.3 to 48.1 meq/kg compared to 23.9–31.85 meq/kg in the current study).^[18] Most studies on the effect of oil frying on chemical characteristics of oils have been conducted in laboratory settings. They found that the magnitudes of PV and TPCs increased following heating oil at high temperatures.^[26] Nevertheless, it seems that under real conditions, i.e., in fast food restaurants, the extent of changes in chemical parameters is far more considerable (sometimes 10–20 times) than in laboratory conditions. Latha and Nasirullah reported that by 8 h heating of oil at 180°C, the PVs and TPM increased to 2.9 meq/kg and 1.8%, respectively.^[26] On the other hand, in the current study, the corresponding values increased on average to 31.85 meq/kg and $4.67\% \pm 4.68\%$.

Fatty acid

According to Table 3, the mean of FFA in oils used was 3.73 ± 1.82 [Table 3]. The maximum level of FFA was related to temperature range of 160°C–180°C of used oils while the minimum value was associated to temperature range of 40°C–60°C. The maximum magnitude of measured FFA was related to oils with 7 times of use, while their lowest was related to oils with one time of use [Figures 3 and 4].

Pearson correlation test revealed a significant relationship between TPM value and acidity, temperature, and duration of oil use ($P < 0.05$). In the oils with a longer duration of use and higher temperatures, the polarity and acidity increased and the oil was deteriorated gradually. Vinci *et al.* showed that only 44% of oils used for frying chicken nugget was in standard range, and in 36% of the cases, the oil was used up to complete corruption.^[27] This is similar to the current study. The results of the study conducted by Mishra and Sharma suggested that the level of unsaturated FA decreased gradually during repeated deep fat frying cycles in both oils.^[28]

Peroxide number

PV is the most common parameter used to evaluate the oxidative status of oils. According to Table 3, the amount of peroxide in the oil samples was 0.38–31.35 meq/kg. The highest measured PV was related to oils with 6 times of usage within the temperature range of 60°C–80°C. In contrast, the lowest magnitude was obtained in oils with five times of use within the temperature range of 160°C–180°C [Figures 5 and 6].

These PVs indicate that the oils used in these centers are highly oxidized. Note that the initial oxidation products quickly decompose into secondary oxidation products, which in turn reveal their accumulation in total oil less than the actual value. The standard PV in Iran is 2 mg/kg for solid oil and 5 mg/kg for liquid oil; the amount of peroxide in studied samples exceeded the standard value and is hazardous to human health.

There was a significant relationship between the level of peroxide and the type of oil consumed as well as the amount of peroxide and sanitation of equipment ($P < 0.05$). This indicates that regular and daily washing of the tool of work and place of production has a significant effect on reducing the PV.

In the study conducted by Sebastian *et al.* in Canada, the range of PV was within 3.3–48.1 meq/kg.^[18] In a study conducted in Shahrekord, the amount of peroxide in the samples was higher than the standard limit, which is consistent with the present study.^[25]

High levels of peroxide can be due to repeated use of oils, inappropriate sanitary conditions of the places and equipment, and the lack of personal hygiene. Meanwhile, oven is not cleaned daily, and the oil is burnt whereby the amount of peroxide grows constantly.^[3]

The results of several studies have suggested that the PV decreases during the frying time.^[13,15,23] The storage of oil leads to an increase in PV. On the other hand, the use of oil for frying does not lead to a significant increase in PV since the peroxides spontaneously decompose at temperatures over 150°C.^[29] Chen *et al.* revealed that the highest PV value was found at temperature of 150°C, beyond which this value decreased significantly at 200°C and then slightly increased at 250°C.^[30]

The results of Birjandi *et al.* suggested that the lowest and highest PV were 1.1 and 2.9 meq/kg, respectively. The minimum and maximum acidity of the samples were 0.7 and

2.9 wt%, respectively. They results revealed that the PVs in Persian doughnuts in Lorestan province were higher than the standard limit. Furthermore, by increasing the heating time and the frequency of oil use, the chemical reactions and the PV increased.^[29]

The smoke produced during the cooking, oil opacity, the lack of changes in the oil, the unpleasant smell, and finally, the high PV of the oils consumed suggest the existence of harmful and toxic compounds in the foods provided in fast foods restaurants.

Ghobadi *et al.* surveyed acid and PVs and TPC of frying oils in fast food restaurants of Shiraz. They found that the acid and PVs of 27 samples (64.3%) were higher than the permissible value. This number for TPC was 19 (45.2%).^[31]

The study conducted by Sebastian *et al.* revealed that the PVs were as high as 10 meq/kg, and FFA level was higher than 1%, and suggested that 30%–35% of in-use frying oils and 45%–55% of discarded oils were higher than the acceptable values.^[18]

CONCLUSION

In the current study, it was observed that the mean of TPM, FFA, and hydrogen PVs in the oils used in the studied fast foods were 31.85 ± 7.17 , 3.73 ± 0.82 , and 4.67 ± 6.68 , respectively. The results showed that by increasing the oil temperature and the frequency of the oils use, the extent of polarity and acidity increased, which can lead to deterioration of the oil consumed. Furthermore, by raising the oil temperature, the initial oxidation products decompose to secondary oxidation products quickly; as a result, the measured PV obtained was less than its actual value. Thus, the PV is not a proper indicator for assessing the quality of the oil. The high temperature of the oil for frying produces various toxic materials which affect the quality of the food and seriously threatens the consumers' health.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. World Health Organization. Chronic disease, WHO org/chronic disease. Geneva, Switzerland: World Health Organization; 2008.
2. Andrikopoulos NK, Boskou G, Dedoussis GV, Chiou A, Tzamtzis VA, Papathanasiou A. Quality assessment of frying oils and fats from 63 restaurants in Athens, Greece. *Food Serv Technol* 2003;3:49-59.
3. Park JM, Kim JM. Monitoring of used frying oils and frying times for frying chicken nuggets using peroxide value and acid value. *Korean J Food Sci Anim Resour* 2016;36:612-6.
4. Ghidurus M, Turtoi M, Boskou G, Niculita P, Stan V. Nutritional

- and health aspects related to frying (I). *Rom Biotechnol Lett* 2010;15:5675-82.
5. Matthäus B. Utilization of high-oleic rapeseed oil for deep-fat frying of French fries compared to other commonly used edible oils. *Eur J Lipid Sci Technol* 2006;108:200-11.
 6. Pérez-Palacios T, Petisca C, Casal S, Ferreira IM. Changes in chemical composition of frozen coated fish products during deep-frying. *Int J Food Sci Nutr* 2014;65:212-8.
 7. Pristouri G, Badeka A, Kontominas M. Effect of packaging material headspace, oxygen and light transmission, temperature and storage time on quality characteristics of extra virgin olive oil. *Food Control* 2010;21:412-8.
 8. Gertz C. Optimising the baking and frying process using oil-improving agents. *Eur J Lipid Sci Technol* 2004;106:736-45.
 9. Arslan FN, Şaççı AN, Duru F, Kara H. A study on monitoring of frying performance and oxidative stability of cottonseed and palm oil blends in comparison with original oils. *Int J Food Prop* 2017;20:704-17.
 10. Melo A, Viegas O, Petisca C, Pinho O, Ferreira IM. Effect of beer/red wine marinades on the formation of heterocyclic aromatic amines in pan-fried beef. *J Agric Food Chem* 2008;56:10625-32.
 11. Gupta P, Shivhare U, Bawa A. Studies on frying kinetics and quality of French fries. *Drying Technol* 2000;18:311-21.
 12. Choe E, Min DB. Chemistry of deep-fat frying oils. *J Food Sci* 2007;72:R77-86.
 13. Yang M, Yang Y, Nie S, Xie M, Chen F, Luo PG, *et al.* Formation of trans fatty acids during the frying of chicken fillet in corn oil. *Int J Food Sci Nutr* 2014;65:306-10.
 14. Stender S, Dyerberg J, Astrup A. Fast food: Unfriendly and unhealthy. *Int J Obes (Lond)* 2007;31:887-90.
 15. Kaleem A, Aziz S, Iqtedar M, Abdullah R, Aftab M, Rashid F, *et al.* Investigating changes and effect of peroxide values in cooking oils subject to light and heat. *FUFAST J Biol* 2015;5:191.
 16. Song J, Kim MJ, Kim YJ, Lee J. Monitoring changes in acid value, total polar material, and antioxidant capacity of oils used for frying chicken. *Food Chem* 2017;220:306-12.
 17. Pizarro C, Esteban-Diez I, Rodríguez-Tecedor S, González-Sáiz J. Determination of the peroxide value in extra virgin olive oils through the application of the stepwise orthogonalisation of predictors to mid-infrared spectra. *Food Control* 2013;34:158-67.
 18. Sebastian A, Ghazani SM, Marangoni AG. Quality and safety of frying oils used in restaurants. *Food Res Int* 2014;64:420-3.
 19. Iranian National Standards Organization. Edible Fats & Oils 4152. 2nd Revision. Iranian National Standards Organization; 2016.
 20. Markazsalamat Iran. Available from: <http://markazsalamat.behdasht.gov.ir/>. [Last accessed on 2019 Feb 08].
 21. Institute of Standards and Industrial Research of Iran. Sampling method for oil and fat testing. Institute of standards and Industrial Research of Iran publications. 4th Edition; 2007.
 22. Xu XQ, Tran VH, Palmer M, White K, Salisbury P. Chemical and physical analyses and sensory evaluation of six deep-frying oils. *J Am Oil Chem Soc* 1999;76:1091-9.
 23. Sharav O, Shim YY, Okinyo-Owiti DP, Sammynaiken R, Reaney MJ. Effect of cyclinopeptides on the oxidative stability of flaxseed oil. *J Agric Food Chem* 2014;62:88-96.
 24. Clark WL, Serbia G. Safety aspects of frying fats and oils. *Food Technol* 1991;45:84-9.
 25. Hassanien M, Sharoba A. Rheological characteristics of vegetable oils as affected by deep frying of French fries. *J Food Meas Charact* 2014;8:171-9.
 26. Latha RB, Nasirullah DR. Physico-chemical changes in rice bran oil during heating at frying temperature. *J Food Sci Technol* 2014;51:335-40.
 27. Vinci RM, Mestdagh F, De Meulenaer B. Acrylamide formation in fried potato products present and future, a critical review on mitigation strategies. *Food Chem* 2012;133:1138-54.
 28. Mishra R, Sharma HK. Effect of frying conditions on the physico-chemical properties of rice bran oil and its blended oil. *J Food Sci Technol* 2014;51:1076-84.
 29. Birjandi M, Sepahvand R, Hassanzadazar H, Hatamikia M, Kazemi-Vardanjani A. A survey on peroxide content and acidity level of Persian doughnuts in Lorestan Province, West of Iran. *J Glob Pharm Technol* 2016;10:32-5.
 30. Chen Y, Yang Y, Nie S, Yang X, Wang Y, Yang M, *et al.* The analysis of trans fatty acid profiles in deep frying palm oil and chicken fillets with an improved gas chromatography method. *Food Control* 2014;44:191-7.
 31. Ghobadi S, Akhlaghi M, Shams S, Mazloomi SM. Acid and peroxide values and total polar compounds of frying oils in fast food restaurants of shiraz, Southern Iran. *Int J Nutr Sci* 2018;3:25-30.