Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition
Nutrition & Food Security Research Center

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2020; 5(3): 201-208 Website: jnfs.ssu.ac.ir

Quality Assessments of the Fried Oils in Fast Food Restaurants of Yazd, Iran

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ARTICLE INFO

ORIGINAL ARTICLE

Article history:
Received: 2 Feb 2019
Revised: 21 Jun 2020
Accepted: 18 May 2020

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ABSTRACT

Background: Oils and fats are among the important constituents of foods. Lipid oxidation can cause changes in taste, flavor, smell, color, texture, and nutritional value of the foods. Deep-fat frying (temperatures of 150 to 200 °C) leads to a series of chemical and physical reactions, so that the oil is oxidized, polymerized, and hydrolyzed. **Methods:** In a current descriptive cross-sectional study, 100 oil samples were obtained from fast food shops in Yazd city during the spring and summer of 2018. A checklist was prepared including the oil type (oil or fat), odor, color, smoke, and duration of use. The peroxide value (PV), p-anisidine value (p-AV), free fatty acid (FFA) levels, and total polar compound (TPC) of the samples were examined. **Results:** We found that 93% of the oil samples were in form of liquid. In term of color, 45% of the samples had a dark color and about 57% had an undesirable odor during cooking. In 23% of the fast food shops in Yazd, oil is used more than two days. The measurement of peroxide value showed that 73 samples had peroxide values higher than the allowable limits. The allowable average peroxide value was estimated as 2.33 meq/kg. Results showed that 56 samples had allowable FFA level (less than one), while the others were classified as oxidized oils. The p-AV in 55% of the oil samples were higher than 4. According to the results, 46% of the frying oil samples had TPC of higher than 25%, which showed that they should be discarded. **Conclusion:** The results showed that majority of the fast food shops in Yazd used highly oxidized oils to prepare their food. The absorption of such oils by food can endanger the public health. Therefore, continuous monitoring of fast foods and restaurants as well as training the staff seem necessary.

Keywords: Oil; *Peroxide value; Free fatty acid; P-anisidine value; Total polar compound; Yazd*

Introduction

Due to the recent changes in eating habits and lifestyle of people, consumption of ready-to-eat foods have increased (Nafez *et al.*, 2018). Food is one of the major sources of chemical and

This paper should be cited as: Khalili N, Akrami Mohajeri F, Ramroudi F, Mojaver F, Hakimi F, Sardari M. ***Quality Assessments of the Fried Oils in Fast Food Restaurants of Yazd, Iran.*** *Journal of Nutrition and Food Security (JNFS),* 2020; 5 (3): 201-208.

[DOR: 20.1001.1.24767417.2020.5.3.3.2]
[DOI: 10.18502/jnfs.v5i3.3792]

biological contamination. In this regard, oils and fats are among the three major groups of food ingredients along with proteins and carbohydrates (Takeoka *et al.*, 1997). Fats and oils can be oxidized during the processing and storage (Farrokhzadeh *et al.*, 2017). This reaction can lead to changes in the taste, smell, color, texture and, appearance of the oil and reduce its nutritional value (Gotoh and Wada, 2006). Over the last six decades, deep-fat frying has been one of the usual ways of food preparation. Deep-fat frying is a process of cooking, in which the food is immersed in the edible oil at a temperature of 150 to 200 °C. In this method, the thickness of the oil is from 20 to 200 mm and the oil is used repeatedly (Karakaya and Şimşek, 2011). In the frying process, a series of chemical and physical reactions occur and the oil undergoes thermal oxidation, polymerization, and hydrolysis. During these reactions, formation of hydroperoxides and high molecular weight products, such as polar compounds and triacylglycerides increase (Karakaya and Şimşek, 2011). Formation of these polar compounds is related to the primary and secondary oxidation that occurs during frying. Some of these compounds are harmful to human health and contribute to tissue damage, inflammatory diseases, arthrosclerosis, and aging process (Karakaya and Şimşek, 2011). Hydrolytic decomposition occurs after breakage of the triglyceride molecules and leads to the formation of free fatty acids (FFA). The FFA can affect the odor, taste, and other properties of the oil (O'brien, 2008).

One way to identify the oil quality and early stages of oxidation is evaluating the peroxide and FFA levels. The peroxide value measures the total amount of peroxide in oil, as meq of oxygen per kilogram of oil. The FFA level is defined as the number of mg of potassium hydroxide needed to neutralize FFAs in one gram of oil sample. The FFA level is an index for measuring the amount of FFA. Free fatty acids alone are not poisonous but can affect the quality of food (O'brien, 2008). In general, both values are necessary to control the food safety and quality of oils (Gotoh and Wada, 2006). Hydroperoxides, primary products of lipid oxidation, are gradually converted to secondary ones, such as aldehydes, alcohols, carboxylic acids, epoxides, and hydrocarbons (Ruíz and Lendl, 2001). The peroxide value shows the initial stages of oxidation. The peroxide value is measured by weighing the samples, dissolving in chloroform, acidifying by acetic acid, adding potassium iodide and sample incubation, and then titrating with sodium thiosulfate (Ruíz and Lendl, 2001). The amounts of FFAs produced during the lipid oxidation can be evaluated by titration using potassium hydroxide or sodium with phenolphthalein reagent, which is referred to as FFA level (Decker *et al.*, 2010). Frying oils with a FFA level of 1 to 4% are unacceptable. The anisidine value is used for measuring the high molecular weight of saturated and unsaturated compounds in triacylglycerols (Moigradean *et al.*, 2012). Considering the hydrolytic reactions during frying, p-anisidine value (p-AV) could be used as an indicator of oil quality assessment (Farhoosh *et al.*, 2009). Determination of the oxidative breakdown products in frying oils can be measured by total polar compound (TPC) analysis (Sebastian *et al.*, 2014). Productions of the polar compounds have negative effects on frying oil quality, flavor, and nutritional value of fried food (Li *et al.*, 2016). It should be noted that the chemical composition of the frying oil and its physical and chemical properties are important in stability of the oil against oxidation. Therefore, selection of a suitable type of oil for frying is an important problem (Karakaya and Şimşek, 2011). Thermo oxidation reaction due to high temperatures causes extensive chemical and physical changes in oil (Nassehinia and Ahrari, 2016).

Owing to the importance of oil safety and its absorbance by fried foods, the current study attempted to investigate the quality of oils used in fast food shops of Yazd city in 2018.

Materials and Methods

Sampling: In the current descriptive cross-sectional study, 100 oil samples were obtained from fast food shops in Yazd city during spring and summer of 2018. A checklist containing the oil type (oil or fat), odor, color, smoke, and duration of use was prepared and completed at the time of sampling. Samples were collected according to the recommendations provided by Institute of Standards and Industrial Research of Iran (No. 493) (Institute of Standards and Industrial Research of Iran, 2004, Takeoka *et al.*, 1997). Sampling was performed at peak hours (9 to 12 p.m). The collected samples were kept at 5-15 °C until the test was performed.

Peroxide value (PV): Peroxide value was determined based on the standard method (No. 4179) presented by Institute of Standards and Industrial Research of Iran. According to this standard, the permissible PV in fat and oil is 5 and 2 meq/kg, respectively (Institute of Standards and Industrial Research of Iran, 2004). For this purpose, 5 g of oil samples was weighed and 30 ml of acetic acid-chloroform solution (3 to 2) was added. Later, 0.5 ml of the saturated potassium iodide solution was added and placed one minute in the dark. Next, 30 ml of distilled water was added and titrated by sodium thiosulfate (0.1 N) in the presence of starch reagent. The PV (meq/kg) was evaluated according to the equation:

$PV = (V-V_b) \times N \times 1000/W$

Where, V and V_b are the volume of used sodium thiosulfate by sample and blank (ml), N is concentration of sodium thiosulfate, and W is the oil weight (g) (Rahimzadeh Barzoki *et al.*, 2013).

Free fatty acid: In order to determine the FFA, 30 ml of the neutral ethanol was added to 5 g of oil and titrated with potassium hydroxide in the presence of phenolphthalein reagent until the pink color appeared and stable. The FFA was evaluated as below:

$FFA = 5.611 \times N \times V/W$

Which, N is potassium hydroxide concentration, V is potassium hydroxide volume used for titration (ml), and W is the oil weight (g) (Hassanzadazar *et al.*, 2018, Sebastian *et al.*, 2014).

P-anisidine value: p-anisidine value was evaluated using AOCS Official Method Cd 18-90 method. The oil samples (W: 0.5 g) were diluted with isooctane (25 ml) and absorbance was measured at 350 nm by UV-Visible spectrophotometer (A_b). Later, 5 ml of diluted sample was mixed with 1 ml Anisidine solution (0.25% p-anisidine in acetic acid) and the absorbance was read at 350 nm against isooctane and anisidine solution as blank (A_s) (American Oil Chemists' Society, 1998, Zhang *et al.*, 2010). The anisidine value was calculated according to the following equation:

$\text{Anisidine value} = 25 \times (1.2A_s-A_b)/W$

Total polar compound (TPC): The TPCs of oil samples were measured by Testo^{TM} 270 cooking oil tester, which showed the changes in dielectric constant of oil related to TPC concentration of oil samples (Song *et al.*, 2017).

Results

As shown in **Table 1**, about 93% of the samples were oils (in form of liquid). Approximately 45% of the samples had a dark color and about 57% of the samples had an undesirable odor during cooking. As a result, in 23% of the fast food shops, oil was used more than two days.

Table 2 shows the average amount of peroxide and FFA levels in the oils used in fast food shops in Yazd. Among all studied oil samples, peroxide values were higher than the permissible limit in 73 samples. The average permissible peroxide value was estimated as 2.33 meq/kg. In this study, the lowest and highest peroxide values in oil samples were calculated to be 0.56 and 286.49 meq/kg, respectively.

According to the results, most oil samples were oxidized and the production of hydroproxides small volatile molecules, such as aldehydes, ketones, carboxylic acid, and short-chain alkanes not only affected the quality of food, but also could endanger the consumers' health. The FFA level in 56% of oil samples was lower than the allowable limits (less than 1). In the present study, the lowest and the highest FFA levels in oil samples were estimated as 0.53 and 6.05, respectively.

The p-AV in 45% of the oil samples was lower than 4. The p-AV value was higher than the standard limit (higher than 6) in 34 samples with the mean concentration of 49.87.

We found that the mean TPM values of 54 oil samples were within the regulated limit and 46 samples exceeded the limit value of 25%.

Table 1. Oil characteristics in fast food restaurants in Yazd

Oil characteristics	%
Type of oil (liquid)	93
Presence of smoke during cooking	4
Dark color	45
Undesirable odor	57
Using the oil more than 2 days	23

Table 2. The quality assessments of oil sample collected from fast food restaurants in Yazd

Tests	Ranges	%	Mean ± SD
Peroxide value (meq/kg)	Equal or less than 5	27	2.33 ± 1.29
	5 to 20	47	10.77 ± 4.31
	21 to 50	22	28.65 ± 6.25
	Higher than 50	4	144.00 ± 92.84
Free fatty acid levels (%)	Equal or Less than 1	56	0.53 ± 0.22
	1 to 2	37	1.37 ± 0.25
	2 to 3	4	2.43 ± 0.33
	Higher than 3	3	4.39 ± 1.47
Anisidine value	Equal or Less than 4	45	2.78 ± 0.54
	4 to 6	21	5.16 ± 0.23
	Higher than 6	34	49.87 ± 10.34
Total polar compound	Equal or Less than 25	54	21.96 ± 1.76
	Higher than 25	46	30.54 ± 3.09

Discussion

In recent years, changes in lifestyle have led to an increase in the consumption of ready-to-eat foods. Deep-fat frying is one of the usual ways to prepare food, which results in the production of desirable or undesirable compounds in fried foods (Farrokhzadeh *et al.*, 2013). The peroxide value is one of the most common methods to measure oxidation in oil. The refined oil usually has a peroxide value of less than 1 meq/kg, so that it reaches up to 10 meq/kg in oxidized oils. According to the literature, vegetable oil with peroxide value of less than 2 meq/kg has good quality to use (Sebastian *et al.*, 2014). The evaluation of p-AV in oils is the accurate and reliable method for determining oil oxidation. The desirable p-AV for fresh oil is less than 4 and oils with p-AV of higher than 6 are considered oxidized (Sebastian *et al.*, 2014). The TPC was introduced as the reliable parameter for determination of the fried oil quality with recommended limit of 25%. Furthermore, application of the rapid assays instead of column chromatography can be suitable in polar components (Song *et al.*, 2017). In present study, the peroxide value, FFA, p-Anisidine value, and TPC of the oil samples were investigated.

The changes in oil (darken oil) during frying, as visible factors, can occur and can be considered as one of the parameters for determining the quality of frying oil (Sebastian *et al.*, 2014). In the present study, 45% of the oils had a dark color. However, it should be noted that the color of the oil is affected by various factors, such as the type of oil and the type of fried foodstuff. Food compounds can react with oils and its degradation products. So, they produce brown colored compounds, such as Maillard products. Since the oil color can be affected by different chemical processes, only considering the oil color to determine its quality is not correct. In fact, oil color should be considered

[DOR: 20.1001.1.24767417.2020.5.3.3.2]

[DOI: 10.18502/jnfs.v5i3.3792]

along with other diagnostic parameters (Takeoka *et al.*, 1997). On the other hand, about 57% of the oil samples were odorless.

In current study, among all the investigated oil samples, 73% had peroxide values of higher than the permissible limit. The peroxide values in non-consumable oils varied from 10.77 to 144 meq/kg, which indicated extensive oxidation in oil samples. The results of Jahed et al. showed that about 60% and 65% of the oil used in sandwich and falafel shops had peroxide values of higher than the allowable limit, respectively. The highest amount of peroxide values in sandwich and falafel samples was reported 29.79 and 31.22 meq/kg, respectively (Jahed Khaniki *et al.*, 2018), which is lower than results of the current study. Rahimzadeh et al. indicated that 58.3% of the restaurants and 97.3% of sandwich shops in Gorgan City had a higher peroxide value (Rahimzadeh Barzoki *et al.*, 2013). The results of Farrokhzadeh et al. on the residual and consumed oils in the products prepared in delicatessens and confectioneries of Shahinshahr and Meymeh County indicated a high percentage of peroxide value in 27.3% of the oil samples (Farrokhzadeh *et al.*, 2017). Nafez et al. reported that 59% of the fast food shops oils in Kermanshah City were consumable and 41% were unusable containing values higher than the standard limits. The highest and lowest amounts of the peroxide values were reported as 29 and 0 meq/kg, respectively (Nafez *et al.*, 2018), which is considered to have better quality rather than oil samples of the current research. Determination of the peroxides values in the oil used in restaurants and sandwich shops in Yasuj city showed that the peroxide value exceeded the standard limit in 58.3% and 97.3% of the samples, respectively (Pourmahmoudi *et al.*, 2008). Arbabi investigated the oils used in sandwich shops in Shahrekord and stated that in all samples, the peroxide value was higher than the standard limit (Arbabi and Deris, 2011). The same research in Ilam indicated that 61.03% of the oil samples had peroxide value higher than the standard limits (Amarlooei *et al.*, 2013). It was also found that prolonged use of oil (more than two days) resulted in an increase in peroxide values, which is consistent with the results of Amarlooei et al. (Amarlooei *et al.*, 2013).The presence of oxygen and water increases the process of decomposition of frying oil. The lowest and highest peroxide values in oil samples were 0.56 and 286.49 meq/kg, respectively. In Hassanzadazar et al. study on oil samples collected from fast food centers in Zanjan city, the lowest and highest peroxide values were 1.2 and 298.2 meq/kg, respectively (Hassanzadazar *et al.*, 2018).

The temperature and duration of frying, type of oil, and presence of antioxidants in oil can affect the production of undesirable compounds in the oil (Farrokhzadeh *et al.*, 2013). In the present study, 42% of the samples had FFA above the standard limits (upper than 1 %). Study on used oils of the confectioneries and food shops in Borkhar and Meymeh showed that the FFA was higher than standard limits in 7.4% of samples, However, 98.1% of the oil samples were non-consumable (Pourmahmoudi *et al.*, 2008). Sebastian et al. examined the quality and safety of the frying oils used by restaurants. The results showed that 30 to 35% of the used oils and 45 to 55% of the discarded oil samples contained high FFA level, which were not acceptable (Sebastian *et al.*, 2014).

It should be noted that the primary oxidation products are rapidly broken down into secondary ones; thus, it is hard to estimate their total amounts in the oil. Various methods exist for detecting oil oxidations, which is detectable by observation, such as color, smoke, odor, and taste (Sebastian *et al.*, 2014). Except for p-AV value, other analyses are suitable to show the primary oxidation and hydrolysis stage of oil degradation (Sebastian *et al.*, 2014). The mean concentration of p-AV values higher than 6 in oils were estimated as 49.87, which is correlated with the decomposition products such as aldehydes in frying oil (Houhoula *et al.*, 2002). In Sebastian research, all discarded oils were extremely oxidized based on the p-AV value (7.6 to 56.5) (Sebastian *et al.*, 2014). In The current study, about 34% of the oil samples had p-AV values higher than 6.

We found that 54% of the oil used in Yazd restaurants had relatively low TPC levels and 46% of the oils were unacceptable for further use. Andrikopoulos et al. investigated the frying oils of 63 restaurants in Greece. They indicated that 17% of samples had TPC level of higher than 25% (Andrikopoulos *et al.*, 2003). The TPC of the collected oil samples from fast food restaurants in Shiraz was higher than the permitted levels in 45.2% of the samples (Ghobadi *et al.*, 2018). It was shown that the total polar content increased during heating, which is correlated with the number and days of frying (Houhoula *et al.*, 2002). The mean TPC of 16.13% and 15.5 % were reported in the studies by Yilmaz et al. and Sebastian et al., respectively (Sebastian *et al.*, 2014, Yılmaz and Buket, 2011), which is lower than results of our study. The oxidation in frying oil resulted from water and air would increase the number of polar molecules (Innawong *et al.*, 2004).

Therefore, the high peroxide and p-AV in the oil samples can be attributed to the long-term use of these materials, high-temperature heating, and oxygen contact. During frying, the oil is hydrolyzed and produces FFAs, mono, and diglycerides, which are added to the oil in prolonged uses. In addition, oxidized oil produces hydroperoxide, epoxides, hydroxides, and ketones. Increasing these volatile compounds leads to an increase in the amount of FFA and the peroxide values in the oil samples (Innawong *et al.*, 2004). During the cooling period in frequent uses of fried oil, oxygen can be dissolved in oil and accelerate oxidizing reactions (Ghobadi *et al.*, 2018). In addition, the type of oil (fatty acid composition), heat and frying time, light, and concentration of oxygen during storage, lack of daily washing of the food utensils, and burning the remaining oils can also lead to a rise in oil oxidation (Ghobadi *et al.*, 2018, Nafez *et al.*, 2018). Presence of double bonds in fatty acid chains of oil makes it more susceptible to oxidation. Along with oil type, the type of fried food can have effects on acceleration of the oil degradation (Ghobadi *et al.*, 2018). Production of dangerous materials in fried oil can be important threats for not only the fried food consumers, but also for the fast food restaurant workers who exhale vapor and volatile compounds (Ghobadi *et al.*, 2018). According to **Table 1**, approximately 23% of the restaurant owners did not change their oil for more than 2 days. In addition to this fact, oils are used about 3 to 5 hours daily; so, deterioration of oils is expected. Therefore, frequent refilling or changing of oils in fast food restaurants can increase the safety of consumed fried foods.

Conclusion

The study found that a large number of fast food shops in Yazd used highly oxidized oils to prepare their food. In addition, due to absorption of frying oils by fried foods, the degradation of frying oil can be hazardous for the consumers' safety and endangers the population's health. Overall, the fried foods are considered unsafe since they increase the rate of obesity, diabetes type 2, and cardiovascular diseases. So, continuous monitoring of the fast food restaurants for production of healthy foods as well as training the fast-food staff seem necessary.

Authors' contribution

Khalili N, Akrami Mohajeri F, and Khalili Sadrabad E conceived and designed the experiments. Ramroudi F, Mojaver F, Hakimi F, Sardari M, and Khebri M carried out the experiment. All authors contributed to the final version of the manuscript.

Acknowledgment:

This manuscript was financially supported by Shahid Sadoughi University of Medical Sciences, school of public health, Yazd, Iran.

Conflict of interest

There is no conflict of interest.

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