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Original Article

Acid and Peroxide Values and Total Polar Compounds of Frying Oils in Fast Food Restaurants of Shiraz, Southern Iran

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ABSTRACT

Background: Frying is one of the most popular methods of food preparation. Since in fast food restaurants the oil is heated for prolonged and repeated periods of time, toxic compounds in oils likely go up to very high concentrations. In this study, we investigated chemical quality of oils that was used for frying in fast food restaurants.
Methods: Oil samples were collected from 42 fast food restaurants located in Shiraz, Iran. Samples were obtained from oils that were being heated in fryers at the peak of fast food restaurant activity between 10:00 and 12:00 P.M. Acid and peroxide values and total polar compounds were measured according to standard procedures.
Results: Acid and peroxide values of 27 samples (64.3%) were higher than the permitted values for oil health. This number for total polar compounds was 19 (45.2%).
Conclusion: In many fast food restaurants of Shiraz, Iran, oils that are in use contain high levels of toxic materials that may imperil consumers as well as restaurant workers. Strategies that can be used by restaurant staff to improve the condition are discussed.

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Introduction

In the last decades, fast food consumption has become increasingly popular throughout the world (1, 2). Low cost, desirable taste, convenience, and quick preparation are among reasons that people show tendency towards fast food consumption (2). Fast foods are generally prepared from processed meats, which have low nutrient content and high in energy, total fat, trans fatty acids, and salt (3). Accordingly, consumption of fast foods is positively associated with cardiometabolic risk factors (4). In addition to unhealthy components, fast foods are usually prepared by deep-frying, a cooking technique during which a number of toxic and harmful substances are produced in the food (5).

Frying, including deep-frying, is one of the most favorable and popular methods of food preparation at home and in industries because of the desirable flavor, texture, and color that it produces in foods (6, 7). At frying temperature, which sometimes goes up to

200ºC, numerous chemical reactions occur in the oil including oxidation, hydrolysis, and polymerization that lead to production of oxidized fats, trans fatty acids, hydrolyzed fats, sterol derivatives, polymers, polar compounds, acrylamide, and heterocyclic compounds (6). These chemical alterations are accompanied by changes in oil appearance, such as increases in color, density, viscosity, and foaming (7).

Since in fast food restaurants the oil is heated for prolonged and repeated periods of time, toxic compounds in oils likely go up to very high concentrations. There are various ways to evaluate heated oil quality. A simple and easy way is visual inspection of heated oil for changes in color and odor and monitoring for excessive smoking and foaming. However, financial concerns usually prohibit fast food restaurant custodians from timely exchange of heated oil. This leads to repeated use of previously heated oils and production of hazardous chemicals that jeopardizes health of consumers (8). The importance of this issue becomes clearer when we note that during frying, the oil penetrates into the texture of the frying food (9).

There is no published report relative to chemical healthfulness of heated oils in fast food restaurants in Iran. In this study, for the first time in Iran, we used a number of chemical tests to investigate the quality of frying oils in fast food restaurants. The results will indicate the health condition of oil in use of fast food restaurants and the extent of need for the corresponding surveillance actions and educational programs.

Materials and Methods

The collection of samples was performed in June 2016 in Shiraz, southern Iran. For collection of oil samples, Shiraz city was divided into 3 districts, and 14 fast food restaurants (43 samples in total) from each section were selected by random sampling method. A city map was used for selection of the samples. Oil samples were collected with cooperation of the local Sanitation Bureau inspectors at the peak of fast food restaurant activity between 10:00 and 12:00 P.M. from oils that were being heated in fryers. For sampling, the fryer machine was turned off, the oil was gently stirred by a stainless steel ladle, and a 100 mL sample was taken and transferred into clean glass containers. As the control, unheated samples of the same fast food restaurants were collected. This study was approved by the Local Ethics Committee.

Peroxide and acid values were measured based on the method described by the American Oil Chemists' Society (AOCS) (10). For each oil sample, measurements were performed 3 times and the average of the 3 measurements was used. Acid value evaluates the amount of free fatty acids in oil and is an indicator of triglyceride hydrolysis, which occurs as a result of oil decomposition during oil decay (11). It was calculated as the weight of potassium hydroxide in mg needed to neutralize the organic acids present in 1 g of oil using phenolphthalein as indicator. The titration was performed using an automated titration instrument (AD-2 Automatic titrator, Shanghai, China). An acid value of more than 1 mg KOH/g was considered unusable (12). Peroxide value was determined after dissolving oil in chloroform-acetic acid mixture in the presence of a saturated solution of potassium iodide. Iodide was then oxidized by peroxides of oil and form iodine. The iodine then was titrated with sodium thiosulfate using starch as colorimetric indicator (10). A peroxide value of more than 10 meq/kg was considered unhealthy (13).

Total polar compounds were measured by Testo 270 instrument (Testo Company, Lenzkirch, Germany). To measure the percentage of polar compounds, the oil was cooled down to a temperature 40 to 200°C and then Testo sensor was put into the oil and the percentage of polar compounds was recorded after 20 seconds. Before each measurement, the device was calibrated by the calibration oil that was provided by the manufacturer. After each usage, the device was cleaned with hot water and neutral detergents and dried before use for the next measurement. Oils with a total polar compounds of more than 25% were considered unhealthy (14). Data analysis was performed with SPSS software (version 21, Chicago, IL, USA). Data were expressed as mean±standard deviation (SD).

Results

A total of 42 samples were collected. Evaluation of chemical characteristics revealed that the average of acid and peroxide values of oils was higher than the permitted value for oil health (Table 1). For total polar compounds, the average was almost equal to the healthy limit. Figure 1 depicts acid and peroxide values and total polar compounds of the heated oil samples in an ascending manner. The horizontal line in each graph demonstrates the aforementioned threshold for oil healthiness. The color of heated oils varied from yellow to dark brown and black, and their appearance varied from clear to turbid (Figure 2).

Discussion

According to results of this study, acid and peroxide values and total polar compounds of heated oils in some fast food restaurants are higher than safe levels

Table 1: Means and standard deviation for acid value, peroxide value, and total polar compounds of oil samples collected from fast food restaurants.[1]

	No	Heated samples	Unheated samples	Unhealthy samples n (%)
Acid value (mg KOH/g)	42	1.43±0.8	0.06±0.01	27 (64.3)
Peroxide value (meq/kg)	42	41.5±38.6	1.5±0.8	27 (64.3)
Total polar compounds (%)	42	24.2±9.7	5.0±1.3	19 (45.2)

[1]Data are presented as means±standard deviation

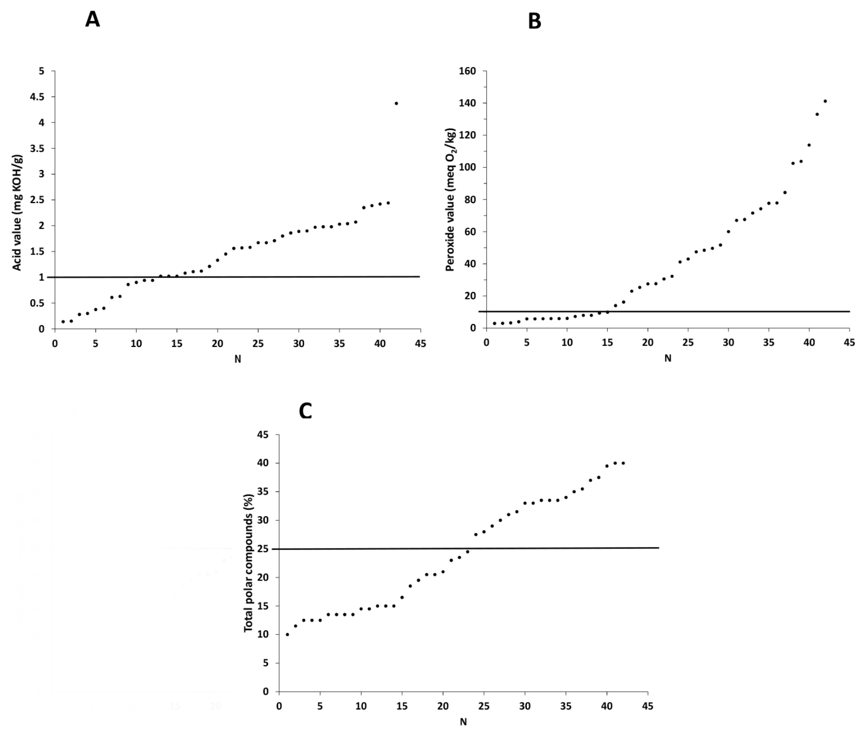

Figure 1: Chemical measurements of oil samples collected from fast food restaurants. A. Acid values. B. Peroxide values. C. Concentration of total polar compounds in oil samples.

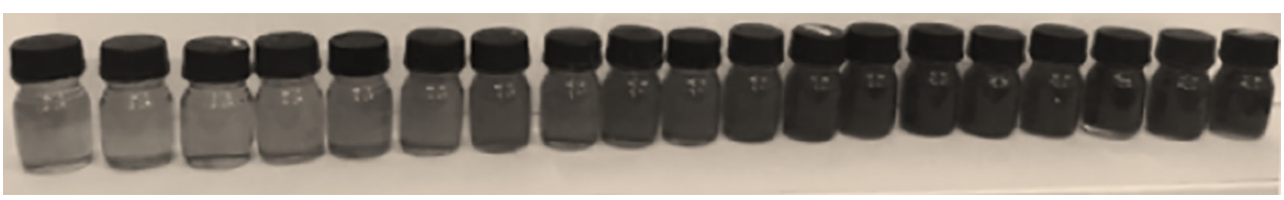

Figure 2: Some of heated oil samples collected from fast food restaurants.

specified by health legislators, indicating that in some cases oils are overheated and are not regularly exchanged with fresh oil. In agreement with our study, Totani and colleagues (15) in Japan collected heated oils from a number of supermarkets, lunch stores, restaurants, and hospitals and found high acid values in many of oil samples (ranging from 0.05 to 2.9 mg KOH/g compared to 0.1 to 4.4 mg KOH/g in this study), but comparably fewer samples had their polar compounds beyond the permitted level (ranging from 4.2 to 25.0% compared to 10 to 40.0% in the current study) (15).

Also, Sebastian et al. (13) collected fresh, in-use, and discarded oil samples from restaurants in Toronto, Canada, and found a high rate of damaged oil as evidenced by high peroxide value (ranged from 3.3 to 48.1 meq/kg compared to 2.9 to 141 meq/kg in the current study), free fatty acid concentration, and *p*-anisidine. The same findings were reported from restaurants in Taiwan (16). Most studies on the effect of heating in chemical characteristics of oils were conducted in laboratory setting. Laboratory studies have also shown increased peroxide value, total polar compounds, and color darkening following prolonged hours of heating oil at high temperatures (17).

However, it seems that in real conditions, i.e. in fast food restaurants, the extent of changes in chemical markers is much more (sometime 10 to 20 times) than that occurred in laboratory conditions (17). For instance, Latha et al. (17) reported that

8 h heating at 180ºC increased peroxide values and total polar compounds to 2.9 meq/kg and 1.8%, respectively, while in the current study the corresponding values increased on average to 41.5±38.6 meq/kg and 24.2±9.7%. Oil oxidation depends on various factors, including fatty acid composition of the oil, temperature, light and concentration of oxygen during storage, duration of the storage and temperature, duration and frequency of heating (18).

Because of the multifactorial aspect of oil oxidation, determination of the appropriate time for oil exchange is difficult. The condition seems more complex when we imagine difficulty of conducting chemical examination of oil in fast food restaurants. Color change is not an accurate method and specification of the exact time for oil exchange based on color change is difficult. Determination of acid and peroxide values and total polar compounds are all easy and comfortable methods. However, total polar compounds is a practical way for in non-laboratory setting because it can be easily performed with a Testo device in a few seconds and without need for preparation of chemical solutions or lab equipment. It is worthy to note that total polar compounds are a reliable method because total polar compounds and triacylglycerol oligomer content constitute the basis for legislation for oil discarding in some European countries (19).

Oils with high quantities of double bonds and considerable amounts of free fatty acids are more susceptible to oxidation. It is not only the type of oil that determines oil degradation rate (20-22); but the type of food that is frying also affects the speed and magnitude of oil destruction. Foods with lower water content accelerate oil degradation during oil frying process (23). For instance, while oil that is used for frying fish nuggets can be heated for 4 days without need for discarding, oil which is used for frying French fries should be discarded after 8 h heating (24). In the current study, all of the oil samples have been used for frying potato, so oil that was used for frying other food types such as meat products may have had a better quality.

The effect of toxic and oxidative chemicals generated during frying on lipid and glucose metabolism and liver function has been indicated (25, 26). The hazardous materials of frying, however, do not only threaten fried food consumers but also can affect fast-food restaurant workers in the form of vapor and volatile compounds (27, 28). Exhalation of frying oil fumes can elevate oxidative damage, as evidenced by excretion of the marker of oxidized DNA, 8-hydroxy-2'-deoxyguanosine, in urine of kitchen staff (29).

Intermittent frying which is usually a practice used in fast food restaurants causes more extended degradation and damage in oil than continuous heating (8). During frying, oxygen which has been previously dissolved in oil is expelled from the oil, resulting in a sharp decline in oil oxygen concentration at 120°C and to very low amounts at 180°C (30). During cooling period, however, oxygen is again mixed with oil and initiate oxidizing reactions. Therefore, the risk of oil damage increases as oil is exposed to intermittent heating processes rather than one time heating.

One approach to attenuate oil oxidative damage is to use antioxidants in oil. Antioxidants present in oil, occurred either naturally or added commercially to the oil, can prevent oxidative damage induced by undesirable environmental circumstances or by heating (31, 32). Likewise, the presence of antioxidants in frying foods can increase stability of frying oil by postponing oxidative degradation of unsaturated fatty acids and reducing formation of *trans* fatty acids (33-35). There are various ways to eliminate thermo-oxidation products of frying and allow for re-use of heated frying oils. These include filtration by special membranes or use of natural or synthetic adsorbents, some of them are cheap, efficient, and readily available, such as ash produced from sugar cane wastages (36).

Also, there are methods other than conventional frying, such as pressure frying, in which less oil penetration into the frying food occurs (37). The temperature of frying is also important; at higher temperatures, for instance 180°C, more oil is penetrated into the food as compared to 130°C (38). Unawareness of staff and managers of fast food restaurants about detrimental effects of oxidized oil and lack of their diagnosis regarding the exact time for oil exchange are among reasons of perilous oil condition in this and other similar studies. Educational programs aiming at increasing awareness for the correct oil frying and use of suitable methods and devices for appropriate monitoring of oil healthfulness during frying are needed to improve the situation.

Regarding the strengths and limitations of the study; this was the first evaluating oils in-use of fast food restaurants in Iran. A good aspect of the study was that we did not mix results of oils fried for various types of foods; instead, all of oils were being used for frying potatoes. However, as the type of food affects the rate of oil deterioration and damage, it would be useful if we also collected samples from other types of foods. Also, due to financial limitations we could not measure *p*-anisidine which is a reliable measure of oil oxidation.

Conclusion

Overall, results of this study revealed that in many fast food restaurantsin Shiraz, Iran, oils that are in use for frying contain high levels of toxic materials which can jeopardize both customers and restaurant staff. Prevention of oil exposure to extra heat, use of antioxidants, filtration or absorbents, pressure frying, avoidance of intermittent frying, and regular exchange of heated oil with fresh one are strategies that can be used by restaurant keepers to improve the condition. Education programs concomitant with more vigilance from administrative organizations may additionally help in the improvement.

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Conflict of Interest

None declared.

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