FRYING OIL QUALITY ASSESSMENT IN BATNA CITY (ALGERIA) AT FAST FOOD RESTAURANTS

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Abstract
The oil quality used in deep frying can affect both, the fried food properties and the consumer's health. In the present work, the frying oils quality in some fast-food restaurants in Batna city (Algeria) is evaluated.
To assess the oils quality, the following physicochemical parameters are analyzed: refractive index, density, viscosity, smoke point, the peroxide value, the acid value and the level of polar compounds which were applied in order to control sample prepared in the laboratory and those collected from ten fast food restaurants.
The results showed that two out of ten samples of different fast-food restaurants are unfit for frying and must be renewed and this taking into account the results of most parameters that exceed the recommended specifications, while taking into account the level of polar compounds, four out of ten of the samples are non-compliant with the standards recommended for oils. Thus, they have either been used more than nine times or in frying adverse conditions.
For that, the frying remains an operation simple to be made, but complex to be mastered, seen the reactions interfering between the oil and the environmental factors as well as between the oil and the food. So it's essential to focus rather on the frying conditions.

Key words: Oil samples, quality, Smoke point, Peroxide Value, polar compounds

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1. INTRODUCTION

Comestible oils are an important component of our quotidian diet. They are a source of energy, essential fatty acids and serve as a vector of fat soluble vitamins (Erum et al., 2014).
Edible vegetable oils are also greatly desired, considering the properties that give to food (Gouveia de Souza et al., 2004). Also, they are the main constituent used for cooking reasons (Erum et al., 2014). On behalf of desirable flavor, color and crispy texture of fried foods (Aladedunye and Przybylski, 2009), deep fat frying is one of the common and oldest methods used to the preparation of food in the home or industry (Gouveia de Souza et al., 2004; Erum et al., 2014; Mudawi et al., 2014).
Frying is a process in which, food is immersing in a large quantity of hot oil or fat (155- 190 °C), with a contact among oil, air and food (Aladedunye and Przybylski, 2009; Mudawi et al., 2014). The fried products quality depends both on the frying conditions such as temperature and oil volume, frying time, food weight and the oils type and to the kind of foods used during the process (Chen and Moreira, 1997).
During the frying process, by a wide range of physicochemical reactions, frying oils can be affected by thermal oxidation, polymerization and hydrolysis (Karakaya and Şimşek, 2011). Those reactions are the most common and produce volatile or nonvolatile compounds (Choe and Min, 2007) and are due to high temperature, water and oxygen absorption. The degraded oil has not only influence on food quality, but also to the nutritional and toxicological effects on human health (Siddique et al., 2013; Erum et al., 2014).
The aim of this study was to evaluate the frying oil quality used in fast-food restaurants in Batna city, Algeria. This assessment was done by determination of several physicochemical parameters such as: refractive index, density,

viscosity, smoke point, peroxide value, acid value, and polar compounds. The results are compared with a control sample prepared in laboratory in frying optimum conditions.

2. MATERIALS AND METHODS

Frying Procedure and Oil Sampling

Fast-food restaurants samples

Ten samples of 75 ml of frying oil were collected from different fast-food restaurants, chosen randomly in Batna city, Algeria. The samples were kept away from light and oxygen to avoid any further deterioration.

Control sample

The sample was prepared by heating 600 ml of oil (composited by 80 % of soybean oil and 20 % of sunflower oil) at a temperature of 170°C. Then, 100 grams of potatoes are fried for 15 minutes. The procedure was repeated 9 times. The frying was carried out in a frying pan and 75 ml were sampled from it, each time in hermetic assay tubes and kept away from light for further analysis.

Physicochemical parameters

Refractive Index

The refractive index was determined using an Abbe refractometer, few frying oil drops were placed in the double prism previously cleaned with soft paper. Then, the prism was closed and retained few minutes before reading, until both sample and instrument temperature stability. The refractometer was cleaned after each analysis and the measure was done in triplicate for each sample.

Density

Density determination was done by pycnometer. Three weight measurements were done. Pycnometer is empty and well dried. The instrument filled with distilled water and the pycnometer with the frying oil sample. After that, the following equation was used to calculate density:

$$d = \frac{ML}{Me} = \frac{ML - MV}{Me - MV}$$

Where: ML: the mass of pycnometer filled with oil.

Me: the mass pycnometer filled with distilled water and

MV: the weight of dry and empty pycnometer (Kohl, 2006).

Viscosity

The oil sample viscosity was carried out using an Ostwald viscometer tube following the method ASTM D 445-65 described by the American Society for Testing and materials (ASTM, 1965). The frying oil samples time flow was measured using a stop watch. The experience was repeated thrice.

Smoke point

The smoke point was analyzed using a smoke point tester APEX. The frying oil sample was heated until smoke generation, when the continuous blue smoke was observed, the smoke point in °C was displayed on the digital screen. The measurement was carried out in triplicate.

Peroxide Value

The peroxide value represents the amount of peroxides present in the oil. It was determined by measuring the iodine liberated from potassium iodide following the method described by Mudawi et al. (2014). One gram of the oil was weighted on which 30 ml of a blend of acetic acid and chloroform was added (3:2) and agitated to dissolve the oil. An aliquot (0.5 ml) of potassium iodide (0.1 N) was poured and kept for 1 minute. Then after adding 30 ml of distilled water, the mixture was titrated with sodium thiosulfate (0.01 N) until the total disappear of the yellowish color. A volume of 0.5 ml of 1 % starch solution is added and the titration was progressed under shaking till. The blue color was completely faded. The potassium iodide volume was noted and the same procedure was carried with the blanks. The peroxide value was calculated using the following formula:

$$P.V. = \frac{(b - a).N.1000}{S}$$

Where: b: the sodium thiosulphate volume required for blank (ml),

a: the sodium thiosulphate volume required for oil sample (ml),

N: the sodium thiosulphate normality and

S: the oil sample weight used (g).

Acid value

The frying oil acid value was determined by the method described by Zhang et al. (2015) with some modifications. 5 gram of the oil was weighted and then 30 ml of solvent mixture (ethanol and petroleum ether) were added. 2-3 drops of phenolphthalein were used as indicator. The flask content was finally titrated using potassium hydroxide solution (0.1mol/l) under continuous shaking until a persistent pink color was obtained. The following formula was used for acid value calculation:

$$A.V. = \frac{V \cdot C \cdot 56{,}1}{m}$$

Where:

V: is the recorded volume of KOH for titration,

C: is the molar concentration of KOH solution (0.1 mol/l), 56.1 g/mol is potassium hydroxide molar mass and

m: is the sample mass (5 g).

Polar compound

The level determination of polar compounds was carried out using a FRITEST type FROTTINO calibrated with the oil type to be measured (frying oil). A known oil amount was transferred into 100 ml beaker, than the instrument was introduced in the oil to be measured in such a way that the 4 ventilation holes are completely covered by the oil to be analyzed at an angle of 45 degrees. The total polar materials percentage was indicated after 3-4 seconds. The test was done thrice and the mean value was calculated.

3. RESULTS AND DISCUSSION

Refractive Index

For the control sample, the refractive index results showed a notable stability during the first three frying batches. After this, a slight increase take place during the other frying cycles. After nine frying times, the maximal value reached is 1.4710 (Figure 1). On the other hand, the samples of fast-food restaurants (FFR) presented much more important refractive indexes; with a value of 1.4733 and 1.4735 for samples FFR1 and FFR7 respectively (table 1). The refractive index increasing during deep frying was in agreement with the results found by Mudawi et al. (2014). That reported an increase from 1.4750 to 1.4810 for sunflower oil.

Density

The results tabulated in table 1, revealed that an increase in density was observed for the control sample. The increase in density after nine frying cycles was from 0.925 to 1.196. The samples from fast-food restaurants showed a density value of varying magnitudes. The maximal value of 1.262 where noticed with the FFR1. The rise of density due to repeated frying has been reported in previous work. The density increase could be related to the products multitude production during frying, due to the reactions oxidation, polymerization, isomerization and hydrolysis. Those products are mainly of high molecular weight (Kalogianni et al., 2011).

Viscosity

The viscosity results listed in table 1 showed an important increase with the number of frying cycles. This increase in viscosity was also observed for sunflower oil and palm olein oil during frying in the work done by Erum et al. (2014) has reported in his previous work an increase of corn oil viscosity during frying process from 90.07 to 94.36 milli Poise after 3 frying cycles. Kalogianni et al. (2011) has also found an increase in viscosity of palm oil over frying time. The viscosity values of the samples from different fast-food restaurants presented a varying viscosity, and the high value of 106 milliPoise was noticed for the sample FFR4. An important correlation is showed between viscosity and the amount of polar compounds for all fast-food restaurants samples. The oil viscosity depends mainly on the nature of triglycerides, and changed with the arrangement of fatty acids on the glycerol skeleton of the triglyceride (Erum et al., 2014). This viscosity rise could be related to the thermal oxidation and polymerization reactions of triglycerides and formation of compounds of high molecular weight, by forming carbon to carbon and oxygen to bonds between oxidized fatty acids. Furthermore the amount of polymeric compounds formed in the frying oil

is responsible of the viscosity increase Debnath et al., 2012).

Smoke point

The smoke point of the control sample and fast-food restaurants samples are summarized in the table 1, the figure 1 showed clearly the decrease of the smoke point after frying process. The smoke point decreased from 249 °C to 214 °C after nine frying batches. The results were in agreement with those found by Tsaknis et al. (1999) that showed a decrease of the smoke point of *Moringa oleifera* seeds oil during frying. The low smoke point of 212 °C was noticed for the sample FFR1. The volatile compounds after reaching a high concentration are evaporating as a smoke after their aggregation to colloidal-sized particles (Tsaknis et al., 1999). The smoke amount emitted from the frying oil during heating is directly proportional to quantity of low molecular weight products (Matthäus, 2006)

Peroxide Value

Peroxide value is a parameter assessing the degree of rancidity reactions have occurred, and could be used as fat and oils quality indicator (Ekwu and Nwagu, 2004). In this study, the peroxide value presented an important increase significantly during frying, the critical value of 10 meq/kg required by the Codex Alimentarius (CODEX STAN, 1999) for edible oils, was achieved after only five frying batches (Figure 1). The results were in correlation with those found by Mudawi et al. (2014) with a rise of peroxide value from 1.0 meq/kg to 8.8 meq/kg after the fourth frying process for sunflower oil. Erum et al. (2014) showed in his work the rise of peroxide value for corn oil to reach a maximum peroxide value of 2.728 meq/kg after the second frying batch. The samples of fast-food restaurants showed varying peroxide value ranging from 4.25 to 26.24 meq/kg, and only three samples (FFR1, FFR4 and FFR9) were above the limit of 10 meq/kg for edible oils. This latest frying oil represented a high degree of deterioration. The increase of the peroxide value is mainly related to the formation of peroxides as a product of primary oxidation (Goburdhun et al., 2001), however the instability of peroxides may lead to their decomposition and consequently forms secondary oxidation products, and a direct decrease of the peroxide value (Debnath et al., 2012; Park and Kim, 2016).

Acid value

The acid value of the control sample increased during frying, the maximum value of 1.10 mg of KOH/g after nine frying cycles (Figure 1). The sample of fast-food restaurant FFR1, presented a high acid value of 1.7 1.10 mg of KOH/g, this is means that the oil was used more than nine times or in inappropriate conditions of frying. The increase in acid value is due to the di- and monoacylglycerols, glycerol and free fatty acids liberated in the frying medium, after hydrolysis reaction caused mainly by the presence of water and food moisture (Choe and Min, 2007). The acid value is not a proved parameter to evaluate the frying oil quality, since the compounds of low molecular weight are easily evaporated during heating of the oil (Sulieman et al., 2006).

Polar compound

The quantification of polar compounds is one of the most reliable parameters to evaluate the quality of oil and fats during deep frying (Debnath et al., 2012). In the present investigation, we noticed a linear progression of the polar compounds amount with the number of frying batches (Figure 1), the limit of 25 % is recommended to appreciate the frying oil quality (Briand, 2007), this value was achieved after eight frying cycles. The samples FFR1, FFR4, FFR5 and FFR7 were highly damaged and presented a high percentage of polar compounds of 30.33, 31.90, 28.13, and 27.70 % respectively. The total polar materials are especially short chain acids, aldehydes, ketones, alcohols, polymeric, cyclic and no volatile compounds (Debnath et al., 2012), resulting from primary, secondary oxidation and hydrolysis (Karakaya and Şimşek, 2011) that can be accelerated by water and oxygen present in the medium (Innawong et al,. 2004)

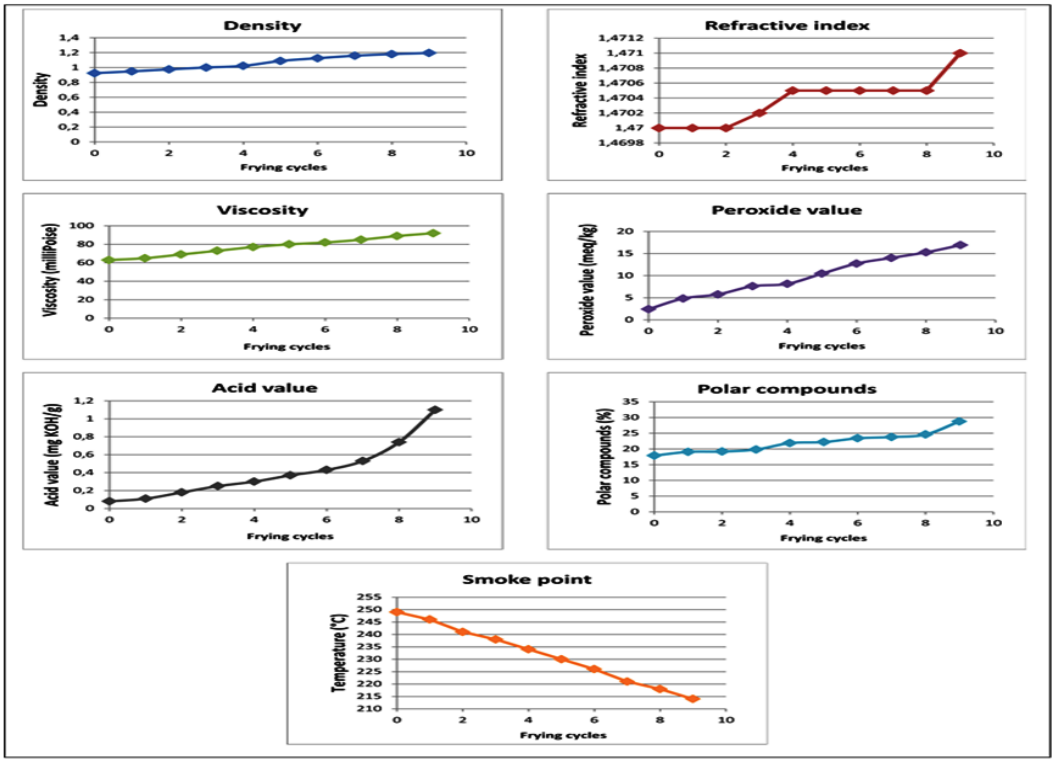

Figure 1. Evolution of physicochemical parameters of oil with frying cycles in the control sample.

TABLE 1. Physicochemical parameters of fast-food restaurants samples.

Sample	Density	Viscosity	Smoke point	Refractive index	Acid value	Peroxide value	Polar compounds
FFR 1	1.262 ± 0.006	103 ± 0.3	212 ± 1.5	1.4733 ± 0.0	1.7 ± 0.01	26.24 ± 0.30	30.33 ± 1.07
FFR 2	1.107 ± 0.005	81 ± 0.2	232 ± 2.6	1.4725± 0.0	0.56 ± 0.01	9.39 ± 0.45	21.50 ± 0.35
FFR 3	1.026 ± 0.005	85 ± 0.4	221 ± 2.8	1.4720 ± 0.0	0.34 ± 0.02	5.83 ± 0.14	23.87 ± 0.23
FFR 4	1.224 ± 0.008	106 ± 0.5	216 ± 1.5	1.4732 ± 0.0	1.36 ± 0.01	21.24 ± 0.26	31.90 ± 0.52
FFR 5	1.067 ± 0.006	93 ± 0.6	232 ± 3.0	1.4732 ± 0.0	0.42 ± 0.03	6.55 ± 0.15	28.13 ± 1.00
FFR 6	1.096 ± 0.004	74 ± 0.4	220 ± 1.2	1.4715 ± 0.0	0.62 ± 0.01	7.94 ± 0.16	19.60 ± 1.25
FFR 7	0.986 ± 0.007	98 ± 0.3	223 ± 1.0	1.4735 ± 0.0	0.59 ± 0.02	6.92 ± 0.11	27.70 ± 0.26
FFR 8	1.185 ± 0.009	70 ± 0.2	225 ± 2.3	1.4727 ± 0.0	0.31 ± 0.01	4.25 ± 0.25	17.70 ± 0.87
FFR 9	1.081 ± 0.003	73 ± 0.1	228 ± 1.5	1.4730 ± 0.0	0.66 ± 0.01	11.68 ± 0.37	17.87 ± 1.97
FFR 10	0.932 ± 0.006	78 ± 0.6	224 ± 1.0	1.4725 ± 0.0	0.31 ± 0.02	7.48 ± 0.21	22.80 ± 2.12

FFR: Fast-Food Restaurant sample

TABLE 2. Control sample physicochemical parameters

Frying cycles	Density	Viscosity	Smoke point	Refractive index	Acid value	Peroxide value	Polar compounds
0	0.925 ± 0.005	63 ± 0.6	249 ± 2.1	1.4700 ± 0.0	0.08 ± 0.04	2.42 ± 0.03	17.9 ± 0.17
1	0.949 ± 0.006	65 ± 0.5	246 ± 1.5	1.4700 ± 0.0	0.11 ± 0.03	4.84 ± 0.23	19.07 ± 0.15
2	0.976 ± 0.003	69 ± 0.5	241 ± 2.3	1.4700 ± 0.0	0.18 ± 0.01	5.76 ± 0.07	19.18 ± 0.52
3	1.001 ± 0.003	73 ± 0.3	238 ± 3.1	1.4702 ± 0.0	0.25 ± 0.012	7.62 ± 0.41	19.83 ± 0.29
4	1.023 ± 0.006	77 ± 0.2	234 ± 1.1	1.4705 ± 0.0	0.30 ± 0.01	8.14 ± 0.10	21.87 ± 0.21
5	1.089 ± 0.004	80 ± 0.4	230 ± 2.8	1.4705 ± 0.0	0.37 ± 0.023	10.46 ± 1.47	22.2 ± 0.66
6	1.126 ± 0.002	82 ± 0.1	226 ± 1.0	1.4705 ± 0.0	0.43 ± 0.01	12.74 ± 0.44	23.4 ± 0.26
7	1.159 ± 0.007	85 ± 0.2	221 ± 2.6	1.4705 ± 0.0	0.53 ± 0.01	14.02 ± 0.12	23.8 ± 0.36
8	1.181 ± 0.003	89 ± 0.3	218 ± 1.1	1.4705 ± 0.0	0.74 ± 0.04	15.27 ± 0.27	24.6 ± 0.52
9	1.196 ± 0.005	91 ± 0.5	214 ± 1.7	1.4710 ± 0.0	1.10 ± 0.06	16.91 ± 0.72	28.77 ± 0.23

4. CONCLUSION

The research was carried out to assess the quality of the frying oil used in fast-food restaurants. The results of the present study confirm that the quality of frying oil changes during frying process and revealed also that the oil used in fast-food restaurants can be of imperfect quality, due to the excessive use or the inappropriate conditions of frying such as temperature and the number of frying batches, which may affect the food quality and the consumer health. The correlation noticed between viscosity and polar compounds amount needs further research to confirm the applicability of this parameter as an indicator of frying oil quality.

5. REFERENCES

[1] Erum Z., Rehana S., Mehwish A. H. and Anjum v. Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Transform-Infrared (FT-IR) Spectroscopy. Arabian Journal of Chemistry, **10**: 2014; 3870–3876.

[2] Gouveia de Souza A., Oliveira Santos J. C., Conceição M.M., Dantas Silva M. C., Prasad S. A thermoanalytic and kinetic study of sunflower oil. Brazilian Journal of Chemical Engineering. **21**: 2004; 265-273.

[3] Aladedunye F.A., Przybylski R., Degradation and Nutritional Quality Changes of Oil During Frying. Journal of the American Oil Chemists' Society, **86**: 2009; 149-156.

[4] Mudawi H.A., Elhassan M.S.M., Sulieman A.M.E. Effect of Frying Process on Physicochemical Characteristics of Corn and Sunflower Oils. Food and Public Healt, **4**: 2014; 181-184.

[5] Chen Y., Moreira R. G. Modelling of a batch deep-fat frying process for tortilla chips. Food and Bioproducts Processing, 75: 1997; 181-190.

[6] Karakaya S. and Şimşek Ş. Changes in Total Polar Compounds, Peroxide Value, Total Phenols and Antioxidant Activity of Various Oils Used in Deep Fat Frying. Journal of the American Oil Chemists' Society, **88**: 2011; 1361-1366.

[7] Choe E., Min D.B.Chemistry of Deep-Fat Frying Oils. Journal of food science. **72**: 2007; 77-86.

[8] Siddique B. M., Muhamad I. I., Ahmad A., Ayob A., Hakimi M. Ibrahim M.O. AK. Effect of frying on the rheological and chemical properties of palm oil and its blends J ournal of Food Science and Technology, 2013 (52), 1444-1452.

[9] Kohl P. Mesures de densités. École nationale de chimie physique et biologie de Paris (ENCPB), 2006, 1-9.

[10] ASTM Standard Method of Test for VISCOSITY OF TRANSPARENT AND OPAQUE LIQUIDS (KINEMATIC AND DYNAMIC VISCOSITI ES). D 445-65 (1965), 184-189.

[11] Zhang Q., Wu J., Ma P., Cai J.,Zhang Y.Acid Value Determination and Pre-Esterification of Crude *Euphorbia lathyris* L. Oil. World Journal of Engineering and Technology,**3:** 2015; 70-75.

[12] Kalogianni E.P., Karapantsios T.D., Miller R. Effect of repeated frying on the viscosity, density and dynamic interfacial tension of palm and olive oil. Journal of Food Engineering, **105**:2011;169-179.

[13] Debnath S., Rastogi N.K., Gopala Krishna A.G., Lokesh B.R. Effect of frying cycles on physical, chemical and heat transfer quality of rice bran oil during deep-fat frying of poori: An Indian traditional fried food. Food and bioproducts processing, **90**: 2012; 249-256.

[14] Tsaknis J., Spiliotis V., Lalas S., Gergis V., Dourtoglou V. Quality changes of *Moringa oleífera*, variety fVf bololo of Kenya, seed oil during frying. Grasas y Aceites, **50**:1999; 37-48.

[15] Matthäus B. Utilization of high-oleic rapeseed oil for deep-fat frying of French fries compared to other commonly used edible oils. European Journal of Lipid Science and Technology, 108: 2006; 200-211.

[16] Ekwu F.C., Nwagu A. Effect of processing on the quality of cashew nut oils. *Journal* of Agriculture and *Food Technology*, **4** : 2004 ;105-110.

[17] CODEX STAN 210-1999. Codex Alimentarius: Norme pour les huiles végétales portant un nom spécifique. 17 p.

[18] Goburdhun D., Jhaumeer-Laulloo S. B., Musruck R. Evaluation of soybean oil quality during conventional frying by FTIR and some chemical indexes. International Journal of Food Sciences and Nutrition, **52:** 2001; 31-42.

[19] Park J.M., Kim J. M. Monitoring of Used Frying Oils and Frying Times for Frying Chicken Nuggets Using Peroxide Value and Acid Value. Korean Journal for Food Science of Animal Resources, 36: 2016 ; 612-616.

[20] Sulieman A. E. M., El-Makhzangy v., Ramadan M. F. Antiradical performance and physicochemical characteristics of vegetable oils upon frying of French fries: a preliminary comparative study. Journal of food lipids. **13**: 2006 ; 259-276.

[21] Briand P. Avis de l'Agence française de sécurité sanitaire des aliments relatif au projet de décret portant application du code de la consommation en ce qui concerne les graisses et les huiles comestibles. AFSSA; Saisine n° 2007-SA-0072. 2007, 1-5.

[22] Innawong B., Mallikarjunan V., Irudayaraj J., Marcy V. The determination of frying oil quality using Fourier transform infrared attenuated total reflectance. Lebensmittel-Wissenschaft and Technologie, 37 : 2004; 23-28.