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QUANTITATIVE ASSESSMENT OF FRYING OIL QUALITY IN FAST FOOD RESTAURANTS

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Abstract
The average quality of 28 frying oil samples collected from fast food restaurants has been determined by acid and peroxide values, total polar materials, refractive index, viscosity, instrumental color and turbidity measurements. In addition, a questionnaire composed of 9 questions has been applied to the cooks of these restaurants. It has been found that the general quality statuses of the frying oil are acceptable. Only three samples of those have exceeded the limit total polar materials value of ≤ % 25. Their color and turbidity values have proved large variations. It has been determined that the ones using small fryers for long-term frying change their oil on daily basis. It has been detected as a problem that waste oil is poured into city pipeline. Hence, education is needed for both purposes to protect public health and effectively utilize waste frying oils.

Keywords: Restaurant, frying, oil, quality, questionnaire, assessment

HAZIR GIDA RESTORANLARINDAKİ KIZARTMA YAĞ KALİTESİNİN KANTİTATİF DEĞERLENDİRİLMESİ

Özet
Hazır gıda restoranlarından toplanan 28 kızartma yağı örneğinin ortalama kalitesi, asit ve peroksit değeri, toplam polar madde, kırılma indisi, viskozite, aletsel renk ve bulanıklık ölçümleriyle belirlenmiştir. İlaveten bu restoranlardaki aşçılara 9 sorudan oluşan bir anket uygulanmıştır. Genel olarak yağ kalitelerinin iyi olduğu saptanmıştır. Tüm örnekler arasında sadece üç örnek, toplam polar maddede sınır değer olan %25'i aşmıştır. Diğer taraftan renk ve bulanıklık değerleri önemli varyasyon göstermiştir. Küçük fritözlerde uzun süreli kızartma yapanların yağlarını günlük değiştirdikleri belirlenmiştir. Bir problem olarak atık yağın şehir şebekesine döküldüğü de tespit edilmiştir. Dolayısıyla hem halk sağlığının korunması hem de atık yağın etkili kullanımı için eğitime ihtiyaç olduğu ortaya çıkmıştır.

Anahtar kelimeler: Restoran, kızartma, yağ, kalite, anket, değerlendirme

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INTRODUCTION

Food frying has long been used as a technique to prepare various foods both at home and in industrial food sectors. Since fried foods develop a much desired texture, flavor and appearance, they are consumed in large quantities all over the world. The popularity of fried food is due to the surface texture, crunchiness and flavor. Especially the fast-food sector uses frying widely (1).

In frying, the frying oil serves as a heat transfer medium and an ingredient of fried food. During this process, heat transfer from oil to food and cooking of food, meantime water vaporization from food into the oil and then to the atmosphere, penetration of oil into the capillaries formed in food, air-oil mixing at the surface and similar phenomena occurred constantly. The heat reduces moisture content of food surface nearly to %3, and oil enters into the spaces left by the evaporating water. A series of physical and chemical changes take place in frying oils used at around 175 oC or above. The factors that affect the oil and product quality during deep-fat frying are refreshing ratio of oil, frying time and temperature, heating type, composition of frying oil, quality of start up oil, composition of fried food, fryer type, antioxidants and oxygen availability. During frying, some chemical reactions like oil hydrolysis, thermo-oxidation, dimer and polimer formation, Maillard reactions and others take place in the oil. The products of these reactions accumulate by time and lead to deteriorate oil and to reduce the frying oil quality and healthiness properties of fried foods (2, 3).

Stevenson et al. (4) have suggested ideal frying oil as having a maximum of 0.05-0.08 % free acidity, a maximum of 1.0 meq/kg peroxide value, a minimum of 200 °C of smoke point, a maximum of 1.0 % moisture with mild flavor and taste. To protect public health, some regulations and guidelines to control frying operation and frying oil have been developed in different countries. There are different regulations for fresh and used frying oil in European countries (1). In Turkey, the first regulation (5) for frying oil has issued by the Ministry of Agriculture (Regulation no: 2007/41) as "the control criteria for the solid and liquid oil used for frying". This notification emphasizes especially two parameters; total polar materials must be ≤ % 25 and smoke point must be > 170 °C. Although the restaurant owners or cooks usually decide when to change frying oil by visual examination, after this regulation it is obligatory to measure total polar materials.

The aims of this study have been to objectively evaluate some frying oil samples collected from fast food restaurants and to assess the attitudes and knowledge of the cooks operating frying in the restaurants by a survey.

MATERIALS AND METHODS

Collecting Oil Samples

A total of 28 frying oil samples were collected twice a month from the restaurants in Çanakkale city during January 2009. During the second sample collection, if the same kind oil was used previously, the sampling was continued and a questionnaire was applied to the cooks responsible for frying. Around 200 ml of oil samples were taken directly from the fryer in-use into an amber colored capped glass and labeled. Until and during the analyses, the samples were kept in a refrigerator. All the physical and chemical analyses were performed twice in each sample. The questionnaire (Table 1) was once applied to the cooks and data were collected for the statistical analysis.

Analytical Methods

Viscosity measurements of the oil were carried out with a Brookfield viscosimeter (model DV II+Pro with Rheocalc software, Brookfield Eng. Lab., Inc., MA, US) equipped with LV-SC4-18 spindle at 25 °C. Turbidity values of the samples were measured by Micro T100 Lab Turbidimeter (HF Scientific Inc, US) instrument at 25 °C. Refractive indexes of the samples were measured during daylight with a 2WAJ model Abbe refractometer, calibrated against pure water at 25 °C. Instrumental color of the samples were measured by a Minolta CR-400 Chroma Meter (Osaka, Japan) by immersing the probe of instrument into the oil sample and readings of the L, a* and b* values.

Table 1. The Questionnaire Used for Assessment of Frying in Fast Food Restaurants.

Name of the restaurant:
Date of the survey:
Q1) Which oil are you using for frying in your restaurant?
a) Sunflower oil (sfo)
b) Hazelnut oil (hno)
c) Corn oil (cno)
d) Olive oil (olo)
e) Other (els)
Q2) What is the reason for you to prefer this oil?
a) Price (pri)
b) Quality (qua)
c) Flavor (fla)
d) Other reasons (otr)
Q3) How many hours a day do you perform frying?
a) 0.5-2.5
b) 2.5-5.5
c) 5.5-8.0
d) 8.0-10
e) 10-12
Q4) After the end of a day, how do you utilize the remaining oil next day?
a) use oils until expiring (finishing) from the fryer (fin)
b) make up with fresh oil daily (ref)
c) dispose all and refill with new oil (dis)
Q5) How often do you change your oil?
a) every day (evd)
b) every other day (eod)
c) every week (ewk)
Q6) What do you do with your waste frying oils?
a) pour into the wastewater pipe (pou)
b) collect and dispose it into trash (trs)
c) collect and sell to a buyer (sel)
d) other usage (osa)
Q7) How do you clean your fryer?
a) hot water and soap (how)
b) grease cleaner detergent (det)
c) spray cleaner (spr)
d) other way (otw)
Q8) Do you perform any treatment to extend the usage life of your frying oil?
a) do not perform (not)
b) use adsorbant materials (ads)
c) filter oil (fil)
d) add antioxidants (ant)
e) other treatment (ott)
Q9) Do you have any knowledge about the Turkish Food Codex regulations for frying oils?
a) do not know (dnk)
b) be aware (bwr)
c) use control instruments (uci)

Free acidity and peroxide value of the samples were determined by Ca 5a-40 and Cd 8-53 methods of the American Oil Chemists Society methods (6, 7). Quick assessment of the total polar materials (TPM, %) of the frying oil samples were performed by Testo 265 (Lenzkirch, Germany) sensor (probe) readings at oil temperature above 40 °C.

Statistics

The mean, median and range of the measured values were determined. Multidimensional Scaling (MDS) method was used to compare the measured physical and chemical parameters and surveys together. Similarly, the relationship between some of the questions of the questionnaire was evaluated by MDS plots. For MDS analysis, the SPSS package program (version 10.1, SPSS Institute Inc.) was used (8).

RESULTS AND DISCUSSION

The mean and median values and ranges of the measured parameters in the 28 frying oil samples are shown in Table 2. Turkish regulation (5) has only indicated total polar materials (TPM) and smoke point for controlling of frying oils. In this study, % TPM are measured by quick probe technique, but it is previously found in our laboratory (9) that this technique is well correlated with the colon chromatographic method to measure total polar materials. Also, probe technique has been found to give correct results very quickly and cheaply to apply for regular inspection purposes. Although mean % TPM values (Table 2) are within the regulated limit, there are only three samples exceeding (data not shown) the limit value (≤% 25). There are different regulations in European countries for used frying oil. Maximum acid value of 2-2.5 %, TPM values of 24-27 %, maximum oxidized fatty acid value of 0.7-1.0 % and maximum dimer and polymer value of 16-25 % have been issued in different European countries. Only Belgium puts a maximum value of 37 mPa.s at 50 °C for viscosity (1). If 2.5 % free acidity is considered as limit value, it has been found that only 5 samples have exceeded this limit. Samples in this study have showed great variability for the color and turbidity

measures. Although these parameters have not been issued for regulations, they may provide knowledge about quick assessment of oil degradation status (10).

In one study, 49 oil samples were collected from grill restaurants and analyzed for common quality criteria. Average acid value has been 1.3 in this study and only 16 % of samples have been found as inadequate for quality (11). A similar study was performed in 86 samples from Taipei area. In this study, acid and peroxide values, smoke point, specific gravity, viscosity and UV absorbance have been measured. It is concluded that 24.6 % of the total samples has been regarded as deteriorated. It has been concluded that a fast, easy and cheap method of frying oil quality assessment technique is needed for inspectors (12).

A questionnaire composed of 9 questions has been applied to 28 restaurant cooks and their responses (%) for each selection within each question are shown in Table 3.

It is obvious that most restaurants use sunflower oil and an oil other than corn, hazelnut or olive oil for their frying. They prefer their selected oil mostly due to its quality and they mostly perform frying for 0.5-2.5 hours daily. They usually dispose the remaining oil at the end of the day and refill their fryer in the next day. It is interesting that in question five, 57.14 % have indicated that they change frying oil every day, but answers in question six indicate that 60.72 % treat waste oil in a way other than pouring into pipe, collecting and disposing it into trash or collecting and selling to a buyer. Most restaurants clean their fryers with grease cleaning detergents and do not perform

Table 3. Percentage of Distribution of the Selections for the Questions in the Questionnaire.

Question number	Selections	Selected (%)
Q1	a	46.43
	b	0
	c	0
	d	0
	e	53.57
Q2	a	13.33
	b	46.66
	c	26.66
	d	13.33
Q3	a	49.14
	b	8.71
	c	11.45
	d	13.02
	e	17.68
Q4	a	17.86
	b	17.86
	c	64.28
Q5	a	57.14
	b	39.29
	c	3.57
Q6	a	7.14
	b	17.86
	c	14.29
	d	60.72
Q7	a	35.71
	b	57.14
	c	3.57
	d	3.57
Q8	a	82.14
	b	0
	c	17.86
	d	0
	e	0
Q9	a	39.29
	b	60.71
	c	0

Table 2. The Quality Parameters of Frying Oils Collected from the Restaurants.

Parameter	Mean±SD	Median	Range
Acid value (% oleic)	2.09±0.13	1.849	0.876-4.083
Peroxide value (meq/kg)	12.74±2.23	9.52	2.50-59.06
Total polar materials (%)	16.13±1.63	13.50	9.25-50.25
Refractive index (25°C)	1.4685±0.00	1.4668	1.4640-1.4745
Viscosity (cP)	61.74±0.08	62.20	48.95-78.15
L value	33.90±0.82	34.755	25.28-45.14
a* value	4.95±0.55	4.673	-1.930-9.655
b* value	9.89±0.96	11.67	-1.170-16.780
Turbidity (NTU)	48.60±26.20	13.0	2.7-733.5

any treatment to extend usage life of the frying oils. Finally around 60.71 % of them have indicated that they are beware of the Turkish regulation for the frying oil control, but none of them uses any controlling instruments. Although it has been clearly indicated that the purpose of this survey is solely a scientific investigation, there might be different motives with the respondents, since it is directly related to public health. From these results, it can be inferred that the attitudes and precautions of fast food frying in Çanakkale restaurants have not showed great potential hazard for human health.

In order to evaluate the questionnaire and measured parameters all together for a keener understanding, multidimensional scaling analyses (MDS) have been performed. The data is shown in Figure 1.

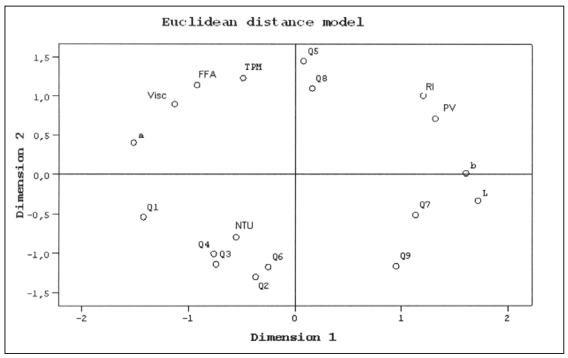

Figure 1. Geometrical Representation of the Measured Parameters of the Frying Oil Samples and Questions in the Questionnaire by Multidimensional Scaling (FFA, acid value; TPM, total polar material; RI, refractive indexes; PV, peroxide value; NTU, turbidity value; Visc, viscosity; L, L value; a, a* value; b, b* value; Q1-9, questions1-9).

The visual representation of similarities and distances between 9 measured parameters (Table 2) and 9 questions in the questionnaire applied (Table 1) are shown within two dimensions. There are some groups, though they are not very distinctive. Acid value (FFA), viscosity (visc) and total polar materials (TPM) seem to be clustered together. This means that among the samples these three measures have changed in the same way. Several literatures (3, 9, and 13) have indicated a close relationship between FFA and TPM. It can also be observed from Figure 1 that refractive indices and peroxide values are related in these samples. The level of turbidity (NTU) in the collected samples seems to relate with questions 3 and 4 (Q3 and Q4). In fact, daily frying time and consecutive day's practice may change oil turbidity. On the other hand, a similar term, the L value of color measurement, has not related with any of these parameters. Although it is not very concise, the questions five and eight (Q5 and Q8) are located in a close proximity (Figure 1), indicating some degree of relevance. Obviously, if the cooks have not performed any treatment to extend the usage life of their frying oil, they may change their oil more frequently, as can be observed from the MDS map.

To evaluate the relationship among 9 questions in the questionnaire more closely, individual MDS analyses have been performed among some questions which previously indicated some degree of correlations. The differences between the selections of question 3 and 5 are shown in Figure 2.

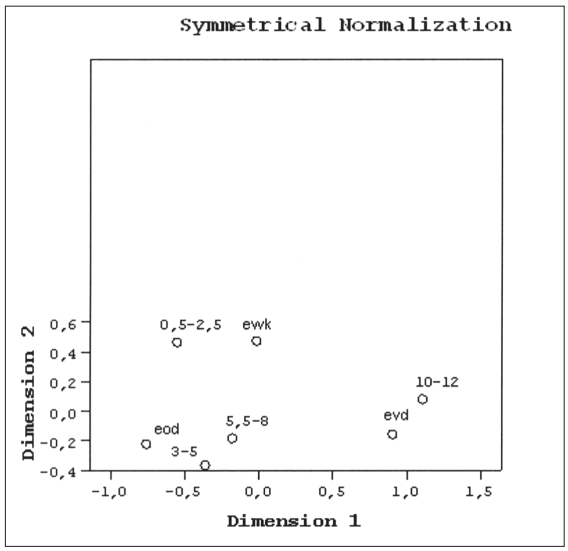

Figure 2. Geometrical Representation of the Selections of Questions 3 and 5 in the Questionnaire by Multidimensional Scaling (evd, every day; eod, every other day; ewk, every week).

It is obvious that restaurants performing frying 0.5-2.5 hours daily change their oils every week (ewk), those performing 3-5 hour-daily-frying change oil every other day (eod) and those frying 10-12 hours daily change their oils every day (evd). This is quite an expected result shown with the differences on the MDS map. Numerous publications (3, 13, and 14) have previously shown that as frying time is longer; the usage-life of frying oil gets shorter. A similar relationship between question 4 and 5 is shown in Figure 3.

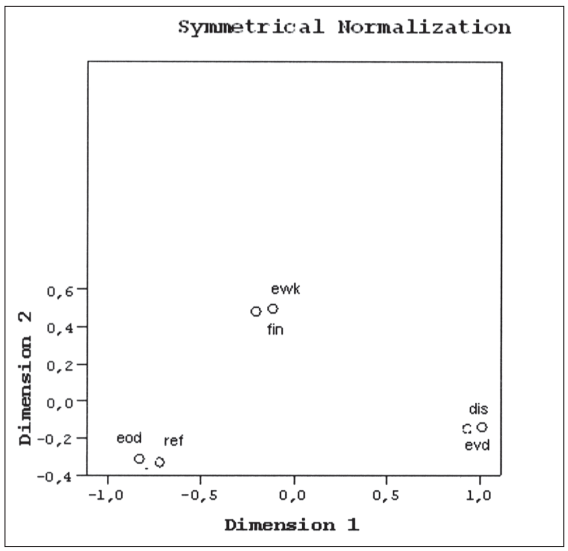

Figure 3. Geometrical Representation of the Selections of Questions 4 and 5 in the Questionnaire by Multidimensional Scaling (fin, use oil until finishing from the fryer; ref, make up with fresh oil daily; dis, discard all and refill with new oil; evd, every day; eod, every other day; ewk, every week).

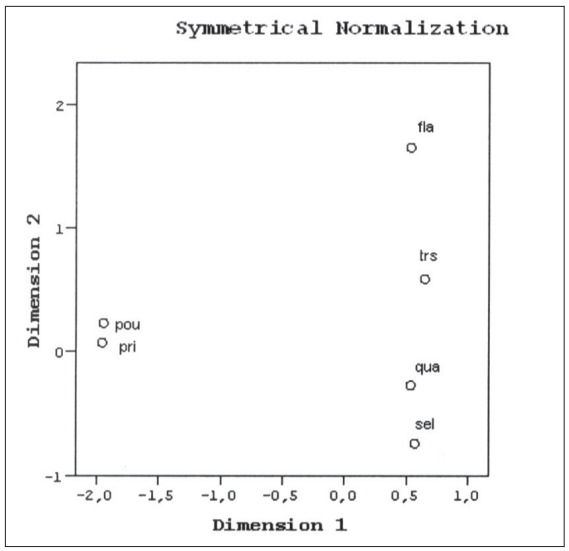

Figure 4. Geometrical Representation of the Selections of Questions 2 and 6 in the Questionnaire by Multidimensional Scaling (pri, price; qua, quality; fla, flavor; otr, other reasons; pou, pour into the wastewater pipe; trs, collect and discard into trash; sel, collect and sell to a buyer; osa, other usage).

It is clearly classified into three distinct groups. If they use frying oils until it is expired in the fryer (fin), they change their oils every week (ewk). This is the most possible due to that large fryers are preferred to refill weekly, when they are used. The second group shows that when they dispose (dis) remaining oil and refill the next day, they do this every day (evd), as expected. It is also evident that if they perform 10-12 hour-daily-frying, they change oil daily, as well (Figure 2). The third group shows that if they make up with fresh oil (ref), they usually do this every other day (eod). These results also indicate the expected practice that usage life of oil gets shorter and refilling or change frequency increases if frying period is longer. Lastly, the relationship between question 2 and 6 is shown in Figure 4.

There is only one group composed of oil price (pri) and pouring waste frying oils into pipe (pou). Clearly, if they use cheap oils they may easily pour the used oils into wastewater pipe. Although only 7.14 % of the restaurants has selected (a) in question six (Table 3), it is found that this behavior is mostly related with oil price.

CONCLUSION

In general, frying oils analyzed in this study has been found fine in terms of quality, and consequently may not pose important health hazard. This is quite important for public health. TPM measured with probe and acid value correlated very well; hence, quick measuring probe can be used for routine inspection purposes adequately. The survey has indicated that especially in small frying facilities, pouring waste oil into pipeline is a common practice. This is in fact a problem for the environment. Also, as a renewable source, waste frying oils can be used in biodiesel production (15) and must be collected. Therefore, education of the restaurant owners and cooks and organizing an effective way of collecting waste frying oils are needed in this area. Also, the survey has indicated that cooks are well aware of the government regulation and control procedures for frying oils. Education to get TPM measurements to be implemented regularly is also needed.

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