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A survey on operating conditions and quality of commercial frying fats in Hungary

Anna Gere

National Institute of Food Hygiene and Nutrition, Budapest (Hungary)

Summary

An extensive survey on commercial frying fats was conducted in Budapest. It was based on sample collection, analysis and questionnaires filled in with each sample. Frying fats and oils were collected from restaurants, fast-food services and public catering facilities. The quality of samples was assessed by determining their polar components. An evaluation of questionnaires containing over 20 questions yielded detailed information on the usage of fats as well as the fryer operators' habits of conducting frying processes and their knowledge on the subject.

The survey consisted of two periods. During the first period 252 samples were collected at random. Quality assessment indicated that 53.6 % of all samples was of good quality (with concentrations of polar materials below 25 %) while the rest were at the discard point or deteriorated. The second part of the survey was aimed at a re-check of the places where fat had been found deteriorated. Second samples were obtained from 53 establishments. The results showed an improvement both in operating conditions and quality of frying fats.

Based on the results, the necessity of instructing fryer operators and introducing regulations and routine quality testings of frying fats became obvious.

Zusammenfassung

In Restaurants, Imbißstuben und Großküchen in Budapest wurden zahlreiche Proben kommerzieller Fritierfette entnommen und gleichzeitig Fragebogen, in denen zahlreiche Angaben zur Verwendungsart, zur Herkunft usw. der Fritierfette gestellt wurden, erhoben. Die Qualitätsbeurteilung der Proben erfolgte über die Bestimmung der polaren Anteile. Die Fragebogen lieferten ausführliche Angaben über die Belastung der Fettproben sowie über die Kenntnisse der Anwender von Fritierbädern hinsichtlich optimaler Fritierbedingungen. Von den zuerst erhobenen 252 Proben waren rund 54 % von guter Qualität (Gehalt an polaren Anteilen weniger als 25 %). Die anderen Proben mußten zu einem ganz erheblichen Teil als verdorben bezeichnet werden. Eine erneute Probenahme in den entsprechenden Betrieben (53 Proben) führte zu etwas besseren Ergebnissen; es zeigte sich aber, daß verstärkte Informationen von Anwendern sowie gesetzliche Regelungen und regelmäßige Kontrollen der Qualität der in Fritiergeräten verwendeten Fette notwendig wären.

Key words: deep frying, survey, commercial frying fats, frying conditions, quality assessment of frying fats

Introduction

In frying processes fats and oils perform functions as nutrient, flavour carrier and heat transmitter. It has long been known that in fats subjected

to extensive heat abuse a complex series of chemical reactions, such as oxidation, polymerization, hydrolysis, isomerization and cyclization (2, 18, 21) produce a great number of alteration products. As a result of the accumulation of these newly formed compounds during the frying operation, the functional, sensory and nutritional qualities of the fat are damaged. After a certain duration of frying the quality impairment may reach a point at which the oil has to be regarded as deteriorated.

It therefore became important to study the chemical and nutritional properties of used frying fats (1, 3, 4, 12, 19, 23, 25). Most types of decomposition products have been isolated and identified (12, 23, 25). Some of these compounds (for instance those of a cyclic structure) appeared to have harmful effects in animal experiments (1, 6, 15). Studies on the thermostability of different fats showed that the rate and extent of degradation depends on the composition of fat (highly unsaturated fats being most susceptible to breakdown) and the type of fried food as well as the operating conditions (10, 13, 19, 24, 27). Based on the results of these studies attempts have been made to adjust optimal frying conditions in order to extend the length of time a batch of oil is suitable for use (7, 11, 19).

Much work has been done to find adequate methods for assessing the quality of used frying fats. Although sensory evaluation in any food operation is an important quality measurement, it is unreliable for routine quality testing. For an objective evaluation of frying fats numerous methods have recently been introduced. These include rapid tests for on-the-spot use (16, 20) as well as methods requiring laboratory facilities (9, 17, 22).

Considering that the fried food absorbs some of the fat, it is obvious that high quality foods can only be prepared when using a good quality frying medium. In several countries there are regulations (7) establishing cut-off levels (mostly 25–30 % of polar materials) to indicate that a frying fat is deteriorated to the discard point.

In Hungary, as in other countries, deep fat frying has won increasing popularity. However, there are as yet neither any regulations concerning frying fat quality nor routine quality testings of commercial frying fats. Therefore it appeared to be of interest to undertake an extensive survey on the subject. The purpose of the survey was to investigate the degradation state of commercially used oils and fats as well as to obtain as much information as possible on the operating conditions under which frying procedures are usually conducted. This paper reports the experiences and results of our work.

Organization of the survey

The investigation of operating conditions and quality of commercial frying fats was conducted by the National Institute of Food Hygiene and Nutrition in cooperation with Budapest Station of Public Hygiene.

Our studies were based on sample collection, analysis and evaluation of questionnaires filled in with each sample. Sample collection was directed by Budapest Station of Public Hygiene. Inspectors of the districts' services of public hygiene took the frying fat samples and filled in the questionnaires on the spot. Laboratory analysis of the samples and evalua-

tion of the questionnaires were carried out at the National Institute of Food Hygiene and Nutrition. The work was started in April 1983 and finished in March 1985.

Sample collection

Collection of frying fat samples included two periods. The first part of it was conducted as follows. Oils and fats used in actual deep frying processes were collected at random from restaurants, fast-food services and public catering facilities in Budapest. From April 1983 until November 1983 a total of 252 samples were obtained from different places. During the second period the inspectors were requested to take samples from places, the fat of which had been found deteriorated (with concentrations of polar components above 25 %) after the first testing. This repeated sample collection was done from October 1984 to January 1985. Of the 117 sites concerned we managed to obtain second samples in 53 cases. All the samples were immediately transported to the laboratory where they were stored at −10 °C until analysed.

Questionnaires

The inspectors in charge of sample collection filled in a questionnaire with each sample. The questions were aimed at getting information not only on the type and usage of the frying fat samples but on the usual

Table 1. Scheme of a questionnaire.

1. Sample No.
2. Date and time of sample taking
3. Sample origin (including full adress)
4. Type of fat
5. Type(s) of food fried
6. Amount of one food portion (kg)
7. Initial amount of frying fat (kg or l)*
8. Thickness of fat layer in the fryer (cm)
9. Type, volume and material of the fryer
10. Mode of heating
11. Date of the last oil discard*
12. Frying temperature
    a) Is it controlled?*
    b) What does the operator think the optimal frying temperature is?*
    c) Actual frying temperature (°C)
13. Average daily length of frying (hours/day)*
14. Cycles of the daily frying process (hours)*
15. Adjusting of the oil's temperature during short (< 2 hours) breaks in frying*
16. Storage of frying fat*
17. Frequency of fryer cleaning*
18. Frequency of oil filtration or sedimentation*
19. Replenishment with fresh oil*
20. Frequency of frying fat discard*
21. Fate of fat discarded*

*) Information obtained from the fryer operators without the possibility of being verified.

Table 2. Type and usage of the frying fat samples (data from 292 questionnaires).

Information	Distribution of answers in percent of total answers	
Sample origin		
– privately owned fast-food service	40.5	
– state or cooperative owned fast-food service	18.7	
– privately owned restaurant	1.6	
– state or cooperative owned restaurant	32.9	
– public catering facility	6.3	
Type of fat		
– sunflower oil		33.2
– rapeseed oil		5.2
– lard		46.4
– mixture		
of sunflower oil and lard		11.2
of rapeseed oil and lard		2.4
other		1.6
One batch of fat is used for frying		
– one type of food		74.0
– several types of food		26.0
Type(s) of food fried		
– breaded cutlets	19.6	
– cutlets	1.2	
– mince-meat balls	9.5	
– fat-rich meat (porkribs, spareribs, etc.)	15.4	
– chicken	2.7	
– fish	5.9	
– liver (chicken, pork or beef)	4.7	
– sausages	10.1	
– French fries	15.7	
– vegetables	1.8	
– pastry (doughnuts or lángos)	13.4	
Fat/food ratio (initial amount of fat related to one food portion)		
– <1	18.1	
– 1–2	16.7	
– 2–4	14.1	
– 4–6	15.0	
– >6	36.1	
Thickness of fat layer in the fryer (cm)		
– <5		30.1
– 5–10		39.8
– >10		30.1
Material of the fryer		
– aluminium		25.3
– iron		22.4
– alloy metal		2.6
– stainless steel		34.8
– enamelled iron		10.7
– teflon coated iron		4.2
Mode of heating		
– gas		70.8
– electric		29.2
Actual frying temperature (°C)		
– <160		10.3
– 160–180		9.9
– 180–200		7.9
– >200		4.4
– unknown		67.5
Lenght of frying of the fat sample		
– days: <1		26.3
1–3		36.9
3–5		16.1
5–8		10.6
>8		10.2
– hours <10		68.5
10–20		14.4
20–40		4.5
40–60		2.2
>60		10.4

operating conditions as well. The scheme of a questionnaire is presented in Table 1. The original form in Hungarian was more detailed, designed to be simpler to fill in. In order to achieve this, we gave the possible answers to most of the questions, so the corresponding ones were just to be circled. This system also helped us in evaluating the questionnaires. It should be noted that in several cases, information obtained from the fryer operators could not be verified by the inspectors. The results showed us that in these cases quite a few answers reflected the operator's opinion and not the actual situation. Nevertheless, it seemed of interest to put these questions as the answers gave an idea about the operators' "frying habits" and their knowledge of optimal frying conditions.

Laboratory analysis

Quality of the commercial frying fats and oils was assessed by measuring their polar components. Determination of the polar materials was carried out by adsorption column chromatography on Kieselgel 60 using the DGF method (17).

Results and discussion

Questionnaires and degradation states of the samples from the first (collection at random) and second (repeated collection) periods of the survey were evaluated separately.

First sample collection

The questionnaires from 252 frying fat samples collected at random were treated as follows. The questions were classified into two categories, one with emphasis on the history of usage of the samples and the other concerned mainly with the usual operating conditions. Certain parameters (for instance fat/food ratio) were calculated from answers for each sample. The information was also classified and for each parameter the answers were expressed as the percentage of total answers. Data obtained from the questionnaires are listed in Tables 2 and 3.

Distribution of information on types of fat and food (Table 2) reflects deep frying aspects of Hungarian cuisine. The most commonly used edible fats are lard, sunflower oil and rapeseed oil as well as their mixtures. Among fried foods bread-crumbed cutlets (Wiener Schnitzel), fat-rich parts of pork, French fries, lángos (Hungarian speciality similar to doughnuts with the difference that it is made of salted paste shaped thinner and flattened) and doughnuts are the most popular. Mixed substrates (for instance French fries and meat) are often fried in the same batch of oil. Fat/food ratio and thickness of fat layer vary greatly and depend mainly on the type of food fried. Most fryers are aluminium, iron or stainless steel pans heated by gas. Unfortunately, few electric fryers equipped with automatic temperature control are used, only about 23 % of the fryers were of that type. Consequently, the actual frying temperature was unknown in many cases. For as few as 32.5 % of the samples could we obtain temperature values (some of them measured by the inspectors), about one third of which were higher than the optimal range from 160 to 180 °C.

Table 3. Usual operating conditions (data from 252 questionnaires).

Information	Distribution of answers in percent of total answers
Frying temperature	
a) Is it controlled?	
– yes, by thermometer or automatic temperature control	15.6
– initial temperature is checked by pouring some flour or bread-crumbs into the fat	14.8
– no	69.6
b) What does the operator think the optimal frying temperature is?	
– < 160 °C	19.4
– 160–180 °C	16.3
– 180–200 °C	8.3
– > 200 °C	5.6
– no idea	50.4
Average daily length of frying (hours/day)	
– <1	6.2
– 1–3	34.7
– 3–5	28.9
– 5–8	18.7
– >8	11.5
The daily frying process is	
– intermittent	81.0
– continuous	19.0
During short (<2 hours) breaks in frying	
– the oil is maintained at the frying temperature	3.2
– the temperature is decreased by 30–40 °C	16.2
– the heating is turned off	80.6
The frying fat is stored	
– in the fryer	46.5
– in the fryer, covered	9.4
– in another vessel	33.3
– in another vessel, in refrigerator	10.8

Table 3 (contd.)

Information	Distribution of answers in percent of total answers
Frequency of fryer cleaning	
– several times a day	17.4
– once a day	50.8
– two or three times a week	13.1
– once a week	11.9
– more seldom	5.1
– never	1.7
Frequency of oil filtration or sedimentation	
– several times a day	28.3
– once a day	46.7
– two or three times a week	10.9
– once a week	4.2
– more seldom	1.9
– never	8.0
Replenishment with fresh oil	
– yes	63.4
– no	36.6
Frequency of frying fat discard	
– several times a day	4.5
– once a day	37.2
– two or three times a week	22.7
– once a week	21.6
– once a fortnight	4.1
– more seldom	5.4
– never	4.5
Average length of frying of a batch of oil	
– (hours)	56.9
– <10	12.9
– 10–20	14.2
– 20–40	2.7
– 40–60	13.3
– >60	
What happens to the fat discarded?	
– rejection	37.1
– animal feeding	40.7
– human nutrition	21.5
– heating	0.7

Data listed in Table 3 provide information on the operators' "frying habits" and/or their knowledge of optimal frying conditions. As to frying temperature, in nearly 70 % of the kitchens it was not controlled at all and about half of the operators did not even have an idea about optimal temperature. Average length of frying (hours/day) and cycles of the daily frying process were variable, depending mostly on the place's turnover. As regards conditions of storage, frequency of cleaning, filtration and oil discard, contradictions between answers as well as their comparison to degradation states of fats measured in the laboratory allowed us to conclude that a considerable proportion of answers had indicated the operators' opinion instead of the actual conditions. It was also interesting to learn about the fate of the fat discarded. It is well known that deteriorated, highly abused fats are not suitable for nutrition, they should be rejected or used for technical purposes (19). We found, however, that at the places checked the fats used for human nutrition (preparing meals) or animal feeding were often of good quality with contents of polar materials below 15 %.

Results of quality assessment of the frying fat samples are presented in Table 4. As demonstrated by the data, 53.6 % of all samples were of good quality. 12.7 % just reached the discard point while the rest (33.7 %) were found to be deteriorated or highly deteriorated.

Second sample collection

After evaluating the results of the first part of the survey, we decided to undertake a second study on the places where the frying fat samples had proved to be deteriorated (with concentrations of polar materials above 25 %). The objective of this work was to check whether there had been any changes since the first sample collection.

Second samples were obtained from 53 places and with each sample a second questionnaire containing the same questions was filled in.

As the results were to be discussed in comparison with those of the first sample collection, data for the 53 places concerned had to be selected from total data and evaluated separately. After evaluating questionnaires and quality of the second samples, history of usage, operating conditions and degradation states of the samples were compared.

Table 4. Degradation state of the frying fat samples (data from 252 samples).

Polar components (%)	Distribution of samples in percent of total samples	Evaluation
< 10	8.7	good quality
10–15	15.5	
15–20	15.5	
20–25	13.9	
25–30	12.7	discard point
30–35	12.3	deteriorated
35–40	6.3	
> 40	15.1	highly deteriorated

Table 5. Comparison of questionnaires from first and second sample collections (data from 53 places).

Information	Distribution of answers in percent of total answers	
	First sample collection	Second sample collection
Type and usage		
Sample origin		
– privately owned fast-food service		43.4
– state or cooperative owned fast-food service		24.5
– privately owned restaurant		–
– state or cooperative owned restaurant		30.2
– plant of public facility		1.9
Type of fat		
– sunflower oil	47.8	47.2
– rapeseed oil	2.1	3.8
– lard	31.3	39.6
– mixture		
of sunflower oil and lard	14.6	9.4
of rapeseed oil and lard	4.2	–
other	–	–
One batch of fat is used for frying		
– one typ of food	79.2	62.3
– several types of food	20.8	37.7
Type(s) of food fried		
– breaded cutlets	28.1	26.6
– cutlets	1.6	–
– mince-meat balls	7.8	8.9
– fat rich meat (pork-ribs etc.)	–	1.3
– chicken	1.6	1.3
– fish	6.3	5.1
– liver (chicken, pork or beef)	3.1	7.6
– sausages	4.7	5.1
– French fries	21.8	17.7
– vegetables	1.6	2.5
– pastry (doughnuts or lángos)	23.4	22.8
Fat/food ratio (initial amount or fat related to one food portion)		
– < 1	7.1	5.0
– 1–2	7.1	10.0
– 2–4	16.7	15.0
– 4–6	26.2	7.5
– > 6	42.9	62.5
Thickness of fat layer in the fryer (cm)		
– < 5	16.6	24.5
– 5–10	39.6	36.7
– > 10	43.8	38.8
Material of the fryer		
– aluminium	20.8	17.3
– iron	29.8	28.8
– alloy metal	2.1	1.9
– stainless steel	41.0	44.2
– enamelled iron	4.2	5.8
– teflon coated iron	2.1	–

Table 5. contd.

Information	Distribution of answers in percent of total answers	
	First sample	Second collection
Mode of heating		
– gas	58.3	64.2
– electric	41.7	35.8
Actual frying temperature (°C)		
– < 160	2.0	4.2
– 160–180	2.0	12.5
– 180–200	10.4	6.2
– > 200	6.2	2.1
– unknown	79.4	75.0
Length of frying of the fat sample		
– days: < 1	31.3	43.4
1–3	20.8	26.4
3–5	14.6	11.3
5–8	12.8	7.5
> 8	20.8	11.3
– hours: < 10	57.8	59.2
10–20	6.7	14.3
20–40	8.8	10.2
40–60	6.7	2.0
> 60	20.0	14.3
Usual operating conditions		
Frying temperature		
a) Is it controlled?		
– yes by thermometer or automatic temperature control	15.1	20.8
– initial temperature is checked by pouring some flour or bread-crumbs into the fat	14.1	11.3
– no	70.8	67.9
b) What does the operator think the optimal frying temperature is?		
– < 160 °C	20.8	26.0
– 160–180 °C	25.0	37.4
– 180–200 °C	12.5	5.8
– > 200 °C	6.3	5.8
– no idea	35.4	25.0
Average daily length of frying (hours/day)		
– < 1	2.2	–
– 1–3	17.8	19.6
– 3–5	33.3	21.6
– 5–8	26.7	37.2
– > 8	20.0	21.6
The daily frying process is		
– intermittent	76.6	77.4
– continuous	23.4	22.6
During short (< 2 hours) breaks in frying		
– the oil is maintained at the frying temperature	2.4	–
– the temperature is decreased by 30–40 °C	19.5	22.9
– the heating is turned off	78.1	77.1

Table 5. contd.

Information	Distribution of answers in percent of total answers	
	First sample collection	Second
The frying fat is stored		
– in the fryer	53.2	49.0
– in the fryer covered	8.5	11.8
– in another vessel	34.0	27.4
– in another vessel, in refrigerator	4.3	11.8
Frequency of fryer cleaning		
– several times a day	6.4	5.7
– once a day	46.8	64.1
– two or three times a week	17.0	3.8
– once a week	12.8	20.7
– more seldom	14.9	5.7
– never	2.1	–
Frequency of oil filtration or sedimentation		
– several times a day	12.5	28.9
– once a day	54.1	55.4
– two or three times a week	14.6	2.2
– once a week	4.2	8.9
– more seldom	4.2	4.4
– never	10.4	2.2

Table 5. contd.

Information	Distribution of answers in percent of total answers	
	First sample collection	Second
Replenishment with fresh oil		
– yes	72.9	79.2
– no	27.1	20.8
Frequency of frying fat discard		
– several times a day	4.2	5.9
– once a day	25.0	29.4
– two or three times a week	29.0	21.5
– once a week	18.8	25.5
– once a fortnight	14.6	11.8
– more seldom	4.2	5.9
– never	4.2	–
Average length of frying of a batch of oil (hours)		
– < 10	40.0	42.0
– 10–20	8.9	16.0
– 20–40	22.2	14.0
– 40–60	6.7	8.0
– > 60	22.2	20.0

Table 6. Comparison of degradation states of frying fats from the first and second sample collections (data from 53 samples).

Polar components (%)	Distribution of samples in percent of total samples	
	First	Second sample collection
< 10	—	13.2
10–15	—	9.4
15–20	—	11.3
20–25	—	15.2
25–30	4.1	24.6
30–35	24.4	7.5
35–40	14.3	7.5
> 40	57.2	11.3

The comparison of the data from the questionnaires, presented in Table 5, showed that the second time there were slight improvements for several parameters (such as values and control of frying temperature, storage of fat, frequency of cleaning, filtration and oil discard), which certainly means that the operators' knowledge of optimal frying conditions had improved. This is conceivably attributable to the effect of instruction given by the inspectors during the first collection.

Comparison of the values for polar components (Table 6) shows much higher quality for the second samples. Besides instructions, there can be other reasons for this considerable improvement. In several cases, as the inspectors arrived accidentally, they took the second samples, by chance, shortly after the previous oil discard, so that these fats had been used for a shorter period than those of the corresponding first samples. Quality changes may also be associated with seasonal variation. Most of the first sample collection was done in summer, while the second was conducted in winter when even room temperature is much lower. At lower temperatures degradation of improperly stored (i.e. not in a refrigerator) frying fats during storage may be slower.

Conclusions

There are several conclusions to be drawn from the results of our survey on operating conditions and quality of commercial frying fats.

Results for 252 samples collected in the first part of the work indicated that a great number of Hungarian fryer operators know too little about optimal frying conditions (especially about frying temperature, storage of fat, ideal type of fryer, frequency of cleaning, filtration and oil discard), which leads to improper usage of frying fats. As a result of extended use and wrongly conducted frying procedures, the degradation state of frying fats was at the discard point for 12.7 % of the samples and 33.7 % of the fats and oils were of inacceptable quality. This was observed, above all, for

small, fast-food services. Only 53.6 % of all samples were found to be of good quality.

The second part of the work included a repeated sample collection with the aim of re-checking places where fat had proved to be deteriorated. As to operating conditions, slight improvements were observed, which was probably due to the effect of instructions given by the inspectors during their first visits. Quality of the fats was much better: in contrast to the selected first samples, 49.1 % of the second samples were of good quality.

Based on the results, we thought it useful to improve knowledge of proper usage and optimal frying conditions. In attempts to achieve this, a summary containing instructions on the subject was drawn up. It will soon be published and distributed among fryer operators in Hungary. For improving the quality of commercial frying fats, besides instructing operators, it appears to be necessary to introduce regulations and routine quality testings, too. Therefore, the results of the survey as well as our suggestion to introduce a regulation establishing a cut-off level of 25 % polar components were sent to the Hungarian Ministry of Health.

In a recent study (14) we described analysis of some commercial frying fats collected in our survey: all types of alteration products (polymers, cyclic fatty acids, geometrical isomers, oxidized polar materials, etc.) found in oils heated in laboratories were also detected in these fats used in actual frying processes. There are few papers reporting data (surveys or analysis) on commercial frying fats (5, 7, 8, 26). We have not found any reports on surveys including detailed information on the usual operating conditions and knowledge of the fryer operators on optimal frying processes. Nevertheless, it would be of interest to compare the results of our survey with similar ones conducted in other countries.

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Author's address:

Dr. Anna Gere, National Institute of Food Hygiene and Nutrition, Gyáli út 3/A, H-1097 Budapest (Hungary)