SHORT COMMUNICATION

Survey study of frying oils used by food services in the Czech Republic

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Summary

Frying practices at 135 Czech food services were investigated. The quality of their frying oil baths was evaluated by two rapid tests: Testo 265 (Testo, Lenzkirch, Germany), which determines content of total polar compounds (% TPC) and 3M LRSM (3M, Maplewood, Minnesota, USA), which determines the concentration of free fatty acids (FFA). Firstly, performance of the tests was verified by corresponding standard ISO methods, revealing a relatively good correlation (R^2 = 0.87 and R^2 = 0.93). Subsequently, these tests were used for a survey study of frying oil baths from food services. The quality assessment has indicated that majority of the samples was of good quality, while only 7% of samples exceeded the limit for total polar compounds (25% TPC) and only 1.5% of samples exceeded the limit for free fatty acids (2.5% FFA) and were at discard point or deteriorated. The study proved that rapid tests are an effective tool for quick evaluation of oil quality. On the other hand, the common practice of food services based on sensorial evaluation of frying baths was found in most cases to be sufficient to maintain the oil quality at an adequate level without the need to use chemical or physical tests.

Keywords

frying oil quality; total polar compounds; free fatty acids; food services; Testo 265; 3M LRSM

Frying is a common and popular method of preparing foods because it is fast, simple, develops typical flavour of foodstuffs and is very efficient from a culinary point of view. During deep frying, oils are repeatedly and often over long periods of time exposed to temperatures between 130 °C and 200 °C in the presence of the food that is being fried, and in the presence of air and water. The properties of frying oil have a principal effect on the quality of deep-fried foods [1, 2]. Impurities and degradation products that accumulate in frying baths worsen technical properties of the oil and spoil the food. They also have a negative effect on human health [1, 3].

The limits at which oil or fat needs to be replaced can be determined sensorially or according to the levels of selected deterioration products. Oil quality criteria include physical properties such as consistency, viscosity, colour and dielectric capacitance, and chemical markers e.g. free fatty acids (FFA), anisidine values, total polar compounds (TPC), peroxide value and others [4].

In a number of countries, food-related legislation includes practical instructions and agreed parameters specifying the overall content of degradation products, which helps to monitor oil quality during frying. The values of 2.5% for fatty free acids, 10% for polymer triacylglycerides of all lipids and 25% for total polar compounds are considered to be the upper limits [5].

Chemical methods for assessing oil quality are usually laborious, time-consuming and expensive. Practical monitoring of oil quality in food services, where the results have to be known quickly, requires simple, fast and easy procedures, without the use of chemicals [6, 7]. Recently, several rapid tests based on different approaches have come onto the market, e.g. Food Oil Senzor (Northern Instruments, Lino Lakes, Minnesota, USA), Very-Fry (Libra, Metuchen, New Jersey, USA),

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Fritest (Merck, Darmstadt, Germany), 3M LRSM (3M, Maplewood, Minnesota, USA), Testo 265 (Testo, Lenzkirch, Germany). Unfortunately, the results of independent studies focusing on feasibility of these rapid tests are rare and their conclusions are sometimes contradictory [8].

The objective of the study was to investigate commercial frying practices at 135 Czech food services. Cooking oil tester Testo 265, which measures the content of TPC, and chemical rapid test 3M LRSM, which determines free fatty acids content, were selected for the measurements. Feasibility of the tests was assessed against the results of standard reference methods.

MATERIALS AND METHODS

Preparation of model oil samples for the verification of rapid tests

Degradation was monitored during repeated frying of French fries in canola oil at 170 °C for 630 min in Moulinex deep fryer (Moulinex, Caen, France). Oil samples were collected after every frying cycle, which consisted of sequential frying of three 200 g doses of French fries, each for 8–10 min.

Oil collection in food services

Oil quality was monitored directly in 135 small- and medium-sized food services during their ordinary production practice. This survey included public cafeterias (schools and social care institutions, 46), restaurants and fast foods (89) where different products were fried in different kinds of vegetable oil.

Determination of TPC by Testo 265

Manufacturer's instructions were followed. The sensor was immersed into the oil bath and the value of TPC was read [9]. For the purposes of verifying the Testo 265 rapid test, the method of column chromatography ISO 8420:2002 [10] was used as a reference.

Determination of FFA by 3M LRSM

Manufacturer's instructions were followed. The testing strips were dipped into the oil bath for approximately 5 s and, after approximately 20 s, the results were read. With increasing deterioration of oil quality, the blue marks gradually turned to yellow [11]. The titration method EN ISO 660:2009 [12] was used as a reference method; its results were reported as a percentage of oleic acid.

Determination of oil quality by staff members of food services

Hedonic evaluation of oil quality according to sensorial parameters (colour, foaming, smell, impurities) was performed by the staff of individual establishments to assess whether the oil bath quality is acceptable or not.

Statistical analysis

The tests were done in triplicate for each sample and the mean values are reported. All statistical analyses were performed using Statistica 8.0 (StatSoft ČR, Prague, Czech Republic) and Excel 2003 (Microsoft, Redmond, Washington, USA).

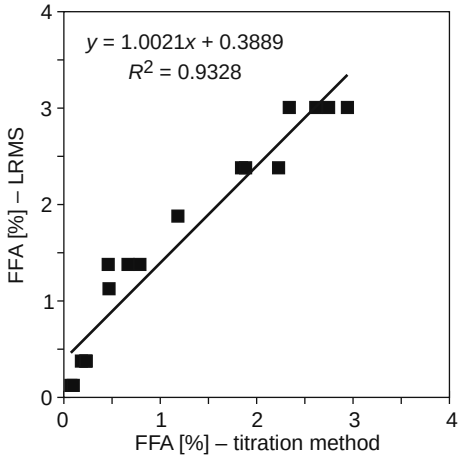

Fig. 1. Correlation between the content of FFA determined by 3M LRSM with the results of the titration method (n = 17).

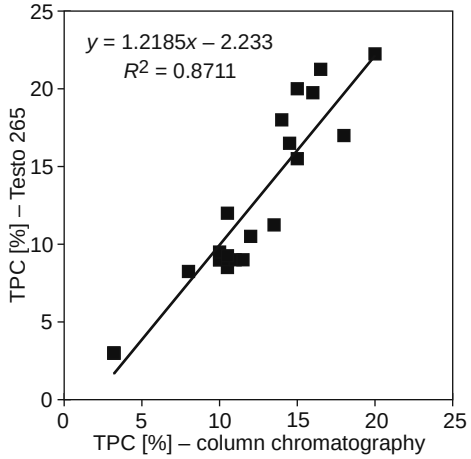

Fig. 2. Correlation between the content of TPC determined by Testo 265 with the results of the column chromatography (n = 21).

Tab. 1. Validation parameters and practical experience with oil bath quality monitoring methods.

	TPC by column chromatography (ISO 8420:2002)	TPC by Testo 265	FFA by 3M LRSM	TPC by titration method (ISO 660:2009)
Limit of detection [%]	0.1	0.5	0.1	0.5
Range [%]	0.1–40.0	0.5–40.0	0.1–5.0	1.0–2.5
Repeatability [%]	2.3	8.0	6.0	Impossible to evaluate*
Time requirements (n = 10)	1 000 min	5 min	5 min	120 min
Ruggedness	Relatively resistant, but difficult to perform and interpret results	Resistant against errors	Resistant against errors	Relatively resistant, but moderate difficulty to perform and interpret results
Correlation of the rapid and the reference method determined in our laboratory	R^2 = 0.93		R^2 = 0.88	
Correlation of the rapid and the reference method according to literature [8]	R = (0.88–0.99)		No correlation found	

* – Impossible to evaluate because of only visual assessment of the coloured strip.

RESULTS AND DISCUSSION

Verification of rapid tests

Correlations between the rapid tests and standard reference methods are depicted in Fig. 1 and Fig. 2. The comparison was performed on 21 and 17 laboratory-prepared model samples, respectively.

These results show clearly that the FFA contents determined by the 3M LRSM procedure were slightly higher than those found by the reference titration method. However, a relatively high value of correlation coefficient of results was obtained (R^2 = 0.93), which shows a good agreement between the two methods. Four samples with the content of FFA above 3% (measured by 3M LRSM) were not included in the correlation analysis, because the values were out of the linear range of the rapid test. These outliers were identified with specified (99%) confidence based on the results of Dixon's Q test.

A poorer correlation (R^2 = 0.87) was found between the total polar compounds determined by Testo 265 method and the reference column chromatography. This was most likely caused by worse repeatability of the Testo 265 measurements.

Nevertheless, the slopes of correlation curves of both procedures were very close to 1, therefore it can be concluded that the rapid tests are comparable to and replaceable for the reference methods, and are suitable for evaluating frying oil quality in food services. The parameters and practical experience with the individual methods for monitoring oil bath quality are summarized in Tab. 1.

Survey of oil quality in food services

The basic rule of the deep-frying process is not to use oil containing large amounts of polyene fatty acids, because such oil is less stable. The types of vegetable oil used in the survey (canola, sunflower, soy), unless partly hydrogenated or produced from cultivars with lower content of linoleic and linolenic acids, comply only partly with this rule and it is therefore necessary to monitor continually their level of degradation during frying.

Tab. 2. Contents of total polar compounds (TPC) and free fatty acids (FFA).

	TPC [%]	FFA [%]
Canola oil (n = 59)		
range	12.7–35.1	< 0.3–2.3
mean	16.7	1.5
median	15.3	1.8
Sunflower oil (n = 45)		
range	9.5–24.8	< 0.3–2.5
mean	14.4	2.0
median	14.1	2.3
Soybean/canola oil (n = 22)		
range	9.6–23.2	< 0.3–1.8
mean	18.1	1.6
median	18.1	1.8
Soybean oil (n = 9)		
range	10.7–17	1.3–1.8
mean	14.1	1.4
median	14.2	1.3

An overview of the value of examined parameters is shown in Tab. 2. FFA and TPC are the groups of compounds of a different structure and origin, and their increase indicates a different stage of oil degradation.

Fig. 3 illustrates freshness of analysed oils according to their TPC content. The highest average TPC values (18.1%) were found in the multi-species soybean/canola oil. For other types of vegetable oil, the average values of TPC were lower. The limit of 25% TPC was exceeded in a few samples of canola (17%) and sunflower (2.2%) oil. This result is better than the conclusion of the survey by DOBARGANES and MÁRQUEZ-RUIZ [13] in which more than 34.5% of all samples exceeded the limit.

Fig. 4 shows presents results on the quality of the tested oil according to the content of FFA. Less than 2% of the total number of collected samples was found to be unacceptable for further use. The highest concentration of free acids was found in the samples of sunflower oil; in 4.4% of samples the oil was unacceptable for further food preparation; in 46.8% the oil was found to be strongly used and needed to be replaced immediately.

In general, the results showed that soybean oil is the most suitable for deep-frying, as it contained the lowest amount of both TPC and FFA.

Not surprisingly, the results differed according to the type of food service; public cafeterias (schools and social care institutions) were found to maintain a better quality of their oil baths than restaurants and fast-food restaurants (Tab. 3).

Applied practice

The assessment of commonly applied good production practices in 135 facilities was focused on the ability of staff members to properly

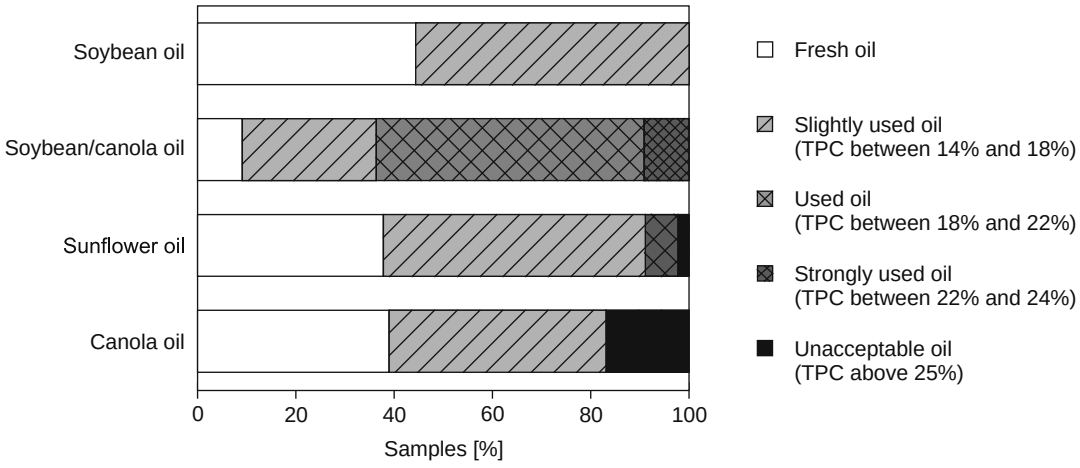

Fig. 3. Quality of frying oil according to the total amount of polar compounds (TPC).

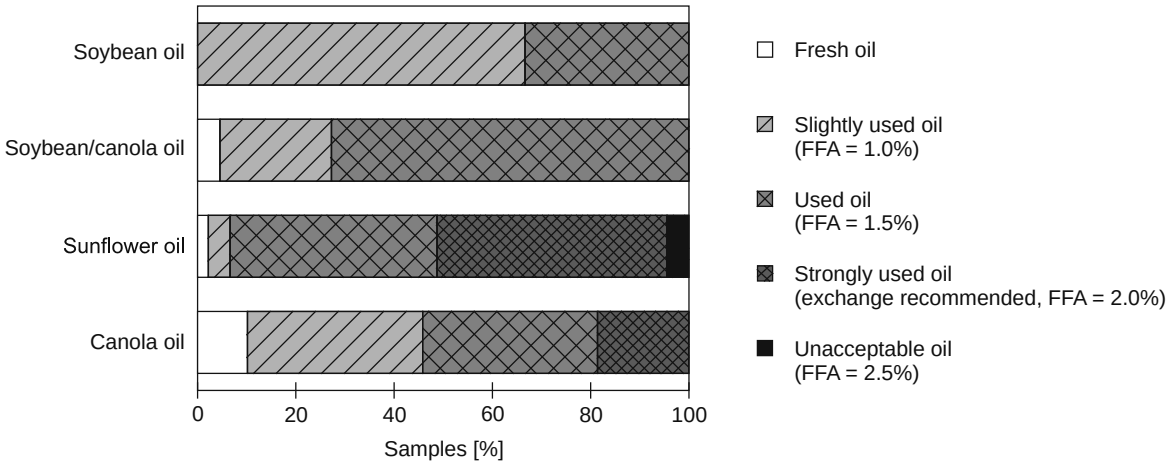

Fig. 4. Quality of frying oil according to the content of free fatty acids (FFA).

Tab. 3. Quality of frying oils in relation to the type of food service.

Quality of oil	Schools and social care institutions		Restaurants and fast foods	
	Proportion [%]			
	TPC	FFA	TPC	FFA
Fresh oil	54.3	10.9	23.6	3.4
Used oil	0	34.7	2.3	48.3
Strongly used or unacceptable oil	0	8.7	12.4	33.7

evaluate oil quality during frying. It was noticed that no chemical or physical tests of oil are used at the surveyed food services, and the freshness and suitability of used frying baths is assessed only based on sensorial properties.

The staff members of all 135 facilities were asked to evaluate colour, foaming, smell and impurities of their oil bath, and to decide if its stage is standard, strongly used or unacceptable and ready to be exchanged.

Forty-four percent of staff members evaluated the oil bath quality as standard; the rest identified the oil as strongly used or unacceptable. No correlation was found between the determined sensorial parameters and physical-chemical parameters; the majority of the staff evaluated the oil quality similarly or more strictly.

Such a responsible approach corresponds with the results of the performed survey that has shown the quality of frying oils used in Czech food services is at a satisfactory level. From the 135 facilities involved in the survey, only 7% exceeded the limit of TPC indicating that the oil needs to be changed immediately, and only 1.5% of samples contained an unacceptable level of FFA. Common practice of food services based on sensorial evaluation of frying baths was in most cases found to be sufficient to maintain oil quality at an adequate level.

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