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Quality and Sensory Evaluation of Used Frying Oil from Restaurants

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Summary

Deep fat frying is one of the most commonly used procedures for the preparation of food. The necessity of using a good quality frying medium becomes obvious when considering that some of the fat is absorbed by the food fried in it.

In 46 samples of used frying oil from restaurants in Zagreb or fast food outlets, iodine value, peroxide value, refractive index, free fatty acid (as oleic fraction), p-anisidine, total polar components, oxidized fatty acids and sensory properties were determined.

The aim of this study was twofold: first, to show the quality of used frying oil obtained from restaurants in Zagreb and fast food services; second, to correlate the results of some investigated physico-chemical parameters with sensory evaluation. Linear relationships among them were determined, coefficients of correlation were generally high (r = 0.850 – 0.942) and, consequently, very accurately predicting equations were obtained by regression analysis. It may be concluded that sensory evaluation is a fast and simple method and can be used as a reliable indicator in the frying oil quality estimation.

Key words: used frying oil, sensory evaluation

Introduction

Deep fat frying is one of the most commonly used procedures for the manufacture and preparation of food. It is known that during frying or heating without frying a complex series of chemical reactions, including thermal oxidation, hydrolisis polymerization, isomerization and cyclization, lead to formation and accumulation of a great number of decomposition products (volatile and nonvolatile) some of which may be nutritionally harmful. The extent and nature of these decomposition products are affected by the food being fried, the fat being used, the choice of the fryer design and the nature of the operating conditions (temperature, oxygen exposure, heating time, turnover rate). As these reactions proceed, the functional, sensory, and nutritional quality of frying fats is changed and may reach a point where it is no longer possible to prepare high quality fried products and the frying fat will have to be discarded. The necessity of using a good quality frying medium becomes obvious when considering that some of the fat is absorbed by the food fried in it. It, therefore, became important to assess the rate of degradation as well as to determine the endpoint at which the used frying oil has to be regarded as deteriorated (*1-3*). While much research has been expended in the study of the mechanisms and products of fat deterioration under laboratory conditions, relatively little recent information is available on the changes that occur in cooking fats and oils during use in restaurants and other establishments, especially in Croatia (*4-7*). For the quality evaluation of frying fats numerous methods have recently been introduced, including rapid tests on the spot and methods requiring laboratory facilities (modern separation techniques and

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Table 1. Physical and chemical properties of used frying oil samples

Iodine value $w(I_2)$/ (g/100g)	Peroxide value $n(O_2)/m$(sample) mmol/kg	Refractive index	Free fatty acids expressed as oleic fraction / %	p-Anisidine value	Total polar components w / %	Oxidized fatty acids w / %	Sensory evaluation scores
83.3	1.26	1.4737	0.62	89.6	27.1	0.99	12.4
119.4	2.57	1.4735	0.65	105.6	29.0	1.17	12.4
111.5	9.73	1.4736	0.66	123.5	31.3	2.48	11.6
119.9	1.29	1.4748	1.12	234.8	39.3	2.79	9.0
122.7	2.18	1.4741	0.22	41.7	8.9	0.13	17.0
131.4	30.61	1.4744	0.42	70.1	19.5	0.32	11.4
105.2	11.58	1.4733	0.66	122.8	31.3	1.31	11.0
93.6	0.67	1.4739	0.90	196.4	32.5	1.89	10.3
88.7	1.59	1.4718	0.98	204.0	28.5	1.40	9.4
127.1	2.83	1.4739	0.28	45.5	11.1	0.23	15.1
120.5	11.61	1.4737	0.50	72.3	18.1	0.35	14.1
95.3	7.99	1.4753	1.02	258.8	42.4	2.68	8.6
113.1	1.65	1.4722	0.53	74.2	11.3	0.08	14.1
123.5	1.97	1.4736	0.76	143.6	29.0	1.37	10.6
119.6	1.81	1.4726	0.32	65.4	21.5	0.49	14.7
113.0	9.62	1.4733	0.59	83.8	22.6	0.71	13.8
112.0	0.86	1.4725	0.65	112.8	26.5	0.98	12.0
98.1	4.05	1.4720	1.00	204.5	35.1	2.07	9.6
114.4	0.71	1.4737	0.65	117.5	29.6	1.54	11.8
113.3	8.44	1.4751	0.78	149.2	34.9	2.51	10.3
117.5	22.48	1.4741	0.56	79.3	20.8	0.51	13.9
132.8	0.57	1.4747	0.70	129.9	28.0	1.04	10.6
125.0	3.07	1.4740	0.25	40.1	9.5	0.11	16.4
115.1	2.81	1.4749	0.30	60.3	16.5	0.35	14.6
115.3	1.17	1.4736	0.62	95.2	25.8	0.73	13.1
106.1	1.79	1.4734	0.53	74.0	21.4	0.46	14.1
87.0	5.62	1.4750	1.18	244.8	37.5	2.61	9.0
72.5	13.64	1.4735	0.73	129.0	30.4	2.48	10.7
121.6	1.67	1.4745	0.40	72.5	18.8	0.20	14.4
118.6	1.33	1.4747	0.59	88.9	20.2	0.34	13.2
115.0	6.12	1.4754	0.64	101.6	24.2	0.35	12.3
83.4	1.51	1.4742	0.56	84.4	18.2	0.29	13.6
135.0	1.93	1.4738	0.36	61.8	14.8	0.32	14.6
114.8	6.04	1.4749	0.61	89.2	19.4	0.24	13.1
109.1	8.30	1.4718	0.30	59.3	13.6	0.70	15.3
126.4	2.74	1.4745	0.25	40.9	11.5	0.09	16.4
117.6	3.51	1.4718	0.20	21.3	7.7	0.05	17.6
103.6	9.48	1.4754	0.67	124.4	29.2	1.08	11.0
108.9	6.15	1.4745	0.90	192.3	32.2	1.23	10.3
116.8	6.70	1.4767	0.81	205.0	32.4	1.42	10.3
105.5	25.41	1.4734	0.76	126.2	32.1	1.67	10.6
122.8	5.09	1.4746	0.42	70.6	21.4	0.72	14.3
99.2	5.27	1.4732	0.90	201.1	33.0	1.91	10.1
133.5	1.39	1.4747	0.36	63.7	19.0	0.10	14.8
139.0	1.85	1.4747	0.25	38.4	12.5	0.12	15.5
128.5	2.63	1.4748	0.39	70.6	23.8	0.68	14.4

spectroscopic methods) (*8-13*). Because the more complicated time-consuming tests tend to monitor quality changes more accurately, a number of researchers have attempted to study the correlation of these test results with those of the simpler physical and chemical tests (*14-17*). The objectives of this work were to study the quality of used frying oil from restaurants in Zagreb and fast food outlets, and to evaluate the relationships among the data of some chemical methods and sensory evaluation as a simple, fast and accurate method.

Materials and Methods

Used frying oil samples were collected at random from restaurants and fast food outlets in Zagreb. There was no information about foods cooked, type of frying oil, conditions of usage including temperature, hours per day, days used, type of filter and frequency of filtration. Used hot frying oil samples were obtained directly from the frying cookers, put directly into glass bottles and allowed to cool. Collections of used frying oil samples from all restaurants were made over a period of one week. At the laboratory all samples were stored at 4 °C until analyzed.

Iodine value, peroxide value, refractive index and percentage of free fatty acids were determined according to AOAC methods (*18*). Anisidine value, total polar components and petroleum ether-insoluble oxidized fatty acids content were determined according to IUPAC methods (*19*). Sensory analysis was conducted in sensory laboratory by five expert assessors, using a scoring system with weighted factors on the 20-point scale (*20*). They tested three samples daily (50 mL sample served in beaker) with half hour intervals between each session.

Results and Discussion

The obtained results are summarized in Table 1.

Iodine number is an accurate measure of the total number of double bonds present in fat and therefore decreases in used frying oil. Reduction in iodine number is, therefore, quite a useful measure of overall deterioration, but it is not useful in determining whether an oil is suitable for further use as in this case there was no information about iodine value in fresh oil samples before frying.

Under frying conditions the peroxides decompose rapidly to give secondary oxidation products. Therefore, the peroxide value was not proved to be a useful test for frying oils. It can be quite misleading because peroxides continue to be formed not only while the oil is cooling down but also before it is tested. The obtained value therefore probably does not reflect conditions in the fryer and the degree of deterioration caused by frying.

Refractive index is characteristic of oil type and offers some identification opportunities among unsaturated, conjugated, hydroxy-substituted, or uniquely structured members. Increases in molecular weight and degree of unsaturation cause increases in refractive index. In this case this measure was not satisfactory for quality control evaluation.

The development of free fatty acids (FFA) arises partly from hydrolysis, but also partly as an end product of oxidation. It is therefore dependent on the food being fried as well as on the equipment, the amount of heating, *etc.* The upper limit of FFA, when oil must be discarded is between 1 and 2 % (as oleic fraction/%) (*1*).

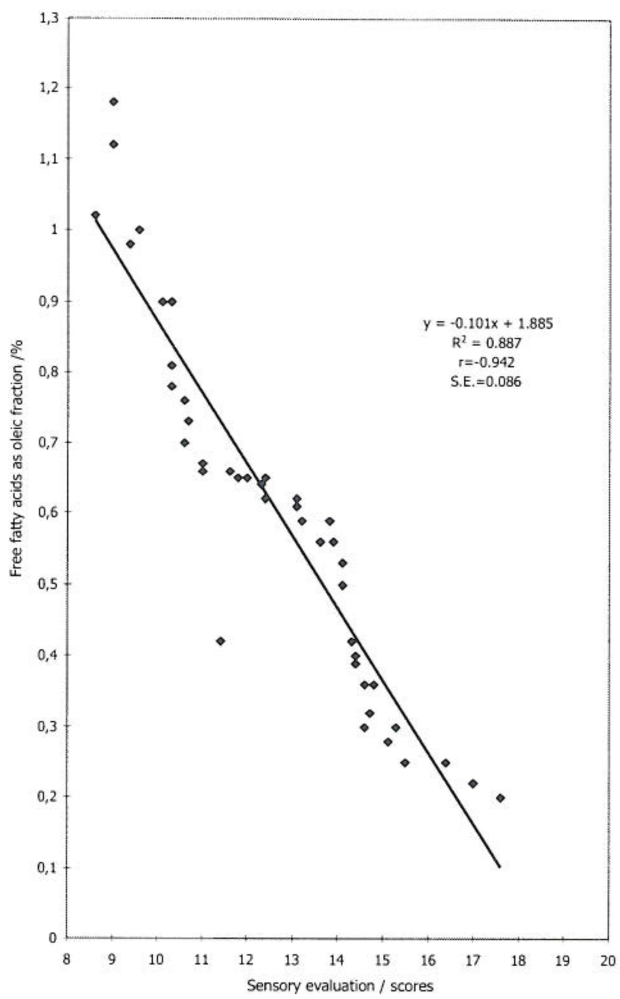

Fig. 1. Correlation between sensory evaluation and free fatty acids content in used frying oil samples

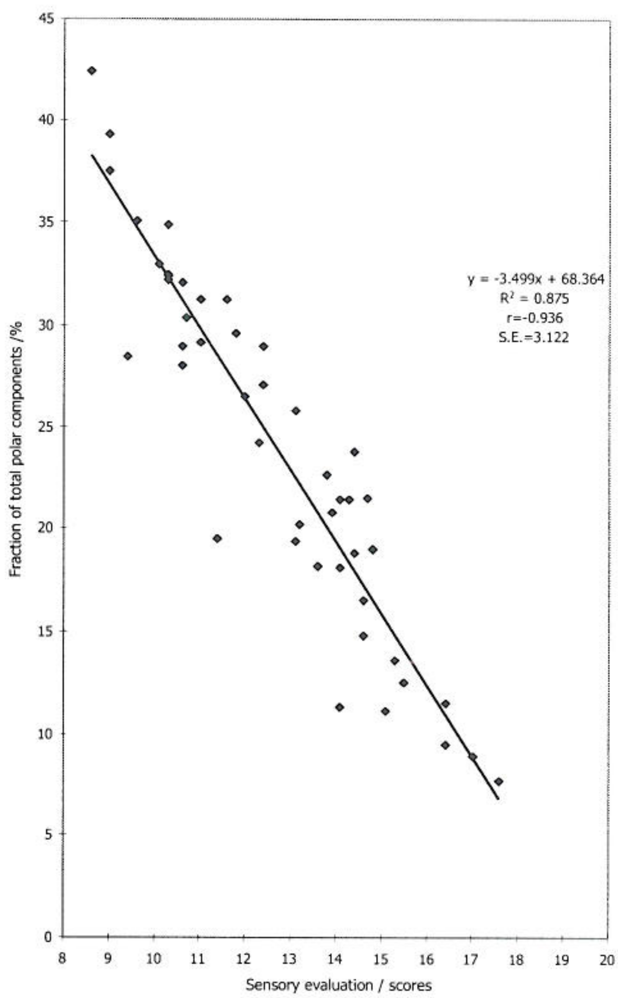

Fig. 2. Correlation between sensory evaluation and total polar components in used frying oil samples

Therefore, 43 samples were suitable for further use, while 3 were spoiled.

Anisidine value measures aldehydes which have resulted from oxidation and subsequent breakdown. Small molecules of breakdown products are rapidly volatilised from fryer while large fragments still attached to glycerol remain behind, and are measured in this test. Therefore, the anisidine value does not give a measure of progressive deterioration of the oil.

Total polar components reflect the total level of breakdown products from the frying process. The researchers found that 25 and 29 % total polar components corresponds to 0.7 and 1.0 % oxidized fatty acids, respectively (*21*).

Oxidized acids are an overall measure of the fatty acids in the glyceride molecules that have formed stable new compounds with oxygen. This measure has been widely adopted in Europe as a test to determine suitability for further use. Numerous European countries and the U.S. have specific regulations against the use of deteriorated frying fats and oils. According to these regulations frying fat should not have polar components above 27 % or oxidized fatty acids insoluble in petroleum ether above 1.0 % (*22,23*). In this study, with respect to total polar components, 19 samples reached the cut-off level while 27 were suitable for further use. With regard to oxidized acids, 19 samples also exceeded the regulation limit, while the remaining 27 were below the limit value.

According to some regulations a used fat is considered to have deteriorated if its odour and flavour are definitely not acceptable. Here, sensory evaluation showed out that 16 samples were below the regulation limit (≤ 11.2) and had to be discarded.

Measuring the oil quality is a complex problem and an on-line sensor is needed. A number of researchers have attempted to study the correlation of complicate, time-consuming tests results with those of the simpler and faster tests. In this work sensory evaluation was taken as a faster and easier method and correlated with some of the analysed physico-chemical parameters. A high correlation (r = 0.850 – 0.942) was obtained between sensory evaluation and free fatty acids (Fig. 1), total polar components (Fig. 2), oxidized acids (Fig. 3) and p-anisidine value (Fig. 4). A high correlation (r = 0.898) was obtained between p-anisidine value and total polar

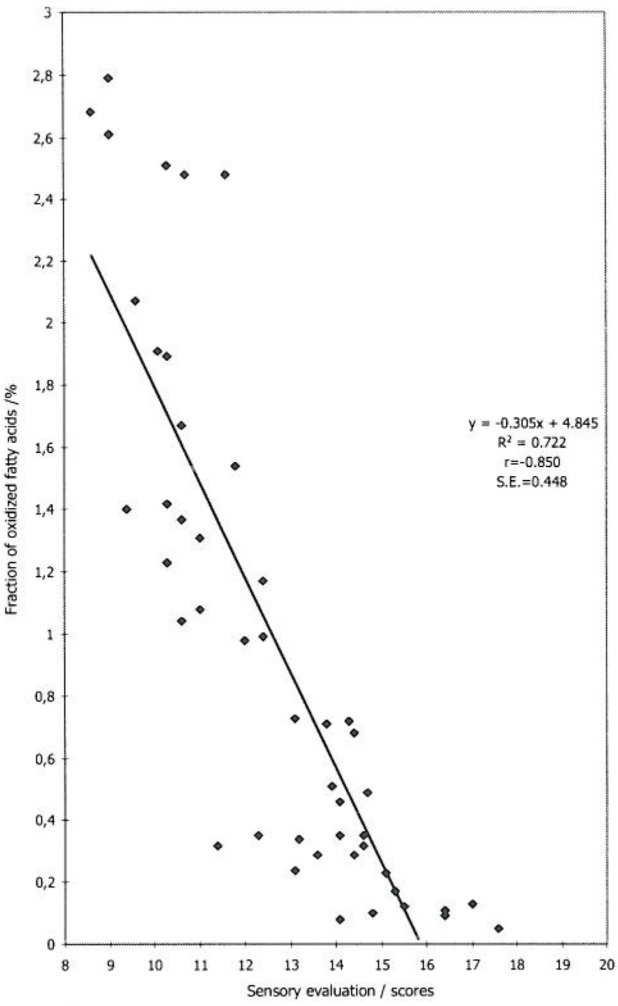

Fig. 3. Correlation between sensory evaluation and oxidized fatty acids in used frying oil samples

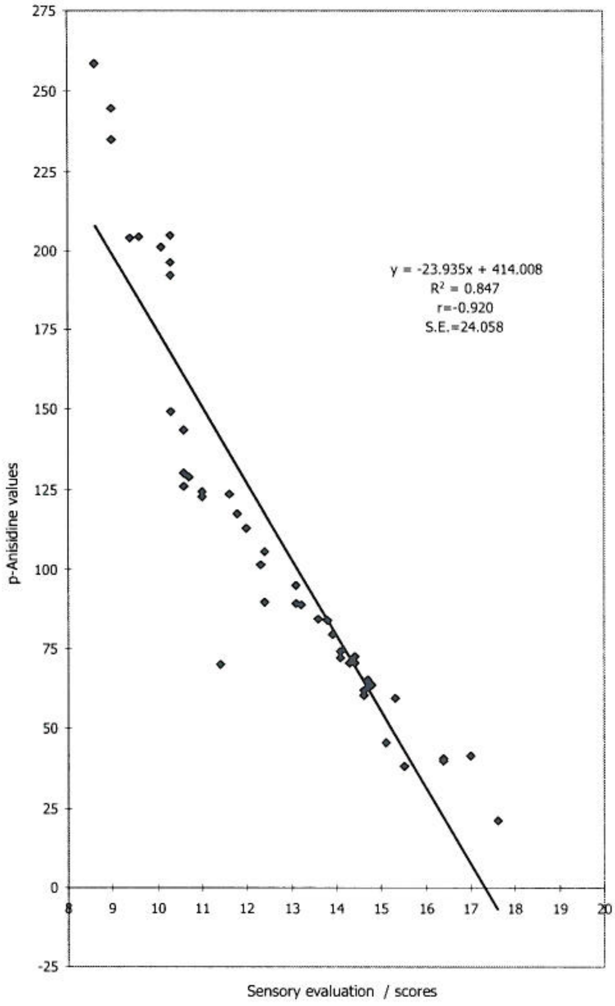

Fig. 4. Correlation between sensory evaluation and p-anisidine value in used frying oil samples

components, too (Fig. 5). The relationships shown in Figs. 1-5 are very close to linearity. In fact, they are exponential or polynomial, and not exactly linear, but linear relations were used for simplicity, and the use is justified by only very small deviations from linearity.

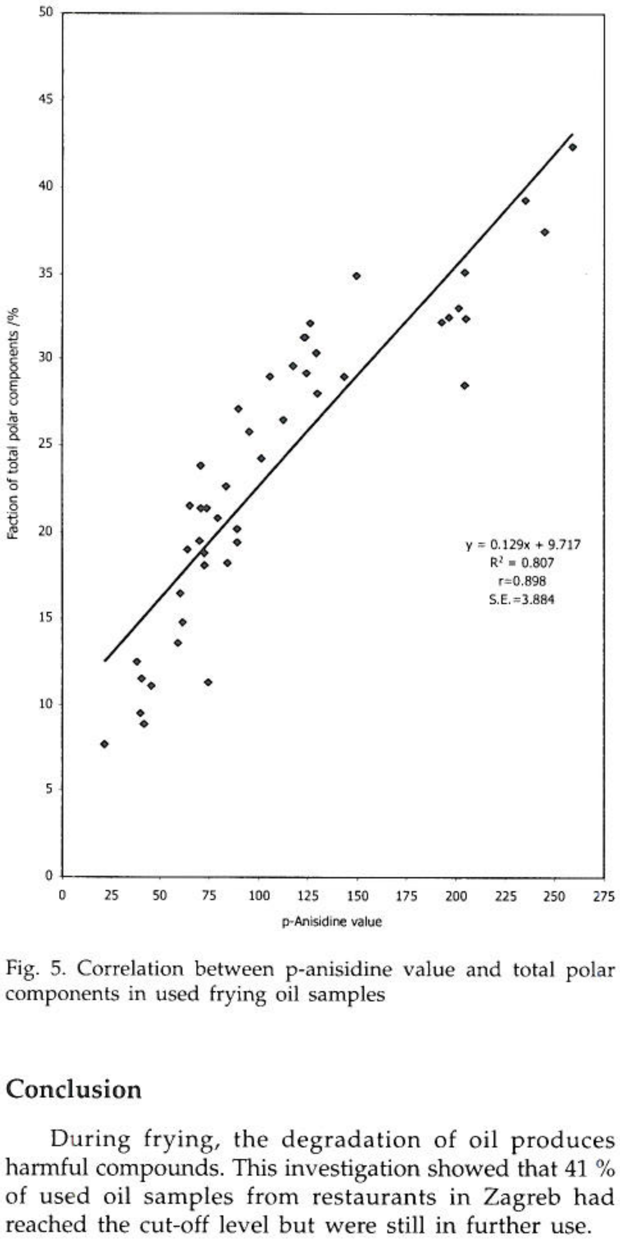

Fig. 5. Correlation between p-anisidine value and total polar components in used frying oil samples

Conclusion

During frying, the degradation of oil produces harmful compounds. This investigation showed that 41 % of used oil samples from restaurants in Zagreb had reached the cut-off level but were still in further use.

Due to the absence of a suitable on-line frying oil quality sensor in restaurant conditions, the sensory evaluation conducted by expert panel has proved to be useful and reliable for routine quality control testing. A very good correlation between this method and total polar components and oxidized acids, which are subject to specific regulations for control of frying fats and oils worldwide, is obtained.

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Kakvoća i senzorna procjena već korištenog ulja za prženje iz zagrebačkih restorana

Sažetak

Prženje u dubokom sloju masnoće jedan je od najčešćih načina pripreme hrane. Prijeko je potrebno koristiti ulje za prženje dobre kakvoće jer se djelomično apsorbira u hranu prženu u njemu. Stoga je važno odrediti brzinu degradacije, a i krajnju točku do koje je ulje upotrebljivo.

U 46 uzoraka upotrijebljenog ulja za prženje iz zagrebačkih restorana i prodavaonica brzo pripremljene hrane određeni su: jodni broj, peroksidni broj, indeks refrakcije, udjel slobodnih masnih kiselina (izražen kao frakcija oleinske kiseline), p-anisidinski broj, udjel polarnih spojeva i udjel oksidiranih masnih kiselina. Određena su i senzorna svojstva ispitivanih ulja.

Svrha je ovoga istraživanja bila dvojaka: odrediti kakvoću ulja za prženje iz zagrebačkih restorana i prodavaonica brze hrane i usporediti rezultate istraživanih fizikalno-kemijskih pokazatelja sa senzornom kakvoćom. Rezultati su pokazali visoke koeficijenta korelacije ($r = 0.850 - 0.942$) između istraživanih fizikalno-kemijskih pokazatelja i senzorne kakvoće te su regresijskom analizom dobivene točne, očekivene jednadžbe. Dakle, senzorna procjena kao brz i jednostavan postupak može biti pouzdan pokazatelj kakvoće ulja za prženje.