NIR CLASSIFICATION OF FRYING FAT SAMPLES BY MEANS OF POLAR QUALIFICATION SYSTEM

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Albert Apponyi programme

Established by the support of the National Office for Research and Technology.

NKTH

INTRODUCTION

Food consumption habits have changed significantly within the past decades. Today deep fat frying is a very important method of cooking in the food service industry. In the Hungarian culinary technology the mainly important oils are sunflower and rapeseed, while porcine subcutaneous fat, referred to as lard is still traditionally used. In some special instances, melted goose fat is also used. The heating conditions are generally less controlled and the temperature interval ranges from 150 to ca. 220 °C. Natural fats start decomposing from the initial moment when they are isolated from their original environment. Decomposition and deterioration at such high temperatures are augmented, while all these processes drastically decrease the original nutritional value of fats. Consequently, there is a demand for quick quality assessment methods for quality control purposes. The aim of the present study was to test the applicability of Polar Qualification System[1] (PQS) for identifying different sets of oil and fat samples by their near infrared (NIR) spectra.

MATERIALS AND METHODS

Aliquots (450 g) of four commercial frying media, i.e. rapeseed and sunflower oils, goose and pig fats were heated at 140, 150, 160, 165, 170, 175 and 180 °C for a total of 36 hours, in a single run. Sampling was done using the hot aliquots, after 4, 8, 12, 16, 20, 24, 28, 32 and 36 hours of treatment. (Total sample number was: 9 samplings x 7 temperatures x 4 types = 252) To define the doses of heat-treatment, the so-called "heat-sum value" [°Cxh] was introduced (heating temperature [°C] x duration of heating [hours]). Samples of each types were sorted into four heat-sum classes ((1) below 1500 °Cxh, (2) 1501–3000 °Cxh, (3) 3001–5000 °Cxh, (4) above 5001 °Cxh) representing different stages of fat deterioration during commercial use.

Samples were scanned at 20 °C using camlock cell, with aluminium-plated reflector back (layer thickness = 0.1 mm). FOSS NIRSystem 6500 spectrometer (Foss NIRSystems INC., Silver Spring, MD) was used to measure transflectance spectra (1100-2500 nm) with a spectral step of 2 nm. Log(1/R) spectra acquisitions were performed with WinISI II version 1.5 software (InfraSoft International, Port Matilda, PA). The recorded spectra were analysed with PQS32 software (MetriNIR Research, Development and Service Co., Budapest, Hungary). PQS was utilized for identification of types or heat-sum classes. In PQS the so called quality points of the samples were defined as the gravity point of the smoothed second derivative spectra represented in the polar co-ordinate system. Using wavelength range optimization algorithm, the wavelength ranges providing the best classification results were calculated. Non selected intervals were zero. The effectiveness of the classification is expressed numerically by the sensitivity value (distance of two spectral groups divided by the sum of the deviations). Sensitivity shows how much the distance is larger than the sum of the standard deviations of the groups (the greater value, the more difference between groups).

RESULTS AND DISCUSSION

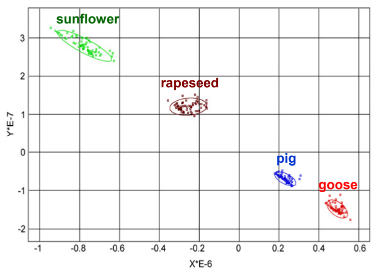

Figure 1 Location of the quality points of the investigated samples by types (1160-1200 nm)

Table 1 Sensitivity of classification of fat or oil types (results concerning 1160-1200 nm wavelength interval)

1160-1200 nm	Rapeseed oil	Sunflower oil	Lard
Sunflower oil	4.610		
Lard	6.916	10.835	
Goose fat	10.458	13.546	4.842

Table 2 Results of the identification of heat-sum classes within fat and oil types, respectively. Sensitivity is presented under the diagonal line. The optimal wavelength range [nm] for the respective classes is presented above the diagonal line. **Heat-sum classes: (1) below 1500 °Cxh; (2) 1501–3000 °Cxh; (3) 3001–5000 °Cxh; (4) above 5001 °Cxh**

type	class	1	2	3	4
Rapeseed oil	1		**1424-1472**	**1916-1988**	**1128-1396**
	2	**1.855**		1412-1540	1928-2020
	3	**3.653**	1.393		1108-1892
	4	**6.858**	3.079	2.052	
Sunflower oil	1		1436-1456	1124-1412	2012-2036
	2	1.599		1932-2036	1120-1400
	3	2.861	1.630		1524-1560
	4	4.736	3.060	1.710	
Lard	1		**1420-1492**	**2100-2124**	**2092-2204**
	2	**0.962**		1964-2072	1124-1408
	3	**1.437**	0.745		2092-2204
	4	**3.218**	2.336	1.612	
Goose fat	1		1140-2004	2092-2204	2088-2200
	2	1.274		2092-2200	1128-1412
	3	1.697	0.950		1828-1856
	4	3.420	2.463	1.452	

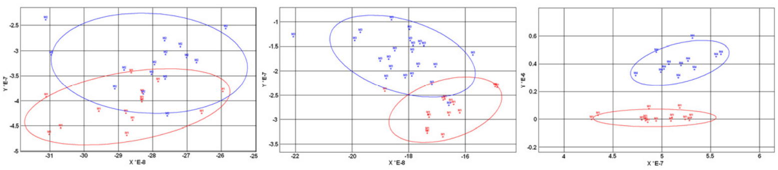

Figure 2 Location of the quality points of lard (pig fat) samples. a) class 1 vs. class 2: Sensitivity = 0.962, wavelength range = 1420-1492 nm; b) class 1 vs. class 3: S = 1.437, range = 2100-2124 nm; c) class 1 vs. class 4: S = 3.218, range = 2092-2204 nm

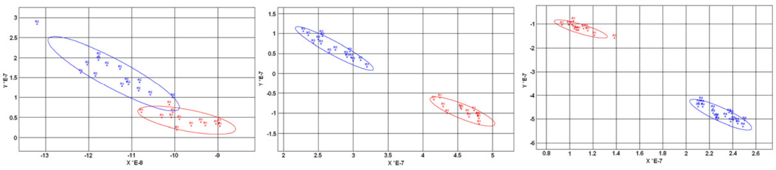

Figure 3 Location of the quality points of rapeseed oil samples. a) class 1 vs. class 2: Sensitivity = 1.855, wavelength range = 1424-1472 nm; b) class 1 vs. class 3: S = 3.653, range = 1916-1988 nm; c) class 1 vs. class 4: S = 6.858, range = 1128-1396 nm

Wavelength optimization was run for all fat and oil types in pairs, respectively. Sensitivity was always higher when vegetable and animal products were compared, which showed the marked difference between the NIR spectra of these two primary groups. 1160-1200 nm wavelength range was found to give very precise results for all coupling of types (**Figure 1, Table 1**), thus this interval can be a basic filter to find which type of culinary fat or oil an unknown sample belongs to. After fat and oil types were identified, repeated classifications and wavelength optimizations were run on heat-sum classes within all fat and oil types, respectively. Results, concerning sensitivity and optimal wavelength are shown in **Table 2**. Considerable differences were found in sensitivity values of animal fats and vegetable oils. Lard presented the lowest values, while most accurate separation of heat-sum classes was found in rapeseed oil (**Figure 2** and **Figure 3**). All coupling of classes gave satisfactory results (>1) in both vegetable oils, which means that less than 1500 °Cxh is already detectable efficiently (less than 8 hours of appliance of oil on operating temperature). Accordingly, after recognition of the type of culinary fat or oil, also the doses of appliance can be predicted by sorting an unknown sample into heat-sum classes.

CONCLUSION

Types of frying oils or fats, and doses of heating were properly identifiable by means of PQS-based NIR spectra analyses. The more difference was in the amount of heating, the more accurate discrimination of the groups was performed. Weaker results obtained for animal fats show that vegetable oils underwent more expressed degradation during heating. The mostly applied vegetable oils can be tested accurately from the early stage of usage, while short heating results also detectable changes.
Near infrared reflectance technique combined with polar qualification system is ideal for monitoring quality alterations of culinary frying fats and oils without any sample preparation procedure. It provides a quick, accurate, solvent-free and non-destructive tool for finding over-used, wasted frying fats and oils in the practice.

ACKNOWLEDGEMENT

This work was established by the support of the National Office for Research and Technology (BGY_IDRC) and by the Bolyai Research Grant (BO-00108/07) by the Hungarian Academy of Science. The Award of the Council For Near Infrared Spectroscopy is gratefully acknowledged. Thanks are due to Professor Karoly Kaffka and his team at the Corvinus University of Budapest for the kind guidance.

[1] Kaffka, K.J., Gyarmati, L.S. (1998): Investigating the polar qualification system. Journal of Near Infrared Spectroscopy, 6, A191-A200.

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