THE USING OF NEAR INFRARED SPECTROSCOPY WITH THE FOURIER TRANSFORMATION FOR THE DETECTION OF THE TYPE AND THE DEGREE OF COFFEE ROASTING

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ABSTRACT

The aim of this study was to verify the possibility of using near infrared spectroscopy with the Fourier transformation (FT-NIR) for the quality control and the determination of the *Arabica* coffee origin in three roasting profiles. Differentiation of the measured spectra is demonstrated by the discriminatory crosses in most of our analyses, all the variations between groups were sufficient. Colour was best distinguished at the profile of filtration according to the CIELAB system and it was confirmed by sensory analysis. Profiles of Costa Rica and Ethiopia were not distinguished by coffee degustation.

Key words: roasting, FT-NIR, quality, colour, sensory analysis

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INTRODUCTION

In the quality control, authenticity of coffee accuracy and ease of measurement, there are important some factors (Bogdanescu et al., 2005). Sensory profile is an applicable method for the determination of the type and roasting degree of the coffee (Bicho et al., 2013), moreover it is an effort to use a quick and easy repeatable methods of the quality control of food (McCraig, 2002). Mathematical models based on chemometric analysis may describe the acidity, bitterness, taste, purity, body and overall quality of the coffee. The spectra areas important for sensory analysis are closely related to the NIR spectra of caffeine, trigonelline, cellulose, 5 CQA, lipids, sucrose and other substances (Ribeiro et al., 2011). Although, there is only a small quantity of substances in coffee, identification can be based on the analysis of coffee (Pohl et al., 2013) and also by-products (Pascoe et al., 2013). Quality is determined by flavour and aroma, which are acquired during the roasting process. It depends on the variety and origin, conditions and procedures during harvest, storage and, especially on the time and temperature of the roasting profiles (Ruosi et al., 2012). Our aim was to verify whether NIR Antaris FT spectrometer is able to detect differences in our comparisons of selected samples of coffee in the terms of their origin or roasting technology, which serves as a quality control of the process for smaller coffee roasters.

MATERIAL AND METHODS

Two origin-based of Arabica coffee - Costa Rica Fancy SHB Miralinda Especial and Ethiopia Yirgachffe washed Gr. 2 were used in this experiment. Coffee Costa Rica SHB (Strictly Hard Bean) was grown at high altitudes; grains are characterized by the wrinkled texture and the compact size. Ethiopia Coffee was grown in Yirgachffe, which is located in hilly terrain in southwest Ethiopia and it was processed using the wet method. Both species were roasted at three different roasting profiles thus, there were available six different samples and the repetition was performed twice (Tab. No.1).

Tab. No.1 Overview of combination of coffee roasting profiles used in the experiment

Kind	1st roasting profile	2nd roasting profile	3rd roasting profile
Costa Rica	Costa Rica	Ethiopia	Filtration
Ethiopia	Costa Rica	Ethiopia	Filtration

Profile No. 1 (normally used for coffee, Costa Rica) is a single-phase profile, where the output air temperature is 235 °C and the temperature of grain is 229 °C. Roasting is proceeded 8 minutes and 34 seconds. Profile 2 (normally used for coffee, Ethiopia) is a two-phase profile. While roasting, after the fifth minute of the first roasting phase, when the air temperature is 195 °C, and grains 185 °C, the temperature immediately is increased to 235 °C of outlet air and to 227 °C of grains. Unlike the first profile, the temperature is not increased gradually, but suddenly in the middle of roasting. The roasting of the profile No. 2 is proceeded for 12 minutes and 16 seconds. The profile No. 3 is a new, experimental profile used for coffee intended for the filtration and it is based on the profile No. 2 with the difference that the cut off is after 9 minutes at an air temperature of 228 °C and grains 220 °C.

We used the device Antaris FT-NIR for the measurement. It uses a tungsten-halogen lamp as a radiation source and a KBr beamsplitter. As a comparative beam, there is a helium-neon laser. A computer connected to the spectroscope disposes with the control softwares of Omnic version 7.3 and Result Integration (ThermoNicolet Corp., USA). All samples were prepared in five repetitions and each one was measured twice. We used the control program TQ Analyst, which has created an average spectrum and which was subsequently used for the evaluation. Measurement was firstly carried out in the form of beans and then after the milling, in the mode of interactance on the optical probe by 100 scans and at a resolution of 8. The discriminatory cross between both ways of roasting, countries of origin and, the measurement of samples in the form of beans and after milling was created by using discriminant analysis in the programme TQ analyst. All analyses were performed on the confidence level α = 0.95. Data were processed in the UNISTAT 05.01

RESULT AND DISCUSSION

The first discriminant analysis shows results of comparison of grains by integrity, which means whether the grain was whole or milled. The spectroscope was able to safely identify and distinguish milled and unmilled samples, although it was the same coffee (the Fig. No.1). This may be caused by changes of the chemical composition and structure of coffee after grinding.

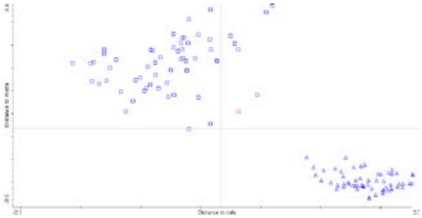

Fig. No. 1 Discriminant cross of differences between milled (□) and unmilled (Δ) grain

The third roasting profile filtration (3) was significantly recognized from profiles Costa Rica (1) (Fig. No. 2) and Ethiopia (2) (Fig. No. 3), distinction of the basic profiles (1 versus 2) does not showed compelling differentiation of the measured spectra, although this difference is sufficient (Esteban-Diez et al., 2004) for subsequent quality control during the production (Fig. No. 4).

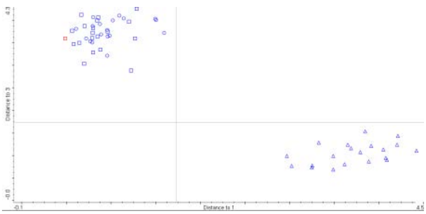

Fig. No. 2 Discriminant analysis conducted for the roasting profile of Costa Rica (□) and filtration (Δ)

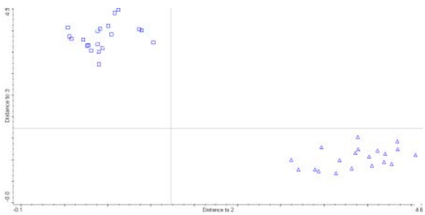

Fig. No. 3 Comparison of roasting profiles for roasting profile of Ethiopia (□) and filtration (Δ)

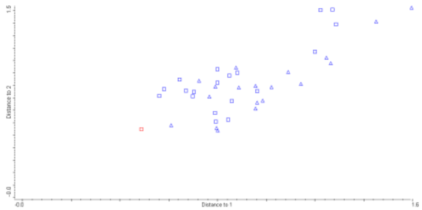

Fig. No. 4. Comparison of roasting profiles of Costa Rica (□) and Ethiopia (Δ)

Other tests, which were conducted by discriminant analyzes, were used for the differentiation of the measured spectra on the basis of the above results. We have compared other profiles of filtration and grains, not according their roasting profiles, but according country of its origin (Fig. No. 5). Even in this analysis, the differences were detected by spectroscope. The fact, that the spectroscope also shared the roasting profile filtration to a higher level of significance, e.g. which is confirmed by the work of Ribeiro et al. (2011), was satisfactory.

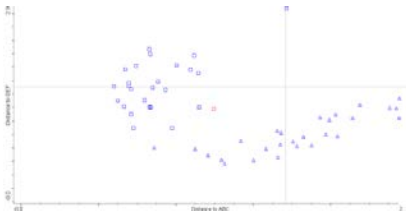

Fig. No. 5 Discriminatory cross showing the difference between coffee Costa Rica (□) and Ethiopia (Δ)

By the analysis of ground coffee using a spectrophotometer KONICA MINOLTA (CIELAB system) in the visible region of the spectrum (Tab. No. 2) differences were detected ($P < 0.05$) in lightness not only between Costa Rica and Ethiopian coffee, but also between profiles of Costa Rica (1) and Ethiopia (2) against the profile filtration. For the colorimetric determination of coffee, models SCE, d/8, D65 were selected.

Tab. No. 2 Colour of milled coffee assessed in the CIELAB ($\bar{x} \pm s_d$)

	Costa Rica			Ethiopia		
	Profile 1 (CR)	Profile 2 (ET)	Profile 3 (FI)	Profile 1 (CR)	Profile 2 (ET)	Profile 3 (FI)
L* (D65)	26,91 ± 1,68	26,10 ± 0,43	32,19 ± 0,59	25,12 ± 1,45	24,61 ± 1,03	27,72 ± 0,96
a* (D65)	9,77 ± 0,23	10,52 ± 0,22	12,61 ± 0,23	9,52 ± 0,21	9,79 ± 0,68	12,60 ± 0,62
b* (D65)	11,13 ± 0,45	11,79 ± 0,65	18,45 ± 0,22	10,03 ± 0,14	10,72 ± 0,71	16,93 ± 1,86
ΔE^*_{ab}	C	1,29	9,46	2,11	2,34	6,51

L* - lightness, C – standard to comparison

a*, b* - colour coordinates

ΔE^*_{ab} - just noticeable difference between the measurements

Sensory analyse did not confirm any differences between the profile of a given region. Roasting filtration profile of respondents was evaluated more negatively than the other two profiles for both coffees.

CONCLUSIONS

The device Antaris FT-NIR in cooperation with TQ Analyst program recognized and identified the differences of selected samples. TQ Analyst compared specimens of the country of origin, integrity and the technology of grain roasting. Our main objective was to determine whether these groups show differences of the chemical composition and whether the spectroscope Antaris FT NIR is able to identify them. Differentiation of the measured spectra in a discriminatory Cross has been proven in most of our analyses. The differences between groups were large and so they were divided into two groups, depending on the size of the differences which are likely to be very far from each other. Only the comparison of the profiles of Costa Rica and Ethiopia coffee with variations of chemical composition could not be convincingly demonstrated. FT-NIR method is the most convincing of the all methods used.

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