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Classification of different roasting processes by MOX nanowire

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Abstract

In the industry of coffee, to obtain a cup of coffee with a balanced aroma, every step in the coffee production chain is crucial; one of the most important steps is the roasting process.
The roasted coffee is one of the most difficult food matrixes for the complexity of the aroma (VOCs).
The aim of this study was to monitor different roasting processes using a novel electronic nose, equipped with an array of MOX gas sensors based on thin films as well as nanowires, in parallel with classical colorimetric techniques to define the homogeneity of the final coffee samples.

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Keywords: MOX nanowire; Rosted coffee; Electronic nose; Colorimeter; Coffee origin; Roasting method;

1. Introduction

The roasting process generates all of the flavor and aroma that we enjoy in coffee cup. Commercially available coffee beans are derived from two genotypes *coffea Arabica* and *coffea Canephora* var. robusta [1], [2]that are cultivated in many tropical countries [3].

For the consumer, flavor is perhaps the most important aspect of a good coffee. Coffee flavor is extremely complex and arises from numerous chemical, biological and physical characteristics strongly depending on cultivar, coffee cherry maturity, geographical growing location, production, processing, roasting and cup preparation.

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Generally in the coffee industry, coffees from different origins were roasted to different roast degrees and along varying time temperature roasting profiles (fig.1)[4], [5]. This choice reached using the knowledge of the expert roster. This decision involves a high price for this important step, for this reason in this work was evaluated the homogeneity and the aromatic creation of coffee beans.
Not surprisingly there is a large volume of published research detailing the volatile and non-volatile compounds in coffee and that are likely to be playing a role in coffee flavor [2], [5], [6].

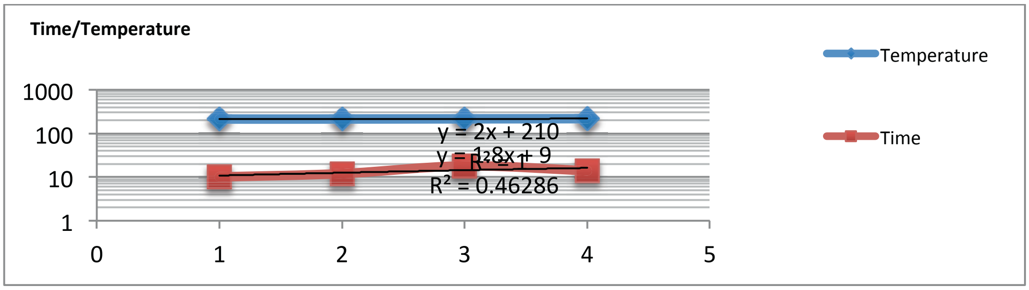

Fig. 1. Temperature and time features of the four different roast programs applied.

The aim of this study was to monitor different roasting processes using a novel electronic nose, equipped with an array of MOX gas sensors based on thin films as well as nanowires [7], [8].
Binary metal oxide nanowires were synthetized by physical-vapor deposition (PVD) on alumina substrates in a tubular furnace, in order to fabricate a sensing device (Fig. 2).
The deposition parameters for the catalyst (deposited by sputtering) were: DC sputtering mode, 50W power and deposition time 2 s. Subsequently, the substrates were placed on a sample holder and inserted in a lateral zone of the furnace, where the temperature was lower (570 °C). The pressure was decreased to 1 mbar. A 100sccm flow of argon was introduced into the chamber, while a pressure controller maintained the pressure at 10mbar. The substrates were maintained at a temperature of about 570 °C for 5 minutes and then brought back to room temperature.

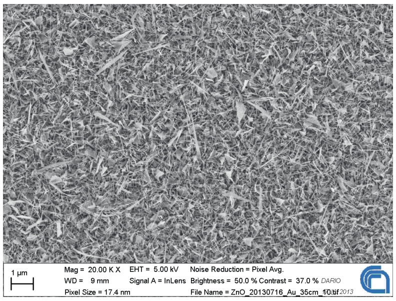

Fig. 2: SEM image of ZnO nanowires synthetized by PVD.

2. Materials and Methods

The performed analyses were carried out as follows. The roasting process was obtained using ROASMATIC DFA75 with four different roasting programs that have been applied to five different origins of green coffee beans. In this work were analyzed 20 different kinds of samples (table 1). All the statistical results has been obtained to a total amount 1000 sample[9].

Roasting Step	Origins
MONO	Honduras
MIXTURE	India
ROYAL	Indonesia
AROMATIC	Nicaragua
	Santos

Table 1. List of all the samples analyzed.

Once the coffee was roasted it was measured with a colorimetric techniques after 1h and also after degassing 24 hours at room temperature in parallel with the Novel Electronic Nose (EN EOS 835)[10], [11].
The EN EOS835 used in this study (SACMI IMOLA scarl, Imola, Italy) is equipped with a thermally controlled sensor chamber of 20 ml internal volume where are placed 6 MOX gas sensor, 2 of them are prepared using a nanowire technology.

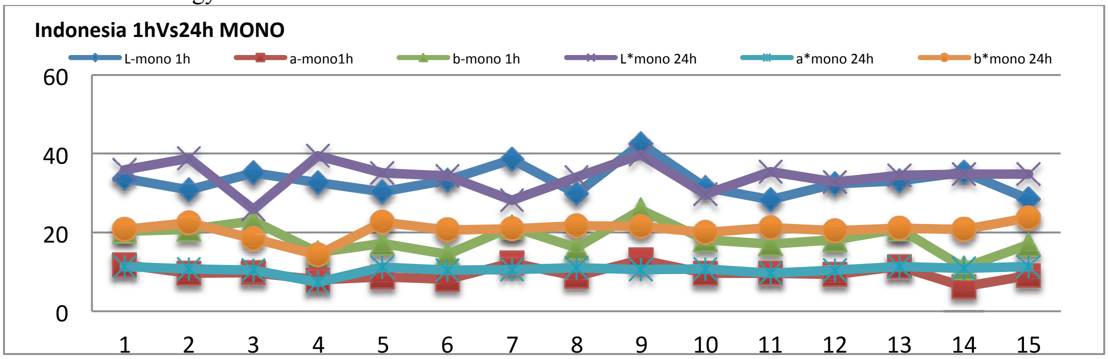

Fig. 3. Indonesia beans roasted with the lighter methods MONO, 1hours Vs 24 hours after roasting process.

The sample headspace for the EN (4 ml) was created in a vial (20ml) adding 2g of grinded coffee then extracted in static headspace path and injected into the carried flow (speed 4 ml min). Properly modified gas chromatography injector (kept at 40°C to prevent any condensation) equipped with a auto samples (HTA 280) with a carousel for 40 positions.

Fig. 4. Different roasting results on Santos origin.

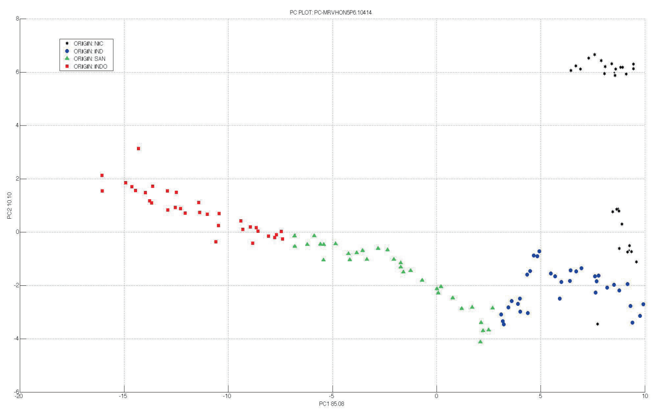

Fig. 5. PCA score PLOT about 4 different origins.

Using synthetic chromatographic air with a continuous flow rate of 10 ml/min performed the sensor baseline and the recovery time was 28 min.
The data analysis was run by means of Principal Component Analysis (PCA), operated with the Nose Pattern Editor software (SACMI Imola scarl, Imola, Italy).

3. Results and Discussions

That results allows to think that combining the two parameters (temperature and time) will lead in a saving of energy and cost for the industry.
In some cases is not highlighted a significant statistical difference between the different kinds of roasting process.
In the Figure 3 is show the difference obtained using the same kind of roasting techniques (MONO) on the same origin (Indonesia) and the figure 4 the homogeneity obtained with the Santos (Brazil)[12].
The PCA score PLOT (Fig. 4) was obtained using the feature extraction algorithm, FFT, Fast Fourier transform of signal. If P1=0 then the FFT is normalized at the max point of BEFORE step otherwise it isn't normalized [13].

4. Conclusions

The results obtained with different technique are in good agreement with our initial goal. The lighter roasting (MONO) processes produce the major inhomogeneity between samples. This difference is not reduced also waiting 24 hours at room temperature after roasting. The EN is able to distinguish between samples keeping in mind the different origins and the different heat treatments. In conclusion it is possible to say that EN is a good tool to be applied in industry for the control of the roasting process.
In the coffee food chain the roasting process is one of the more expensive steps. In this way we will be able to decide and reduce the cost of this heat procedure, using not only mono-origin roasting.

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