# Application of Electronic Tongue in Identification of Soybeans


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**Abstract.** Soybean is a product of great importance in the global economy and recognized by its great nourishing value with high protein content. In this work, a conducting polymer-based electronic tongue (ET) is employed to identify and discriminate five different soybeans cultivars with genetically distinct characteristics. Combination of electrical measurements and data analysis (PCA and PLS), permitted the ET system to discriminate the five different types of soybeans in accordance with a previous analysis performed by a human sensory panel.



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## INTRODUCTION

Soybean is a very versatile grain that originates various products and byproducts. The possibility to produce different types of soybeans is of interest to the food industry since they provide distinct taste features and protein contents [1].

Taste evaluation of soybean cultivars is usually done by humans (sensory analysis) whereas the chemical composition is assessed by analytical techniques, such as chromatography and mass spectrometry. In spite of their effectiveness, both methods require trained operators and are time-consuming. Alternatively, taste assessment can be carried out with chemical sensors arrays, known as electronic nose and electronic tongue (ET). These systems present as main advantages the capability of assessing taste characteristics of foodstuffs in short-time and are easy to be operated, even by unskilled personnel. They are also less expensive. For example, the ET has been widely used in the analysis of beverages, including coffee, tea, and mineral water [2]. In a previous investigation we have observed a straight correlation between the response of an ET and the sensory analysis for different sweetener formulations [3].

In the present contribution we have evaluated the ability of a conducting polymer-based ET in distinguishing five different types of soybeans cultivars with genetically distinct characteristics. The soybean cultivars under analysis were genetically designed for production of grains to be consumed as beverage. The study has two distinct goals: 1) production of grains to improve the taste attributes (cultivars 2, 3 and 4), and 2) grains to increase the protein content (cultivars 1 and 5).

## EXPERIMENTAL AND METHODS

The soybeans samples from five different cultivars were prepared as raw extracts by cooking an weighted amount of beans in an autoclave and grinding it in a mortar. The extracts were then diluted with distilled water, in a proportion 1:10, v/v and evaluated with the ET. For each cultivar, at least five samples were prepared and measured at random.

The ET system was based on an array of eight individual chemical sensors made of conducting polymer films deposited onto interdigitated gold electrodes. The films were prepared via the layer-by-layer technique using an automated system described previously [4] and employing commercially available materials, including polyaniline and derivatives, polythiophene, polypyrrole, Ni(II) phtalocyanine, sulfonated, polystyrene, poly(allylamine hydrochloride) and sulfonated lignin [3]. The variety


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of polymers and other materials ensures the cross-sensitivity to the sensor array.

The electrical capacitance of each individual sensor when immersed into the different soybeans samples was measured with an impedance meter from HP, model 4263A LCR Meter. Data resulted from ET analysis were processed by principal component analysis (PCA) and partial-least square regression (PLS).

## RESULTS

The electrical response of each individual sensor results from the interaction between the polymeric film and the chemicals present in the sample. The extent of such an interaction will depend on the polymer's chemical structure and the frequency of the electrical potential. At 1 kHz, sensors signal is due only to changes on the polymer's conductance [5]. Thus, higher cross-sensitivity is attained when sensors made of different polymers are operated at 1 kHz.

The sensory analysis performed by humans was able to distinguish the five soybeans samples according to taste attributes. The human evaluation has also detected significant differences in cultivars 2, 3, and 5. In a similar manner, the ET was also capable to distinguish the soybeans samples, as shown by the PCA plot in Figure 1. More than 90% of the data variance is provided by PC1 and PC2. Three groups of soybeans cultivars are distinguished along PC1 (cultivars 1, 2, and 4), whereas cultivars 2, 3, and 5 are distinguished along PC2 direction. Samples form cultivar 1, which presents the highest protein content are located in a more isolated region in the plot. It is also noted a clustering of samples from a same cultivar measured in different days. These data indicate that the sensors responses were systematically reproduced in different days of experiments. This performance ensures that the analysis was reliable and that the ET could be used repeated times with constant performance.

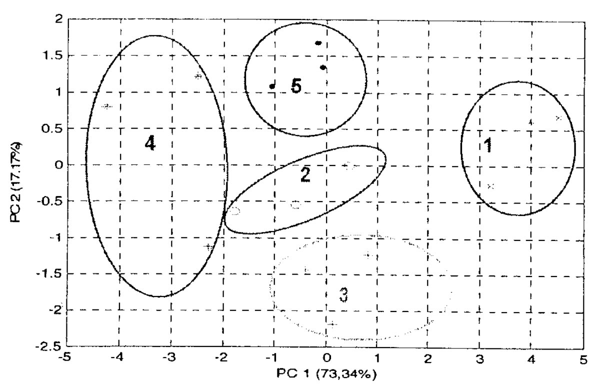


**FIGURE 1.** PCA plot for the 5 soybean cultivars obtained from data collected with the ET at 1 kHz.

## CONCLUSIONS

The taste characteristics of five different types of soybeans cultivars were evaluated by a human sensory panel. With similar performance, an electronic tongue system based on conducting polymer sensors was able to detect differences in the soybeans samples and, consequently, could distinguish them in five different groups. The response of the ET was reproducible in different days of experiments enabling its use for repeated times with constant performance. Although partial, these results are encouraging and indicate a possible aplication for the ET based on conducting polymers.

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