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 soybean 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) phthalocyanine, sulfonated, polystyrene, poly(allylamine hydrochloride) and sulfonated lignin [3]. The variety
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 soybean 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
resulted 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 soybean 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 from
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](image.png)

**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
soybean 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
application for the ET based on conducting polymers.

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