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Monitoring the storage stability of RBD palm olein using the electronic nose

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Abstract

Storage stability of RBD palm olein was monitored using a surface acoustic wave (SAW) sensor-based electronic nose. Fatty acid composition, iodine value (IV), peroxide value (PV), and free fatty acid content (FFA) analyses were used to determine the quality of the oils and to compliment the electronic nose data. A descriptive test was carried out by sensory analysis with ten trained panellists. The results from the electronic nose showed significant difference between fresh oil and rancid oil. High resolution olfactory imaging, called VaporPrint^{TM}, was shown to be particularly useful for assessing oil quality in its entirety. A high correlation was observed between electronic nose responses and chemical test data, as well as sensory evaluation score, by using Pearson's correlation. It can be concluded that the SAW sensor based electronic nose may be utilized as an analytical tool to follow the progress of oxidation and breakdown of vegetable oil.

Keywords: Electronic nose; Fingerprint; Rancidity; RBD palm olein; Surface acoustic wave sensor

1. Introduction

Vegetable oil quality and stability are the main factors that influence its acceptability and market value. Oxidative stability is one of the most important indicators of the keeping quality of vegetable oils (Tan & Che Man, 2002). In general, the term rancidity has been used to describe the mechanisms by which lipids alter in the presence of oxygen or air (Hamilton, 1989). Today, rancidity in processed food is becoming increasingly important as manufacturers require longer shelf-lives and because of public awareness of nutritional issues.

Oxidative deterioration of fat results in the development of a pungent and offensive off-flavour and the destruction of vitamins (A, D, E, K and C), essential fatty acids, chlorophylls, carotenes, amino acids, proteins, or enzymes by the production of toxic or physiologically active compounds (Gardner, 1979) and is believed to lead to deteriorative processes in man, including aging (Pearson, Gray, Wolzak, & Horenstein, 1983).

In general, the time before a dramatic increase in the rate of lipid oxidation is a measure of oxidative stability and is referred to as the induction time (Coppin & Pike, 2001). Historically, the Schaal Oven Test (SOT) and the Active Oxygen Method (AOM) have been the most widely used tests for evaluating oil stability (Wan, 1995). Many objective instrumental and chemical methods have been proposed over the years to evaluate the quality and stability of vegetable oils.

However, faster qualitative and quantitative analyses of chemical compounds are becoming a necessity in today's complex competitive environment. Of all the devices developed, the concept of an electronic nose is becoming popular. Electronic noses made their appearance in the market almost a decade ago. The electronic nose is preferred to routine laboratory analysis

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because it is rapid, simple and easy-to-handle (Biswas, Heindselmen, Wohltjen, & Staff, 2004).

An electronic nose is a vapour analyzer and, the working principle is claimed to mimic the human nose. The sensory array represents the sensors in the human nose. The circuitry represents the conversion of the chemical reaction on the human sensors to electrical signals into the brain. Finally, the software analysis represents the brain itself. The electronic nose is therefore analogous to the human olfactory system.

An electronic nose must have the ability to recognize as well as quantify many different complex fragrances. This is achieved using a visual fragrance pattern, called a VaporPrint™ derived from the frequency of the surface acoustic wave (SAW) detector. A VaporPrint™ is created by transforming the time variable to a radial angle with the beginning and end of the analysis occurring at 0° or vertical. A complete chromatogram always spans 360°. A VaporPrint™ image allows a complex ambient environment to be viewed entirely. Using the unsurpassed ability of humans to recognize patterns, skilled operators are able to assess the nature of vapours and to look for analytes of interest rapidly (Staples, 1999). The objective of this study was to develop a rapid method to identify and quantify the storage stability of RBD palm olein using a SAW sensor-based electronic nose.

2. Materials and methods

2.1. Oil samples

RBD palm olein was purchased from local refineries. The oil was stored at 2 different storage temperatures: room temperature, 28 ± 1 °C and accelerated temperature using an oven at 60 °C. Data was collected every 2 days for a duration of 52 days.

2.2. Chemical analysis

The chemical analyses, namely free fatty acid content (FFA), peroxide value (PV), *p*-anisidine value (AV), and iodine value (IV), were carried out using AOCS official methods Ca 5a-40, Cd 8-53, Cd 18-90, and Cd 1b-87, respectively (AOCS, 1996). All chemicals and solvents used were of analytical grade unless otherwise specified.

The individual fatty acid composition of fats and oils were analysed using gas chromatography (Hewlett-Packard model 5890 instrument, Palo Alto, CA). 0.95 ml of petroleum spirit was added to 50 mg of sample, followed by 0.05 ml of sodium methoxide (PORIM, 1995). Samples were transesterified to convert the fatty acids into relatively volatile methyl ester derivatives (FAME). 0.8 ml of sample was injected into the instrument, with an inlet temperature at 240 °C. A capillary column BPX70 was used with the column head pressure maintained at 145 kPa. Helium (99.95%), with a flow rate 1.3 ml/min, was the carrier gas. The temperature was programmed from 160 °C, equilibrium for 1 min, and then increased to 200 °C at a rate of 10 °C/min, and equilibrium for 2 min. Finally, the temperature was increased to 240 °C at a rate of 20 °C/min and held for 1 min. An FID detector was used with the temperature set at 275 °C.

2.3. Sensory evaluation

A descriptive test was carried out for sensory analysis conducted at the Malaysian Palm Oil Board (MPOB) with 10 trained panellists. Two separate sessions were conducted for oil samples stored at room temperature and oven temperature 60 °C. Six samples, coded with 3 random digits, were evaluated during each session (2, 12, 22, 32, 42 and 52 day). 10 g of oil were weighed into a 30 ml screw cap amber glass bottle. Before evaluation, the bottles were kept for 30 min in a 50 °C regulated oven to help the odour develop in the headspace. This preparation facilitated odour perception by the panellists. Panellists were then instructed to remove the lid of the bottle and take three short sniffs. They were asked to rate the overall intensity of the samples according to a predetermined attribute scale, ranging from 1 (extreme) to 10 (bland) according to Method Cg 2-83 (AOCS, 1996).

2.4. Electronic nose equipment specifications

The electronic nose (4100 vapour analysis system, Electronic Sensor Technology, New Bury Park, USA) is a hand held portable analyzer. The complete system includes a sensor head, a support chassis, and a system controller, is housed within a small carrying case. The sensor head contains the hardware necessary to separate and detect materials. The support chassis include a small helium gas tank, power supply and electronics to run the system. The system controller is based on a laptop computer.

This electronic nose uses a single, uncoated, high quartz SAW sensor. The SAW crystal consists of an uncoated 500 MHz acoustic interferometer or resonator bonded to a Peltier thermoelectric heat pump with the ability to heat or cool the quartz crystal. This detector possesses advantages, such as high sensitivity, easy-to-handle signal, low power and long term stability. Coatings are not used because they reduce the resonator Q, introduce instability, and require excessive time for equilibrium. Sensitivity is excellent because there is no dilution of sample vapour. Minimum detection levels for semi-volatile compounds typically extend well into the part-per-trillion (ppt) range. The temperature of the quartz substrate is held constant during chromatogra-