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Identification of adulteration in uncooked Jasmine rice by a portable low-cost artificial olfactory system

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ABSTRACT

Development of a portable low-cost artificial olfactory system called as electronic nose (E-nose) for rapid assessment of adulteration percentages in uncooked Jasmine rice (Khao Dawk Mali 105) is reported. White rice was used to adulterate the Jasmine rice at various weight ratios (5, 10, 15, 20, 40, 60 and 80% w/w). Volatile aroma compounds released by rice samples including pure Jasmine, pure White and mixed rice samples were detected by the E-nose (room temperature and 55 °C) and solid-phase microextraction (SPME) in conjunction with gas chromatography–time of flight mass spectrometer (GC–TOFMS). The E-nose exhibited the highest sensor responses to Jasmine rice, mixed rice, and White rice samples, respectively, corresponding to number and total concentration of volatile aroma compounds obtained by SPME/GC-TOFMS analysis. 2-Butanone was found to be the most dominant volatile aroma compound in rice samples. Principal component analysis (PCA) with simple Euclidean plane calculation was used for pattern recognition and evaluation of adulteration percentages. Mean distances of PCA analysis showed a strong correlation and linear relationship ($R^2 > 0.94$) with amount of adulteration percentages at both room temperature and 55 °C. Also, support vector machine (SVM) and back propagation neural network (BPNN) were used to classify and predict adulteration percentages. The results confirmed that the developed E-nose with simple proposed method can be used as alternative tool to quantify the adulterations in rice samples with several advantages including rapid, simple, low-cost, reliable and nondestructive measurement.

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1. Introduction

Rice is the staple food of more than half of the world's population, especially in Asia. Rice is a complex carbohydrate and contains all essential amino acids that are necessary for building muscle and maintaining proper cellular functions [1]. Thai Jasmine rice (Khao Dawk Mali 105) is one of the famous fragrant rice variety that owns unique fragrance, soft, tender and fluffy characteristics when it is cooked as well as good qualities in term of low amylose content, low gelatinization temperature and medium gel consistency [2]. Because of its unique properties, the volume of Jasmine rice trade was growing to 2.5 million tons in 2013 and it was exported to many parts of the world [3–5]. However, due to high price of pure Jasmine rice, traders may tend to adulterate the Jasmine rice by mixing with low grade, low price or low nutritious rice. Physical and chemical characteristics of other rice used in mixing such as grain shape [6,7], color [8] or fragrance [3,5,9–11] are quite similar to Jasmine rice that it is hard to differentiate by naked-eye or human sensory evaluation. Therefore, detection of adulteration in Jasmine rice is crucial to guarantee rice quality, minimize unfair trade and raise consumer confidence.

Many analytical methods such as gas chromatography/mass spectrometry (GC–MS) [3,5,9,11–15], DNA based methods [16–19], X-ray fluorescence (XRF) [20] and near infrared spectroscopy [21,22] have been successfully applied to identify volatile aroma compounds and adulteration of rice. However, the limitations of these methods are related to their complex, expensive and time-consuming processes. Moreover, well trained technicians are required to setup, handle, and make qualitative judgments. An alternative method that offers easy operation, rapid, real-time detection, low operation cost, reliable, non-destructive measurement and robust technology, is still in need for quick screening of adulteration in rice samples.

Recently, artificial olfactory system called as electronic nose (E-nose) has been receiving increasing attention in qualitative analysis of food [23–27]. The E-nose relies on signal changing of chemical sensors array and analysis via pattern recognition methods

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[28–32]. The E-nose systems based on both metal oxide sensors and polymer sensors have been proven to exhibit a good performance in classification of rice samples [33–37], assessment of rice quality during storage [38], estimation of the rice plant age [39], evaluation of the optimal cooking time of rice [40] and identification of infestation of rice plant from insects [41]. However, to our best knowledge, no report on development of an E-nose for quantitative identification of adulteration in uncooked Jasmine rice is available. In this work, we have presented the development of low-cost E-nose based on metal oxide gas sensors for monitoring the adulteration of uncooked Jasmine rice. A simple Euclidean distance calculation from principal component analysis (PCA) result has been proposed and used to predict the percentages of adulteration in uncooked Jasmine rice. Other standard methods such as support vector machine (SVM) and back propagation neural network (BPNN) were used to classify and predict adulteration percentages also.

2. Materials and methods

2.1. Sample preparation

Two different samples of rice including Jasmine and White rice were purchased from a supermarket in Bangkok, Thailand. Adulteration of Jasmine rice was obtained by mixing Jasmine rice and White rice at various weight ratios. During the mixing process, the total weight of 50 g was kept to be unchanged. It should be noted that White rice is a fragrant rice and its physical and chemical properties are quite similar to Jasmine rice. The mixed rice sample was thoroughly stirred for 5 min. All samples were directly used and measured without any washing, cleaning, or heating treatments.

2.2. Electronic nose system and measurement

Schematic diagram of our lab-made E-nose system is displayed in Fig. 1. The E-nose consisted of three main parts including (I) air flow part, (II) sensing part, and (III) data acquisition & system control. The air flow system was composed of an oilless diaphragm pump, four electrical 2-way solenoid valves, mass flow controller, sample and reference glass containers and Teflon tubes. It should be noted that this E-nose measurement relied on switching between the reference (normal air) and the sample (rice aroma) glass containers. The four solenoid valves were used to avoid the mixing of volatile organic compounds (VOCs) from the reference and the sample. For the sensing part, eight metal oxide sensors including TGS 821, TGS 822, TGS 825, TGS 826, TGS 2600, TGS 2602, TGS 2610, and TGS 2620 available from Figaro Engineering Inc. were used and installed in a specially designed Teflon sensor chamber. A temperature and humidity sensor (SHT15; SENSIRION Inc.) was included inside the sensor chamber. A simple voltage divider circuit (V_{cc} = 5 V and R_{Load} = 10 KΩ) was employed for mea-

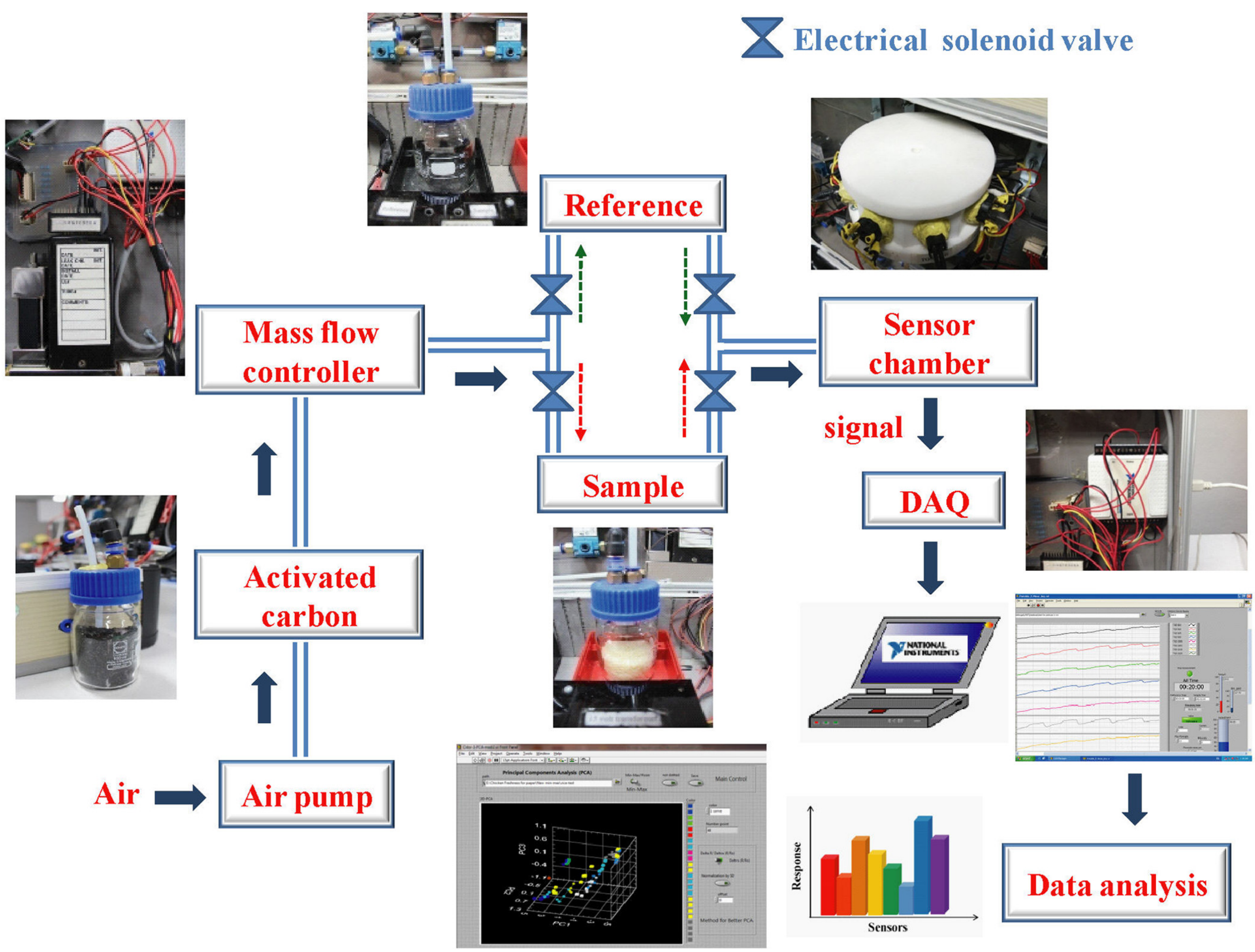

Fig. 1. Diagram of our lab-made E-nose system.

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