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A model for discrimination freshness of shrimp

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ABSTRACT

The shrimp is popular for its nutrition and dainty, however, it is easy to decay, and its freshness degrades, so, it is important to assess its freshness. The shrimp gives off unpleasant odor with its freshness change, detecting its odor difference can evaluate its freshness. The feasibility of using electronic nose for evaluating the freshness of shrimp (*Penaeus vanmamei*) is explored in this paper. The odor of shrimp, stored at 5 °C, was detected by the electronic nose. Combined with the sensory evaluation and TVBN, a model based on the electronic nose was constructed to evaluate the shrimp freshness. In principal components analysis, the first three principal components accounted for 86.97% of total variation, and they are used to establish a model to estimate the shrimp freshness with Fisher Liner Discriminant. The discriminant rates were 98.3% for 120 modeling sample data, and 91.7% for 36 testing sample data. The model could be easily used to evaluate the freshness of shrimp with better accuracy.

1. Introduction

Due to its high nutritional value and distinctive flavor with a tender and delicate texture, the consumer demand for shrimp is enormous. In USA, the volume of imports of shrimp was about 1120 million pounds in 2013 [1]. In China, the volume of shrimp culture was about 5314 million pounds in 2011 [2]. Shrimp undergoes bacterial contamination and enzymatic activity during transportation and storage [3–10], the ingredients like protein, fat and carbohydrates are decomposed into ammonia, hydrogen sulfide, ethyl mercaptan, aldehydes, aldehyde acids, alcohols, ketones, aldehydes, and carboxylic acid gases [3,6]. These chemical compounds give rise to off-flavors and other unpleasant characteristic [4–7], the freshness of shrimp degrades. Consumption of spoilage shrimp could cause serious health hazards [3,5]. It is important to assess the freshness of shrimp.

The shrimp freshness is often determined by means of sensory analysis, chemical experiments and microbial population evaluation. The disadvantages of sensory analysis are lack of objectiveness and poor reproducibility. Chemical experiments and microbial population evaluation, such as Total Volatile Basic Nitrogen (TVBN) and the microbial population in shrimp are detected to indicate its freshness; however, these two methods are complex procedures, more expense, time-consuming and destructive. Therefore, a simple and nondestructive method is expected to evaluate the shrimp freshness.

The spoilage shrimp gives off unpleasant odors. If the shrimp odor is detected, its freshness could be assessed. A simple, quick technology to inspect food odor is electronic nose. Electronic nose is a simulation of biological functions to identify some simple or complex odor [11,12]. The electronic nose is used as a non-destructive method for food quality detection [13–17], such as classifying stored grain, analyzing water and wastewater, monitoring roasting process, testing freshness of fish and fruit, controlling the manufacture of cheese, sausage, beer, and bread, and detecting bacterial growth in meat and vegetables.

The electronic nose was also used to measure the shrimp freshness [18–22], the result showed that the electronic nose could detect the odor change of shrimp. Most application of electronic nose focused on pattern recognition techniques [19–26]. Principal component analysis (PCA) was a pattern recognition technique which was often used to reduce the dimensionality of a data set while retaining as much information as possible, employed with tin oxide gas sensor arrays [23]. PCA scores was plotted to demonstrate the separation achieved but no classification algorithm was tried [26], it was inconvenience for predicting unknown samples. The purpose of this study is to construct a model to predict freshness of shrimp; firstly, the principal component was obtained, secondly, Fisher Liner Discriminant was employed to establish a model with the principal component above, and then the freshness of shrimp was predicted with the model.

2. Materials and method

2.1. Sample preparation

Fresh shrimps (*Penaeus vanmamei*, 48 to 54 shrimps per kg) were from Farmers' Market located at Jianing Road in Tianjin Beichen District, China. These shrimps were killed using crushed ice. Each shrimp was

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placed in 40 ml plastic bottle, sealed with lid and kept in a refrigerator (5 °C). Measurements of shrimp were conducted at scheduled time intervals (12 h) during storage. At first, the sample was performed using sensory analysis, then electronic nose measurements, and finally TVBN.

2.2. Electronic nose apparatus

The electronic nose contained a chemical sensor array, a signal processing system and a pattern recognition system. The electronic nose was presented in this work (Fig. 1).

Metal oxide semi-conductors (MOS) respond to many volatile compounds such as formaldehyde, benzene, toluene, ketone, carbon monoxide, carbon dioxide, nitrogen dioxide and ammonia, the MOS was used to make arrays for odor measurement [27]. Six tin oxide sensors was used to form the sensor array, namely TGS2600, TGS4161, TGS2620, TGS813, TGS825 and TGS826 (Figaro Engineering Inc.), these sensors had a good response to the different odors produced by the shrimp. Their feature was listed in Table 1.

These sensors were placed uniformly in testing chamber and respectively numbered X_1, X_2, X_3, X_4, X_5, X_6.

These sensors above are sensitive to ambient temperature and humidity. Air filter, air dryer and temperature controller were designed to minimize the effect of temperature and humidity on signal of sensor (Fig. 1). Air filter and dryer made air dry and clean, temperature controller held the temperature constant. The temperature of the air flowing into the testing chamber was 40 °C, the humidity was 5%, and the air flow rate was 150 ml/min in the tube.

The air, filtered and dried, was sent into sample chamber by the air pump, the odor of the sample was brought into the testing chamber. The odors came into contact with sensors, the sensors responded, and the output voltage was collected, delivered into computer, processed and recognized.

2.3. Method

2.3.1. Electronic nose sampling procedure

The electronic nose was turned on, preheated for 30 min before test. The shrimp was placed into the sample chamber. Air pump was on; clean air went through sample chamber. The volatile from the sample was sent into the testing chamber. The gaseous compounds were in direct contact with the sensor arrays located in testing chamber, and the voltage of each sensor changed. The voltage of each sensor was collected by the computer. After each experiment, the testing chamber was cleaned with clean air for 300 s.

Table 1
Sensors used and their object substances.

Array number	Sensor	Substances for sensing
X_1	TGS2600	Air contaminants
X_2	TGS4161	CO_2
X_3	TGS2620	Alcohol, organic solvent
X_4	TGS813	Combustible gases
X_5	TGS825	H2S
X_6	TGS826	NH3 and amines

2.3.2. Sensory evaluation

The sensory evaluation of shrimp was conducted with a descriptive method [28]. It was performed by a trained sensory panel. The trained sensory panel was composed of ten tasters. All tasters were trained and familiar with sensory evaluation procedure of shrimp. Each shrimp sample was evaluated by ten tasters, according to color, viscosity, elasticity and flavor of shrimp. The mean of the 10 tasters was considered as the score of the shrimp.

2.3.3. Total volatile basic nitrogen (TVBN) evaluation

TVBN evaluation of the shrimp samples was performed using standard protocols [29], the TVBN contents were tested with semimicro kjeldahl method, and showed as mg per 100 g of shrimp.

3. Results

3.1. Sensory evaluation

The sensory evaluation result was shown in Fig. 2. The sensory scores of shrimp decreased as the storage time increased. In the first 2 days, the total score curve only declined slightly, the sensory score changed from 15 to 13, this manifested that the shrimp samples have not corrupted until the second day. 2 days later, the color, viscosity, elasticity and flavor of shrimp changed, and the sensory score declined fast. 4 days later, the sensory score was below 10, the shrimp deteriorated with unpleasant odors and the shrimp was inedible.

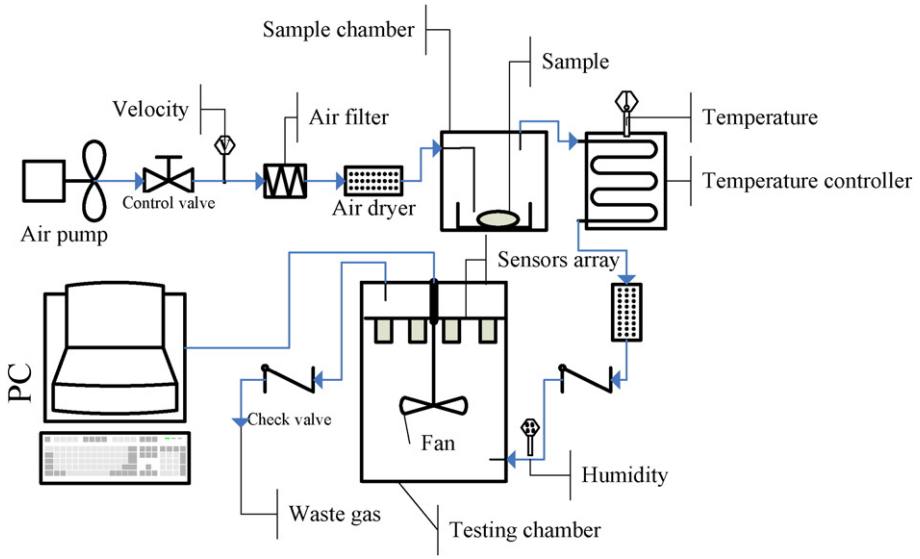

Fig. 1. Electronic nose schematic diagram.