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Development of mobile electronic nose for beef quality monitoring

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Abstract

Meat is one of foodstuff that widely consumed in the world. Unfortunately, the quality of meat can easily degrade if not handled properly and become the serious health hazards if consumed. Hence, the food safety system is very important to guarantee the quality of food to be consumed. In this study, we introduced the development of mobile electronic nose for beef quality detection and monitoring. This system is developed using low-cost hardware and possible to integrate with cooling box or refrigerator for real time monitoring and analysis during distribution and storage processes. K-Nearest Neighbor with signal preprocessing is used to classify two, three, and four classes of beef. The experimental results show that the system can perfectly distinguish fresh and spoiled beef. Moreover, it has promising classification accuracy for binary, three classes, and four classes classification with 93.64%, 86.00%, and 85.50%, respectively. Hence, this system has a potential solution to provide low-cost, easy to use, and real-time meat quality monitoring system.

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Keywords: Mobile Electronic Nose; Beef Quality Monitoring; Classification; K-Nearest Neighbor

1. Introduction

Meat is the main product of livestock as a source of protein for humans. The Food and Agriculture Organization of the United Nations has been reported that the per capita meat consumption in the developing countries is still continuously growth (about 1.3%) until 2050. Meanwhile, although meat consumption in developed countries has decreased, the meat consumption per capita is still high (the 80 kg at present). On the other side, meat is good media for microbial growth. Hence, it is easy to decay if not handled properly. The storage of meat in the open air can

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accelerate the meat quality degradation. For instance, the beef storage life is about 20 hours if exposed by open air [1] compared 10-12 weeks in the vacuum-packed storage [2]. In fact, many improper handling of meat in developing countries occurs. Meat left for hours exposed to air in the market. Moreover, the meat quality degradation also occurred during distribution processes. The biotic factors, ambient temperature, humidity, and transportation are causative factors of meat quality degradation [3]. The spoiled meat products consumption can trigger serious health hazards. So, it is very important to develop the mechanism to monitor and assess the quality of meat products.

Until now, the analysis of the total count of bacteria is the gold standard to determine the quality of meat products. However, the drawbacks of this approach are complicated, laborious, and needs more than 72 hours to get the analysis results [4]. It contrasts with requisites of the meat industry and the end consumers that need more rapid, simpler, and cheaper system for meat quality assessment and monitoring.

On the other hand, the development of machine olfactory system as known as electronic nose (e-nose) is a prospective instrument in many areas. Hitherto, food/product quality control is one of widely used of e-nose utilization. For instance, e-nose coupled with a pattern recognition algorithm has been successful to classify tea [5–10] and coffee [11,12]. It also uses to assess livestock products such as milk [13,14], beef [15–20], sex pheromones detection secreted by cows [21]. Furthermore, wireless e-nose also has been reported to detect the odors [22,23]. The advantages of e-nose utilization are cheap, easy to operate, and suitable for online monitoring and analysis [24]. In this paper, we introduce the development of mobile e-nose (MoLen) and the prospective applications in meat quality monitoring and detection. In this study, the cost of proposed device is only USD 300. It is cheaper when compared with Fourier Transform Infrared spectroscopy (USD 10000-35000) and gas chromatography (USD 3000-70000). More detail comparison of meat freshness evaluation techniques was explained by Wojnowski et al. [4].

The rests of paper has organized as follows: the first section gives a brief overview of the meat quality problems and potential of e-nose for meat quality assessment. The second section describes the e-nose development including the basic principle of e-nose, the proposed scheme of e-nose application, and the experimental setup in this study. The third section presented the results and discussion. Finally, the last section is the conclusion of this paper.

2. The development of mobile electronic nose

In this section, the basic principle of e-nose is explained and the proposed scheme of mobile electronic nose applications is demonstrated. Moreover, the materials and methods used are also discussed.

2.1. The basic principle of e-nose

E-nose is an instrument that mimics the mammalian olfactory system. The functional components of e-nose are similar with the mammalian olfactory system. Fig. 1 shows the functional components of e-nose compared with the component of mammalian olfactory system [25].

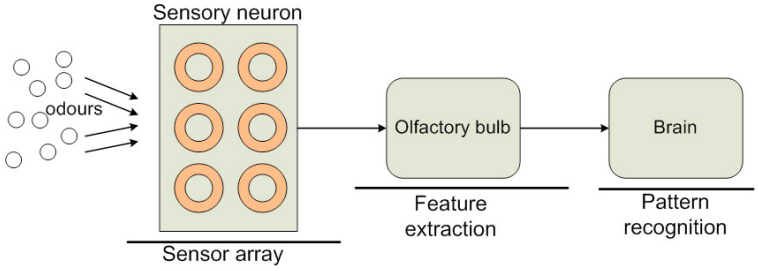

Fig. 1. The functional component of mammalian olfactory system and e-nose.

The volatile odor molecules are detected by sensory neuron. In a human olfactory system, there are about 100 million sensors which have different selectivity of various gases. In the e-nose system, sensor array acts as sensory neuron. The olfactory bulb extracts and transmits the signals to the brain. The pattern (a set of signals) is processed in the brain to recognize the pattern and produce the appropriate responses. The functions of olfactory bulb and