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Pork meat quality assessment based on multispectral imaging technique

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Abstract

Production of pork is a daily objective for both producers and consumers. Pork quality and its economic advantages can be enhanced by using quick, non-destructive, and inexpensive monitoring techniques. This study investigates the potential of using international photos to monitor pork quality. Image processing is done using the ROI-based processing, and then using a specific algorithm for food quality assessment. This allowed structural characteristics to be retrieved from the several photos of flesh tissue. A monochrome camera and four sets of optical filters covering the red (625 nm), green (525 nm), blue (465 nm), and near-IR (940 nm) spectra were employed in this work. In this research, the use of multispectral imaging and chemometrics combined modeling is validated as a non-destructive, quick, low-cost quality control tool that can effectively monitor pork quality. This offers a scientific foundation for the next study and creation of broadly applicable devices for both assessing pork quality and multispectral imaging techniques.

1 Introduction

Due to its balanced nutritional makeup and availability in a variety of forms, meat and meat products are popular foods [1]. According to K. Grunert, quality and safety perception is linked to

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food choice and consumer demand, addressing questions of price perception and the validity of willingness-to-pay measurements [2]. Meat quality can be defined according to physical attributes; chemical and nutritions; microbiological and organisms and sensory attributes [3]. It resulted in rapid application of optical technologies for detection of the quality attributes of fruits, vegetables, meat and meat products, eggs and egg products, fish, processed products, etc.. It is obvious that optical technologies have received wide attention in the research community because of their rapid, non-destructive, real-time, and precise detection ability [4]. Multispectral imaging, which combines optical (visible and NIR area) and computer vision techniques in an effort to collect spectral and spatial data for the metabolites on the surface of the inspected sample, satisfies these requirements [5]. Fast image acquisition and the use of straightforward methods for image processing (ROI region) and decision-making are the key advantages over hyperspectral analysis [6].

Myoglobin, which often appears in cut meat as oxy-myoglobin (oxy-Mb), deoxy-myoglobin (deoxy-Mb), and met-myoglobin, is the most prominent pigment in muscle (met-Mb). Deoxy-Mb has a purplish red color, met-Mb is brownish, and oxy-Mb is a brilliant red color that resembles fresh meat [7]. The different proportions of myoglobin species lead to the transformation of meat color [8]. The process of color changing begins when the meat is first cut. The surface is quickly changed to a thin layer of oxy-Mb from deoxy-Mb due to oxidation, while the inner layer is still occupied by deoxy-Mb. A thicker oxy-Mb layer is produced as a result of the oxygenation process, which first begins at the meat surface and eventually extends inside over several days [9]. Along with the oxygenation process, the sliced meat also undergoes the oxidation process, which converts oxy- and deoxy-Mb to met-Mb. However, this process begins in the internal meat layer and gradually travels to the flesh surface. The oxidation and oxygenation processes separate the layers of cut meat into three. Oxy-Mb builds up in the outermost layer, where oxygen is available, while deoxy-Mb occupies the interior layer [10]. The met-Mb layer forms in the space between these two layers. More storage speeds up the oxidation process but slows down the oxygenation process, which causes the oxy-Mb layer to contract and the met-Mb layer to expand to the cut surface [11]. According on previous studies, oxy-Mb has peaks at 418, 544, and 582 nm, deoxy-Mb has peaks at 434 and 557 nm, met-Mb has peaks at 410, 505, and 634 nm [12].

In this study, a optical-based method was applied to assess quality of pork meat. Myoglobin, itself is considered to be the key of quality processing using multispectral imaging.

2 Materials and Methods

2.1 Preparation of Pork Sample

Samples of pork tight were obtained at a supermarket (Ho Chi Minh City, Vietnam) and immediately transported to the laboratory. The pork sample includes muscle and fat. The pork was then chopped into a piece of 70 mm in length, 50 mm in breadth, and 20 mm in thickness and kept in the room temperature of 27ºC with 0.5ºC of measurement error. The entire experiment lasted three days.

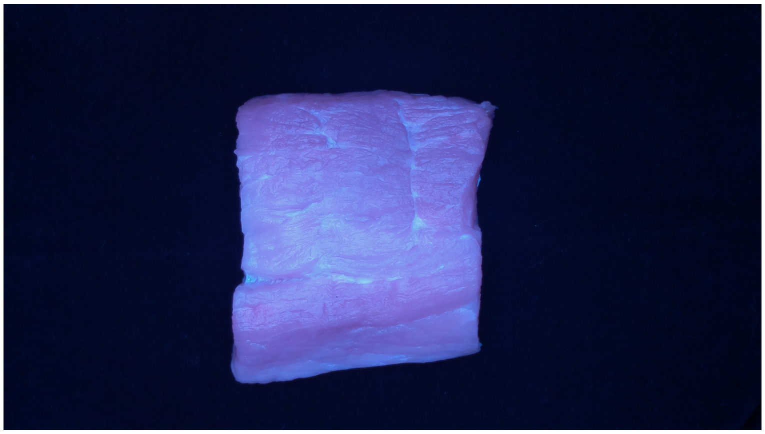

Figure 1. The pork sample at the beginning of the experiment.

2.2 Image collection

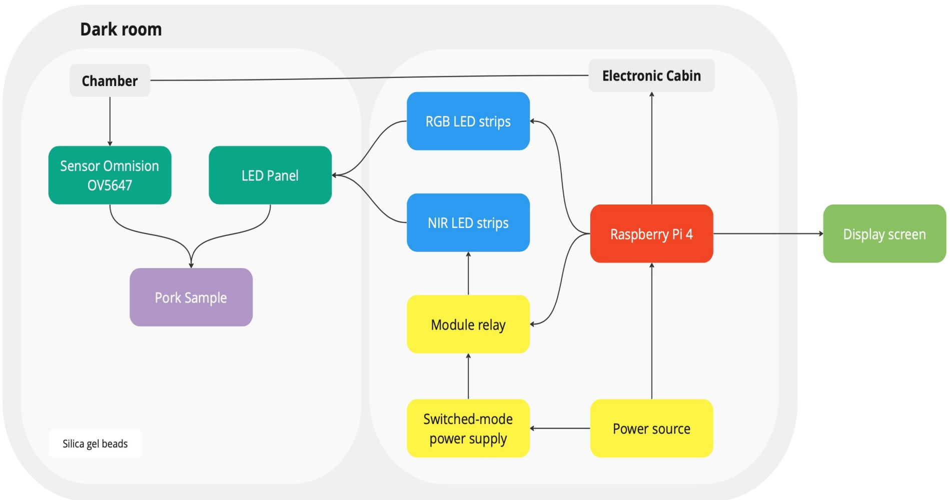

Figure 2. Diagram of Multispectral Image acquisition system

This system consists of two main parts: Chamber and Electronic Cabin. These parts were put in a big box, separated by a thick carton. To reduce the amount of light reflected around the sample, the walls of the chamber were painted completely black. The whole system was maintained in a dark room to avoid the effects of external light.

The sample was placed on a plate covered in a black cloth. The camera was coded and controlled by a Raspberry Pi 4 to acquire images with 4 different light colors (Red, Green, Blue, and VIS-NIR) each 3 hours. The image generated by this system was of 3840×2160 pixels.

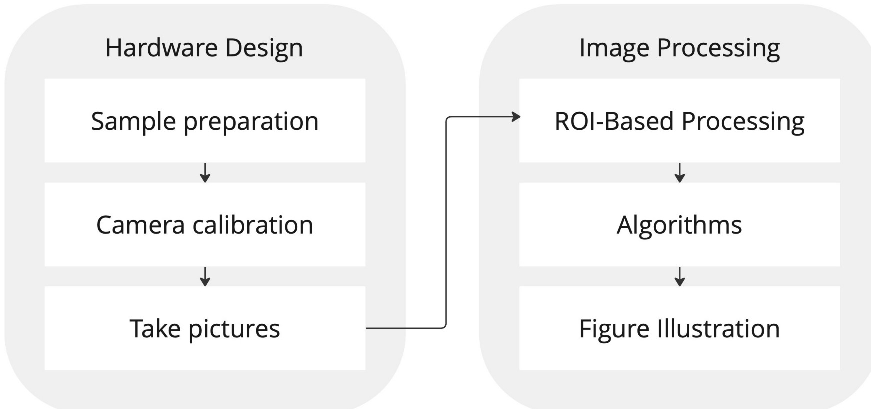

Figure 3. Procedure of Pork - Image Processing

The input data of the process consists of 25 image files, classified by time intervals. There are 41 images in each image file, of which 10 are with 4 wavelengths and 1 captured with white light.

Using MATLAB R2019a, all of the spectral images were processed using ROI-based processing and a specific algorithm. Then, a plot of the spectral intensity line graphs with 4 wavelength peaks of Red (625 nm), Green (525 nm), Blue (465 nm) and NIR (940 nm) is produced.

3 Results and Discussion

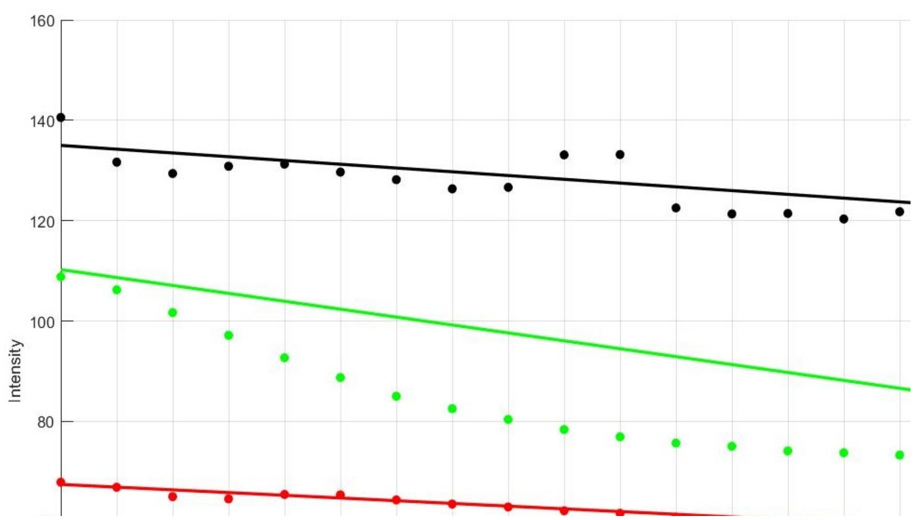

Figure 1. The spectral intensity of four wavelengths

The mean intensity value of the spectrum ranges of Blue (465 nm), Green (525 nm), Red (625 nm), and NIR (940 nm) at each 3 hours, starting from 0h to 72h. It is clearly seen that the trendlines of four wavelengths decrease overtime. It can be referred to the loss of the ability to reduce the oxidized myoglobin, after number of cycles of oxygen absorption and oxidization. The color of the slice becomes brown permanently.

The 525nm wavelength's graph decreases gradually from 0h to 30h and then it fluctuates until the end of the process while the 625nm wavelength's graph slightly fluctuates, which can refer to the marginal increase of 600-650nm wavelength intensity. It can be explained by the appearance of met-Mb formed in the space between deoxy-Mb and oxy-Mb layers.

4 Conclusions

In summary, the performance of the multispectral imaging system showed an efficient result of pork quality assessment. The outcomes of the experiment suggest the possibility of early identification of met-Mb development, before the start of obvious color change. Besides, instead of using the whole spectrum, the use of Green (~510 – 565 nm) and Red wavelengths (~625 – 740nm) can simply verify the quality of meat, overlooking the attenuance of deoxy-Mb and oxy-Mb.

The authors declare no conflicts of interest

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