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Spectrum analyzer development for oxidation diagnosis of Potato semi-finished products

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Abstract: In order to determine the oxidation of potato semi-finished products non-destructively and rapidly, spectrum analyzer was developed. It was designed based on Ocean Optics STS-VIS sensor. The sensor measured spectral reflectance of 350-800 nm using a high-sensitivity 1024 pixel linear CCD array detector. The software was a modular spectroscopy software platform, including the collecting, processing, saving, management, and other functions. The calibration experiment was carried out to test the performance of the spectrum analyzer. The correlation was analyzed between the spectral reflectance measured by spectrum analyzer and ASD Field Spec Hand Held 2. The result showed that the average correlation coefficient value was 0.94. In order to explore the relationship between the potato oxidation conditions and the spectrum information, oxidation experiment was carried out in the laboratory. According to the different oxidation situation, the data were classified in to 5 groups using SVC. The training accuracy was 77.78% and the test accuracy was 60%. The model was applied to distinguish whether the potatoes were oxidized.

Keywords: spectrum analyzer, food processing, potatoes, oxidation

1. INTRODUCTION

Half processed fruits and vegetables is refers to the fresh fruits and vegetables by classification, sorting, selecting, washing, packaging and a series of processing. Because these vegetables is still alive, respiration and metabolic changes sharply activation after segmentation processing.it is an important problem that the surface brown rapidly and losing the characteristics of the fresh produce. The results will lead to the commodity value reduce.

In previous studies, browned chestnut could be chose by near infrared spectrum method (Pan et al, 2013). Tian studied the fluorescence of royal jelly under different storage conditions and found that fluorescence intensity change of proteins could be used as a freshness index of royal jelly (Tian et al, 2013). Tian Haiqing designed a watermelon soluble solids content (SSC) detection system based on the near infrared transmission (Tian et al, 2007). Researchers also discussed using visible near infrared spectroscopy to detect the degree of browning in apple and pear (Han et al, 2006; Li et al, 2008).

Oxidation of potato semi-finished products testing mainly includes observation, chemical methods and spectroscopy method. Traditionally, researchers measure polyphenol oxidase (PPO) activity to determine the degree of potato browning (Gong et al, 2009). They have also determined the absorption spectrum of brown potatoes (Zhang et al, 1999). These methods always conduct in the laboratory with destructive testing and long-time consuming following sampling, soaked with medicine, filtering and other processing. .

With the development of optical sensor technology, it is possible to develop a portable spectrum analyzer to determine the degree of potato oxidation. Thus, a spectrum analyzer was developed to measure the spectral reflectance of 350-800 nm in this paper. Spectral information of potato chips was collected and processed. And the model was applied to distinguish whether the potato was oxidized.

2. DEVICE DEVELOPMENT

2.1 Hardware Device

The hardware of spectrometer was designed with two parts: optical system and the controller. The optical system was developed to measure spectral reflectance of 350-800 nm based on the Ocean Optics STS-VIS sensor. The sensor used a high-sensitivity 1024 pixel linear CCD array detector to obtain reflectance light and used enhanced electronic device to control. It could be used for absorbance/ transmission/ reflection measurements. The controller was a computer and connected to sensor through USB2.0 communications. The supporting software was installed on the controller to control the signal communication.

The mechanical structure is shown in Fig 1. The system includes a set of external light source, an USB cable, a

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shading device, a sensor, an optical fiber and a controller. Because the light in the room was too weak to measure the Spectral curve, an external light source was used to provide the incident light. The shading device is used to separate other lights and reduce the noise influence. The controller is used for data transferring and power supply.

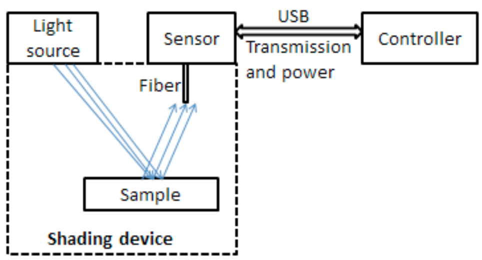


Fig 1 Mechanical structure of the system

2.2 Software System Design

The software developing platform was Windows 7. The spectral information collection and analysis software was developed on Visual Studio 2010, using C#.

The software is a modular spectroscopy software platform, including the collecting, processing, saving, management, and other functions. There are three modules following spectral information collection, collection parameter settings and spectral information analysis. The function of information collection module includes the DN values collection, displaying and storage. The spectral curves of collected data are displayed real-timely and saved as TXT formats. Collection parameter settings module is used to set the mode of collection, sampling frequency, integration time. Analysis module could calculate the reflectance and save as TXT formats.

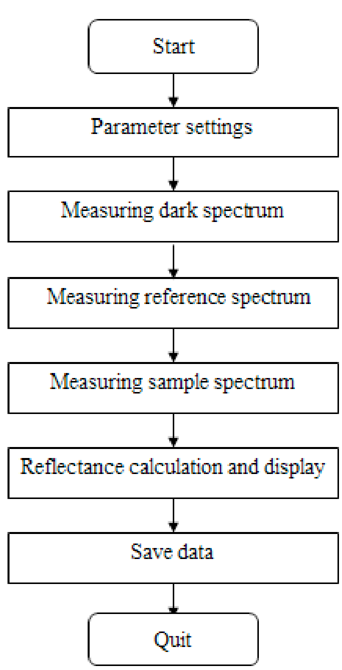


Fig 2 Flowchart of the software

Fig 2 is the overall flowchart of the software. After the controller and sensor connected successfully, users should optimize the system parameters, such as the integral time. Then choose the collection function, DN value. Finally, analyze and storage the reflectance data.

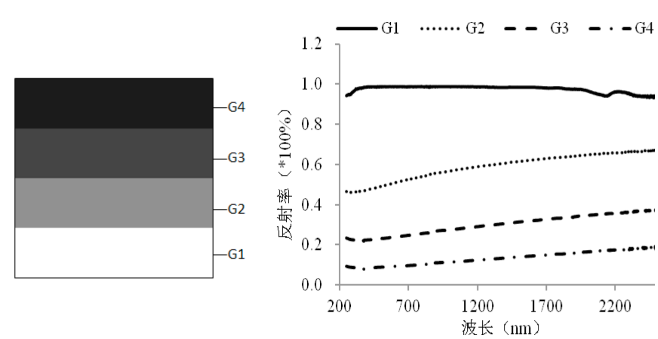
3. EXPERIMENT

3.1 Calibration Experiment

In order to test the performance of the spectrum analyser, calibration experiment was carried out in March 23, 2016, in the top of the building College of Information and Electrical Engineering, China Agricultural University. It was sunny day without cloud.

A gray calibration board with four different gray values was measured (Zhao et al, 2015). It was measured from 12:00 to 15:30 with 10min interval, a total of 20 sets of data. The ASD Field Spec Hand Held 2 (Analytical Spectral Devices, Inc., USA, 350-1050 nm) and the spectrum analyzer were placed 10cm over the gray board, and four different gradations was measured in turn. Each measurement was repeated three times and averaged. Because of the light changes, ASD and the spectrum analyzer would measure the whiteboard to optimize before each measurement. At the same time, an illuminance-meter was used as reference substance. Data needed to be measured twice when the light intensity changed suddenly (the value of illuminance-meter changed over 1Lux).

The gray board has four different gradations standard board. G1 ~ G4 represented from white to black as Fig 3(a) shown. Different gradation has different reflectance. Gray board manual provided a standard reflectance data from 250 nm to 2500 nm of the four gray gradations. The standard reflectance is shown in Fig 3(b).



(a) Gray board (b) Reflectance of calibration board

Fig 3 Spectral reflectance of calibration board

Because the spectral data was smooth in the 400-700 nm and fluctuated significantly in the 350-400 nm & 700-800 nm, correlation was analysed between the reflectance measured by spectrum analyzer and ASD from 400nm to 700nm. As shown in the Table 1, the results indicate that the values of correlation coefficient are in (0.6724, 0.987). The average value is 0.9404 and the highest is 0.9987.