Nondestructive Detection of Pesticide Residue on Banana Surface Based on Near Infrared Spectroscopy

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Abstract: *In this paper, nondestructive detection of a pesticide on banana surface based on near infrared spectroscopy was analyzed. Principal component analysis (PCA) method was applied to analyze the spectra data within the wavelength range from 350nm to 2150nm. Satisfied results were achieved from clustering based on the scores of PC1 and PC2. This study may provide a way for fast and nondestructive fruit surface pesticide residue detection.*

Keywords: Infrared spectroscopy; pesticide residue; principal component analysis (PCA);

1. Introduction

NIR spectroscopy applied to the rapid analysis of moisture, protein analysis, and fat content of a wide range of agriculture and food products. It also widely used in chemistry procedure for qualitative and quantitative analysis in many fields such as food, agriculture, pharmaceuticals, textiles, cosmetics and polymer production [1]. The operation of spectra measurement by spectroscopy is simple and more convenient than chemistry methods [2]. NIR spectrometer advantages are its non-destructiveness and in situ analysis. Also include critical factor for spectrometer development like cost, size, weight, power consumption, robustness, safety, user-friendliness, durability, accuracy of measurement and high performance reliability [3].

Traditional methods and technique Chromatography, High-Performance Liquid Chromatography, and Gas Chromatography – Mass Chromatography are used to detection and analysis of agro-food. These traditional methods are time consuming, wastage producing, destructive and require the instruments which may contact with hazardous samples. Near-Infrared spectroscopy method is non-destructive, rapid, lower costly, multi parameter results and environmental friendly.

NIR spectroscopy used to determine the Soluble Solid Content (SSC) in apple and many fruits. Also numerous studies have been published on NIR spectroscopy and its application in agro-food industry.

The incident light may reflected, observed or transmitted depending on matter physical structure and chemical composition content. Near-Infrared Radiation ranges from 780nm to 2500nm of the electromagnetic spectrum. NIR spectra bands contains hydrogen atom such as C-H, O-H, N-H, S-H. Organic compounds contain those hydrogen atoms.

INDIA is one of the largest banana planting and consuming countries in the world. With market expansion and segmentation, the Indian processing industry needs efficient technologies for detection of Pesticide Residue on the surface of banana in order to maintain its leading position. Nowadays, most of methods to detect the Pesticide Residue are destructive and time-consuming. An efficient and effective Pesticide Residue detection system is urgently needed for the fruit industry to identify the defects rapidly and objectively.

2. Related Work

A non-destructive pesticide measurement of the agricultural products based on the Fourier transform in infrared diffuse reflectance spectroscopy (FT-IR-DRS). Both spectra and the concentration of the pesticide residues are measured for real lettuce samples. The calibration models to estimate the residual concentration of the pesticides are derived by the PLS regression of the spectra. The cross validations of the calibration models were carried out. By using that method, it takes two minutes to measure the multi-elements of pesticide residues in a sample lettuce head. The food safety inspection could be enhanced based on FT-IR-DRS [4].

Safety about the Pesticides residues of leafy vegetable to picking live is very important problem for the consumer and farmers [5]. This paper aimed at developing the Remaining Pesticides detection technology of real Broccoli by IR Spectroscopy. As the result, it can think about the easy land vapid technology of the Pesticides residues would be possible by the present method.

Industry needs efficient technologies for detection of Pesticide Residue on the surface of fruit in order to maintain its leading position. Nowadays, most of methods to detect the Pesticide Residue are destructive and time-consuming. An efficient and effective Pesticide Residue detection system is urgently needed for the fruit industry to identify the defects rapidly and objectively [6]. The principle components analysis showed that the samples with Pesticide Residue and no Pesticide Residue were perfectly classified by PC1 and

PC2. The BP artificial neural network model yielded the corrected prediction as 93% ratio.

Peppers are a frequent object of food safety alerts in various member states of the European Union owing to the presence in some batches of unauthorised pesticide residues. This study assessed the viability of near-infrared reflectance spectroscopy (NIRS) for the measurement of pesticide residues in peppers. Commercially available spectrophotometers using different sample-presentation methods were evaluated for this purpose: a diode-array spectrometer for intact raw peppers and two scanning monochromators fitted with different sample-presentation accessories (transport and spinning modules) for crushed peppers and for dry extract system for infrared analysis (DESIR), respectively [7]. RESULTS: Models developed using partial least squares–discriminant analysis (PLS2-DA) correctly classified between 62 and 68% of samples by presence/absence of pesticides, depending on the instrument used. At model validation, the highest percentage of correctly classified samples – 75 and 82% for pesticide-free and pesticide-containing samples respectively – were obtained for intact peppers using the diode-array spectrometer

The feasibility of reflectance Vis/NIR spectroscopy was investigated for taste characterization of Valencia oranges based on taste attributes including soluble solids content (SSC) and attractable acidity (TA), as well as taste indices including SSC to TA ratio (SSC/TA) and BrimA [8]. The robustness of multivariate analysis in terms of prediction was also assessed. Several combinations of various preprocessing techniques with moving average and Savitzky–Golay smoothing filters, standard normal variate (SNV) and multiplicative scatter correction(MSC) were used before calibration and the models were developed based on both par-tial least squares(PLS)and principle component regression(PCR) methods. The best model sustained with PLS method had root mean square error so prediction (RMSEP) of 0.33 Brix, 0.07%,1.03and0.37,andpre-diction correlation coefficients(rp) of 0.96, 0.86, 0.87 and 0.92 for SSC, TA, SSC/TA, and Brim A, respectively. It was concluded that Vis/NIR spectroscopy combined with chemometrics could be an accurate and fast method for nondestructive prediction of taste attributes and indices of Valencia oranges. Moreover, the application of this technique was suggested for taste characterization, directly based on BrimA which is the best index related to fruit flavor rather than determination of SSC or TA alone.

3. Materials and Methods

In this work, we aim at applying the ensemble to predict the pesticide values which are measured from spectral signature of the banana fruits at the harvesting period by the NIR spectroscopy measurement. Pesticide values affect the eating of the fruits after ripening [9] [10]. In this section, the materials for evaluating our work as well as the methodology are presented as follows.

3.1 Materials

Banana fruits were used in this experiment. Banana fruits were classified into three groups which were unripe, ripe and overripe with total of 30 samples in each group. Group of ripe and overripe banana were sprayed the Pesticide solution on the surface.

3.2 Spectrometer Equipment

The Field Spec 4 spectrometer (analytical spectral device, ASD Co., USA) was used in this experiment (Fig 1.) having parameter details in Table 1. Its parameters are showed in table1. Spectrum data was exported in ASCII text. ASD View Spec Pro and Matlab were used to analyze the Spectrum data.

Figure 1: FieldSpec 4 spectrometer.

Table 1: Parameter details

Table	Specification of field spec 4 spectrometers	
No.	Performances	Value
1	Spectral Range (nm)	350-2500nm
2	Sampling Interval (nm)	1.4nm@350-1000nm 1.1nm@1000-2500nm
3	Spectra Resolution (nm)	3nm@700nm, 10nm@1400/2100nm
4	Scanning Time (ms)	100ms

3.3 Spectrum Acquisition

The 350nm-2500nm reflectance spectra were measured at one location of each banana. Every location was scanned 30 times, and then the 30 spectra were averaged as the reflectance spectrum of the banana. A white board was used as a reference for reflectance measurements. A reference spectrum was collected and stored every 15-30 minutes when samples were measured.

3.4 Data Analysis

The spectra data were analyzed using the commercial software package, ASD View Spec Pro (ASD Co., USA), and Matlab7.0 were used for processing the data and developing detection models.

4. Results and Discussion

Principal components analysis (PCA) is a method for compressing variables. The method generates a new set of variables named principal components (PC) and it is a linear

combination of the original variables. All the PCs are orthogonal to each other so there is no redundant information. The total 60 samples reflectance spectra of unripe, ripe and over ripen group were analyzed via principle component analysis (PCA). The results demonstrated that the reliability of the principle component 1(PC1) and 2(PC2). So the PC1 and PC2 represent the primary information of the original reflectance spectra.

A. NIR Reflectance

Typical reflectance spectra of banana samples with Pesticide and no Pesticide Residue are taken for computation. The typically observed bands containing the hydrogen atom such as C-H and O-H are frequently present in banana. O-H functional group has the approximate position of overtones and combination bands are 740nm, 950nm, 1430nm and 2000nm [11]. Although the NIR spectrometer covered the spectral region between 350 nm and 2500 nm, the most effective spectral region was only between 500 nm and 1000 m. Reflectance spectrum 970nm, 1200nm, 1400nm, 1450nm, 1490nm, 1530nm, 1540nm, 1580nm of O-H bend in 1st overtone and 990nm, 1820nm, 1900nm, 1960nm, 2000nm, 2080nm, 2100nm, 2250nm, 2300nm O-h stretch 2nd overtone, 1400nm, 1450nm, 1490nm, 1530nm, 1540nm, 1580nm, 1820nm was selected to develop the model to detect Pesticide Residue. Selected spectra of pesticide and non-pesticide reflectance graph shown in figure 2.
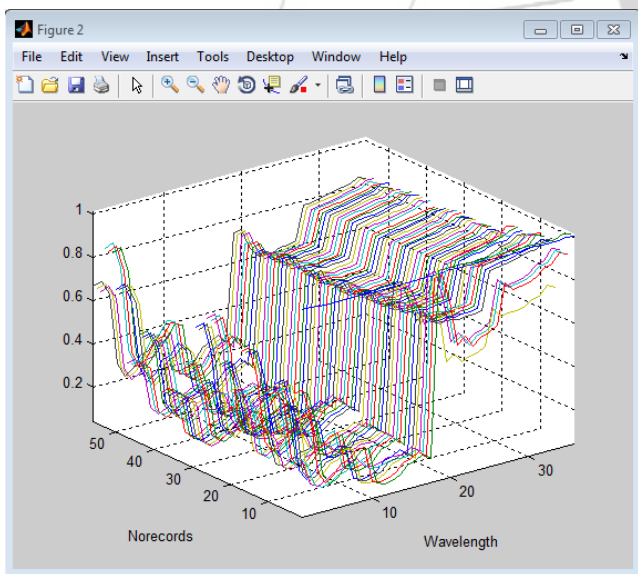

Figure 2: Reflectance spectra of different residue levels

### B. Clustering Results Based On PCA

Partial Least Squares Regression (PLSR) and Principal Components Regression (PCR) are effective two methods for PCA classification. PLSR and PCR are both methods to model a response variable when there are a large number of predictor variables and correlated to each other. Both methods construct new predictor variables, known as components, as linear combinations of the original predictor variables, but they construct those components in different ways. PCR creates components to explain the observed variability in the predictor variables, without considering the response variable at all. On the other hand, PLSR does take the response variable into account, and therefore often leads

to models that are able to fit the response variable with fewer components. Observed response for the PLSR and PCR shown in figure 3.
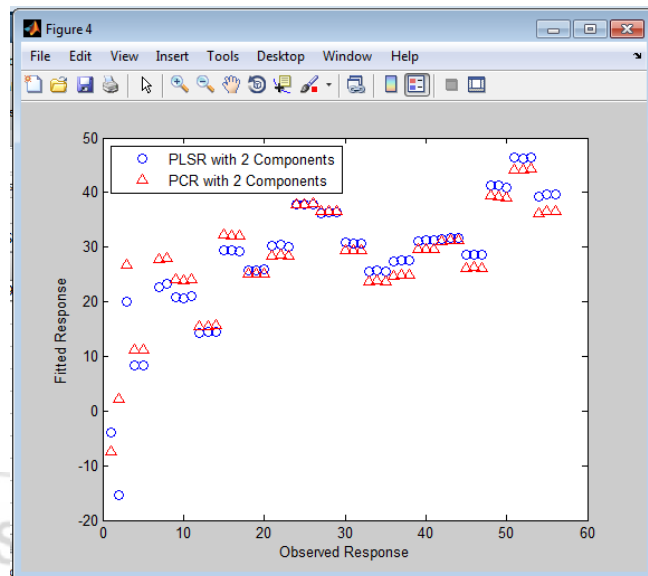
**Figure 3:** observed response for the PLSR and PCR

The PCR curve is uniformly higher suggests why PCR with 2 elements will such a poor job, relative to PLSR, in fitting y. PCR constructs elements to best make a case for X, and as a result, those 1st 2 elements ignore details within the data that's vital in fitting the ascertained y shown in figure 4
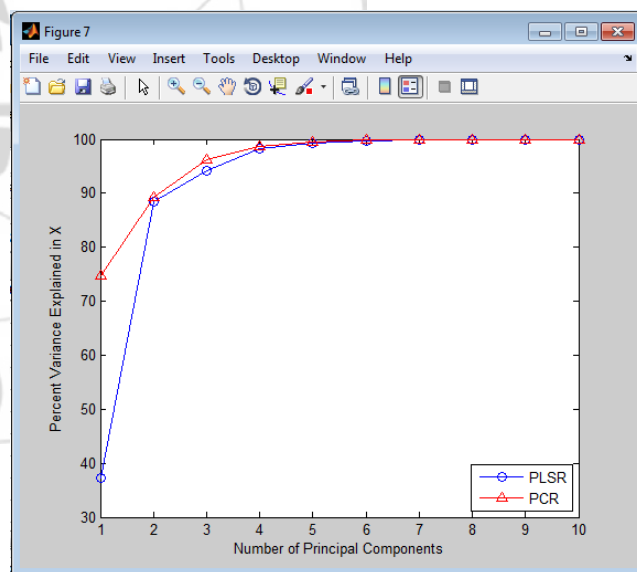
Figure 4: observed response for the PLSR and PCR

The PCA loadings describe however powerfully every element within the PCR depends on the first variables. For either PLSR or PCR, it should be that every element is often given a physically purposeful interpretation by inspecting those variables with chemical. For instance, with these spectral data it may be possible to interpret intensity peaks in terms of more percentage of pesticide. Thus the PCA loadings are shown in figure 5.
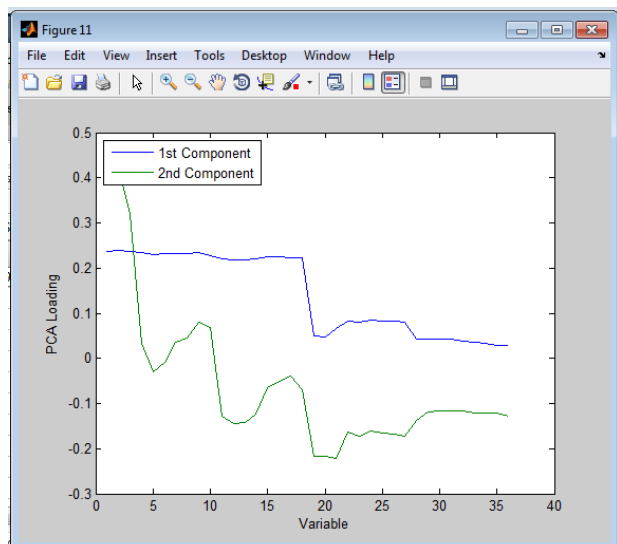
Figure 5: PCA Loading

5. Conclusion

The study demonstrated potentials of NIR technology to extract the spectral information for the assessment of Pesticide Residue on the surface of banana. The principle components analysis showed that the samples with Pesticide Residue and no Pesticide Residue were perfectly classified by PC1 and PC2. This study may provide a novel way for fast and nondestructive fruit surface pesticide residue detection.

6. Acknowledgment

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