Nondestructive detection of watercore damage in asian pear by near infrared spectroscopy

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Introduction

Pears are popularly consumed as intact fresh fruit. In Thailand the most popular fruits come from northern Thailand, where pears have been introduced and promoted for cultivation by the Royal Project Foundation (RPF). The most important cultivated areas are the Royal Agricultural Station Angkhang, Maehea, Maepoonluang and Watchan. Conventionally, the RPF has checked internal quality by random testing, however pears examined by this method were destroyed and could not be distributed. Producers could not guarantee the qualities of all pears. Consequently, non-destructive internal quality evaluation would be readily accepted by both producer and customer. Lymmertyn et al.[1] applied X-ray CT imaging and Magnetic resonance Imaging (MRI) for nondestructively detecting internal defects, such as core breakdown of pears, but both of these methods are relatively complicated in implementation, and the costs of instruments are very high.

As an alternative near infrared (NIR) spectroscopy is a non-destructive method for checking internal quality, and it has been widely used in agriculture and industry. NIR spectroscopy has been applied for predicting chemical composition and total soluble solids in various fruits, such as orange,[2] mango[3] and apple[4] in many countries.

The objective of this study was to develop a discrimination (classification) model for nondestructive detecting of the internal quality of pears, including watercore damage, using the NIRS technique.

Materials and methods

Samples

Ninety-three samples of Asian pear, variety “SH-078” from RPF, were temperature-controlled by putting them on a plastic sheet stretched over the surface of a water bath at 28°C for 10 minutes. The pears at this constant temperature were used for spectral acquisition.

NIR measurement

NIR measurement was performed with a PureSpect NIR instrument (Saika TIF, Japan) over the short wavelength range (700–850 nm) using the transmission mode. The stems of the pears were laid horizontally, and the NIR spectra were obtained at an angle of 90° from the fruit shoulder from whole pears.

Watercore assessment

A slice of pear of 1 cm thickness was cut in cross section through the equator. The cut surface of each pear-slice was photographed with a digital camera (Olympus, Japan), and assessed to have watercore damage when this was visibly apparent, as assessed by the RPF authority (Figure 1).

Discrimination model

A non-destructive discrimination model for prediction of watercore damage was developed, using the relationship of the internal qualities, and near infrared (NIR) absorbance in the short wavelength region (700–850 nm). Prior to developing the model, the spectra were pretreated with the first derivative (number of left and right side were 5 points). Unscrambler software was used to perform principle component analysis (PCA) and partial least squares discriminant analysis (PLSDA), by assigning the dummy variables of 0 and 1 for normal and watercore-damaged pears, respectively.

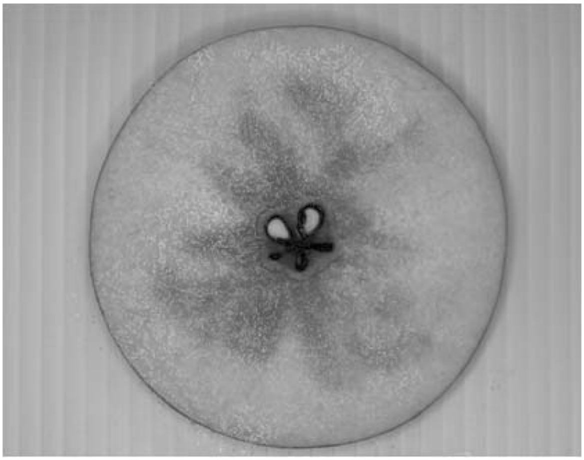


Figure 1. Watercore in Asian pear.

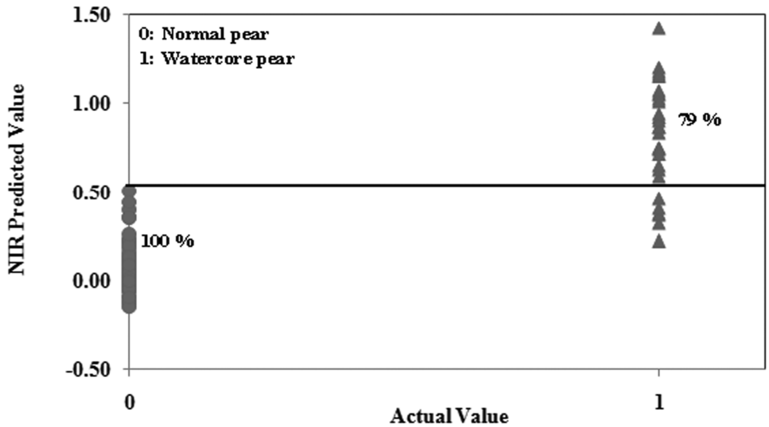


Figure 2. Classification plots of actual and predicted value for discrimination model of watercore damage by PLSDA.

Results and discussion

Spectra of intact pears

Baseline shifts occurred due to the difference of pear size, and the spectra were separated into two groups. The spectra of the severely watercore-damaged pears were located lower than those of the normal pear group, indicating that the watercore damaged pears had relatively lower absorption.

According to the primary pretreatment, the first derivatives developed using the Savitzky Golay derivative in the wavelength region of 700–850 nm was able to reduce baseline shift influence.

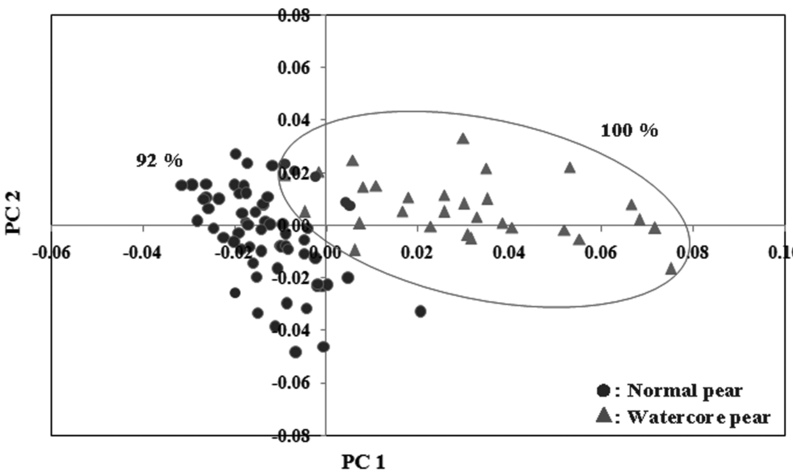
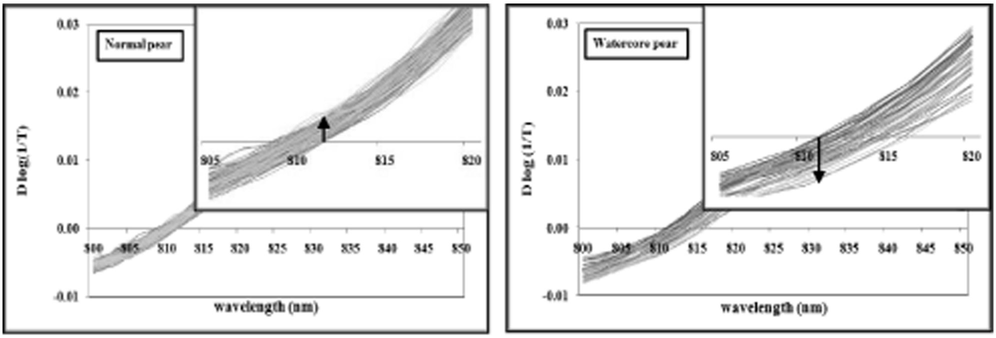


Figure 3. Score plots of PC1 and PC2 for discrimination model of watercore by PCA.



(a) (b)

Figure 4. First derivative spectra at 811 nm of (a) normal pears and (b) watercore pears.

Discrimination model

According to the PLSDA result (Figure 2), the model could predict 100% normal pears and 79% water-cored pears correctly.

From the PCA result (Figure 3), the scores were separated into 2 boundaries, one boundary predicted watercore-damaged pears, and the other included normal pear.

The model showed classification accuracy of 100% for watercore-damaged and 92% for normal pears. The PCA model seems to be suitable for commercial purposes to identify watercore-damaged pears correctly.

From the discrimination model, the important wavelength influencing discrimination was 811 nm. The absorbance of normal pears at 811 nm was greater than or equal to zero, whereas absorbance of watercore pears was less than zero (Figure 4).

The reason was that the watercore-damaged pears are relatively translucent, and allow light at 811 nm to be transmitted to a greater degree than normal pears, which are relatively opaque.

From the score plot, the most important PC factor influencing the model was PC1, which scored very positively for watercore-damaged pears.

Conclusion

NIR technology was sufficiently accurate to detect watercore damage in Asian pears for commercial trade. The PCA model was able to classify internal quality correctly 95% of the time.

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