Non-destructive detection of two cucumber cultivars fruit quality using NIR Spectroscopy

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Abstract. Cucumber fruit quality can be detected by the non-destructive method such as NIR Spectroscopy. NIR determines the content quality of the product rapidly, precise, and accurate. This study aims to predict the quality component of cucumber cultivars Bandana and Wulan by a non-destructive method using portable NIR. The experiment was conducted at Post Harvest Laboratory of Agriculture Faculty of Padjadjaran University and the instrument used to measure the fruit quality in a non-destructive way was the NIR (NirVana AG410, Integrated Spectronics Pty, Ltd, Australia). To determine cucumber internal quality it was done from the evaluations obtained by a non-destructive method (NIR) and a destructive method. The calibration and validation models are built using the partial least squares (PLS) method. The result shows that the quality component of the non-destructive cucumber method using NIR has accuracy values similar to the conventional method. In the observed result quality component, the correlation coefficient (R) was close to 1.00 and the standard error of calibration (SEC) was low or close to 0.00.

Keywords: Cucumber; Firmness; Total Soluble Solids; Water Content

1. Introduction
Cucumber (Cucumis sativus L.) is one of the most consumed fruit vegetables in Indonesia. Determinate cucumber fruit quality is important because can determine the shelf life and feasibility of fruit to be accepted by consumers [1].

Quality estimation of cucumber mostly done by visualization based on weight, color, and size. Nowadays, non-destructive method is developed for determining the internal content of the product rapidly, precise, accurate, and non-destructive [2]. Non-destructive method is defined as a method that identified material characteristic without causing significant damage [3].

One of non-destructive calibration to determine internal quality of cucumber is using portable near-infrared (NIR) spectrometer [4]. NIR portable emits waves that can penetrate the skin of the fruit and the internal quality [12] is translated from the NIR wave data absorbed by the cucumber. Osborne et al. [5]
highlighted that the results of fruit quality data obtained with NIR have a high degree of accuracy. In addition, [6] stated that NIR spectroscopy is able to classify fruit species from other species.

The use of NIR can predict cucumber fruit quality non-destructively. However, it is necessary to further examine the value of the accuracy of the use of non-destructive methods with conventional methods. Application of NIR in fruit vegetables such as cucumbers is still rarely done, so it can be done research on cucumber. Each cultivar has different properties and characteristics, such as Bandana and Wulan cultivars that will be used in this study. The use of two different cucumber cultivars is expected to increase the value of high accuracy due to the increasing variety of data. This study aimed to predict the quality component of cucumber fruit on Bandana and Wulan cultivars by a non-destructive method using portable NIR.

2. Methods
The experiment was conducted at Postharvest Laboratory of Agriculture Faculty of Padjadjaran University. The materials used were cucumber Bandana and Wulan cultivars each amounted to 300 pieces. The tool used in this research is as follows portable near-infrared spectrometer (NirVana AG410, Integrated Spectronics Pty, Ltd, Australia), tension gauge (Tensilon/UTM-4-100, Toyo Baldwin, Japan), refractometer (PR1 Atago, Japan), oven (Jouan EB.100, Germany), digital cameras (SONY DSC-T100, Japan), digital scales (ACIS MN-Series, Japan), digital slide range (CD-20 CPX, Japan), infrared thermometer, Microsoft Excel 2007 and Multivariate Unscrambler (version 9.7, CAMO, Oslo, Norway), Adobe Photoshop CS3. Supporting equipment in the form of a knife, aluminum container, grater, plate, spoon, and tissue.

The experimental method used is a method of axiomatic experiments with multivariate data using modeling. Measurement of the cucumber quality component was done by conventional method and non-destructive method by using portable near-infrared spectroscopy on cucumber with different cultivar. The data processing was analyzed using Multivariate Unscrambler software (version 9.7, CAMO, Oslo, Norway) to model equations of the quality of cucumber.

2.1 Cucumber Sampling
Samples of cucumber fruit used in this research are cucumber cultivars Bandana and Wulan, each of which is 300 fruit obtained from the farm located in Curugrendeng, Jalan Cagak, Subang, West Java. The cucumber used has an age between 7 to 14 days after flowering. Sampling and cucumber quality testing (water content, TSS, firmness, and color value) were performed ten times and each time the test was done on 60 samples in each cultivar. Before the test, the fruit was left for 12 hours in the room.

3. Results and discussion
Measurement of quality components of cucumber fruit included water content, total soluble solids content, color and firmness of the fruit was performed with absorbance data at 300-1100 nm wavelength range using partial least squares (PLS) calibration method.

Cucumber samples were divided into two groups, group one for the calibration stage and group two for the validation stage with each using different samples. The result of calibration and validation data analysis of cucumber regression calibration quality estimation is best found in the data of both cultivars combined compared to the data of each sample.

The data showed that prediction of cucumber water content can be done by NIRS (Figure 1) with the calibration result of correlation coefficient value obtained equal to 0.97 meaning that values close to 1.00. The degree of error is expected to be close to 0, while the correlation coefficient is desired to be close to 1. In other study, [8] reported that NIR spectroscopy was feasible to predict water content of sapodilla with high accuracy prediction. Standard error calibration (SEC) obtained for 0.59 low value means close to
Validation for the sample with the results of correlation coefficient ($r$) of 0.94 and the standard error prediction (SEP) of 0.89. Water content of two cucumber cultivars was different because of genetic characteristic (Figure 2).

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**Figure 1.** Calibration and prediction models of water content.

**Figure 2.** Calibration stage of water content of two cucumber cultivars.

Not only water content, the TSS of cucumber can also be predicted by non-destructive methods using NIR. The non-destructive method using NIR spectroscopy yielded high correlation coefficient for predicting TSS of sapodilla [7][9]. The value of correlation coefficient from the combined data of both cultivars obtained a value of 0.92. Standard error calibration (SEC) generated 0.09 with validation correlation coefficient of 0.91 and the SEP of 0.19. Figure 3 can be interpreted that the validation value is almost equal to the calibration value. Figure 4 shows the points of the two interlocking cultivars. It can be concluded that the distribution of total soluble solids of Bandana cultivar is almost the same as that of Wulan cultivar.
Figure 3. Calibration and prediction models of TSS.

Figure 4. Calibration stage of TSS of two cucumber

Figure 5. Calibration and prediction models of firmness.
Figure 6. Calibration stage of Firmness of two cucumber cultivars.

Fruit firmness can be well predicted by NIR (Figure 5). The value of the combined correlation coefficient of both cultivars was 0.96 standard calibration error obtained at 1.56. From the value of the correlation coefficient in the combined validation stage both cultivars obtained for 0.94 and the standard error validation value of 1.89. Firmness of Wulan cultivar was lower than Bandana cultivar, it was estimated because of high water content (Figure 6) [10][11].

4. Conclusion

Based on the results of non-destructive component quality method analysis using NIR and conventional method on Bandana and Wulan cultivars, it can be concluded that the quality component of the non-destructive cucumber method using NIR has accuracy values similar to the conventional method. In the observed result quality component, the correlation coefficient (r) is close to 1.00 and the standard of calibration error (SEC) is low or close to 0.00.

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