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Determination of Water Content Of Intact Sapodilla Using Near Infrared Spectroscopy

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Abstract. Water content is one of components that affects the fruit firmness of sapodilla. Fruit firmness is used as an indicator of physical fruit quality, which determines consumer acceptance. Generally, determination of water content is done by drying the fruit itself. However, this method damages the fruit, therefore needed a non-destructive method which able to determine the water content of sapodilla. Non-destructive method is also very useful to reduce physical damage to fruit (bruses) caused by the touch of the consumers hands to assess the fruit firmness. Near infrared spectroscopy is a non-destructive measurement that has been widely used to determine various components of fruit quality, including water content. The purpose of this study was to determine water content of intact sapodilla non-destructively using near infrared spectroscopy. This research used experimental method with multivariate data analysis by modelling, continued by data processing using ISIS software (Integrated Spectronics Pty, Ltd, Australia and Unscrambler multivariate data software (version 9.7, CAMO, Oslo, Norway). Further research resulted value has the same accuracy as the value of non-destructive measurements. The result showed that near infrared spectroscopy was able to determine water content of intact sapodilla non-destructively.

1. Introduction

Most sapodilla fruit farmers determines the appropriate time to harvest by visual estimation such as size and skin color. Additionally, it needs laboratory analysis to obtain the internal quality of fruits. Water content of fruit is an important parameter to assess the quality of fruit, because it is related to the shelf life and also the texture of the fruit. The ripe sapodilla contains 72 to 78% of water content and total soluble solids ranged from 12 to 18 °Brix [1]. Composition of ripe sapodilla fruit is presented on Table 1.

Near infrared spectroscopy (NIR) is a non-destructive method to predict fruit quality. It has been used to predict a lot fruits quality since 1990s [2]. This technique is time and labor reducing alternatives. Blanco and Villarroya [3] studied that near infrared spectroscopy offers a rapid and accurate measurement for fresh commodities. Spectrometer records spectra data consist of physical and chemical content such as total soluble solids, firmness and color [4]. The non-destructive method using NIR has been previously performed to measure the fruit quality of mango [5], Jujube [6;7] with high accuracy. NIR also has been used for predicting soluble solid content, moisture content and hue color of on tree and after harvesting tomato [8] firmness, color and lycopene content of tomato [8] and chlorophyll of bitter gourd [9]. Ranganna [10] studied that once separated from the plant, fruits continue to respire until senescence phase because the harvested fruit can not access water from the plant anymore for the ripening process. Respiration determines the potential storage life of fruits [11]. Hence, this research objective aimed to focus on determinating of internal quality of intact sapodilla during storage using near-infrared spectrometer.

Table 1. Composition of ripe sapodilla fruit of 100 g of eatable part [12]

Constituents	Amount
Water content (%)	73.37
Protein	0.70 g
Fat	1.10 g
Mineral	0.05 g
Fiber	2.60 g
Carbohydrates	21.40 g
Energy	98.00 cal
Phosphorous	72.00 mg
Iron	1.25 mg
Calcium	28.00 mg
Vitamin B1	0.02 mg
Vitamin B2	0.03 mg
Carotene	97.00 mg
Vitamin C	0.06 mg

2. The Material And Method

2.1. Sample Collective

225 Sapodillas were all harvested from the orchad then stored for 0 day (H_0), 5 days (H_5), and 10 days (H_{10}). All samples were numbered before further analysis.

2.2. Spectral Data Acquirement

NirVana AG410 spectrometer with wavelength range of 312-1050 nm was used to measure the six separate measurements with three points on each side of fruits distributed along axial region (Figure 1.).

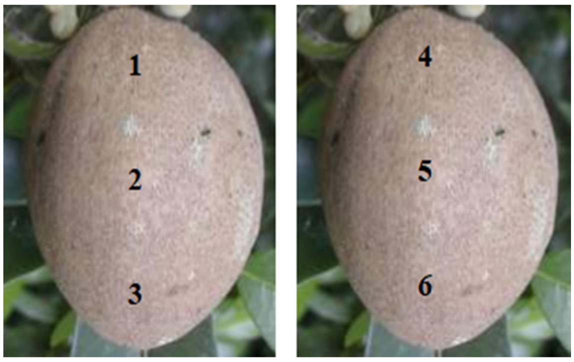

Figure 1. Irradiated points of fruits on each side

2.3. Reference Data Acquirement

Water content was calculated by the mass difference between the fresh fruit and the dried fruit. Sliced sapodilla were put into aluminum foil. Then The sample was dried using an oven until it reached a constant weight. The results were described as percentage of water content. The calculation of water content is described in the following equation :

$$\text{Water content} = (\%)\, \frac{W-Wa}{W}\, 100\%$$

where:
W : fresh fruit (g) Wa : dry fruit (g)

The method used in this research was multivariate data analysis. Then it continued by data processing using ISIS and The Unscrambler 9.7.

2.4. Multivariate Analysis

The calibration model was built using the partial least square (PLS) method. PLS is a chemometric technique that could analyze a large of hidden information in spectral data. It is used to evaluate a series of dependent variables (response) from immense number of independent variables (predictors).

The acceptable model is implied by R_{cal} of 0.71 or above as explained by Williams [13] that this value indicates rough screening ability, and is preferable for further prediction. Then, the acceptable calibration model was used to predict another sapodilla fruits (prediction set) in order to verify the prediction capability. The model was evaluated using coefficient of determination (R^2) which explains the capability of independent variables explaining variations of dependent variables.

Root mean square errors of calibration (RMSEC) is the difference in values between predicted and reference value of calibration set. Root mean square errors of prediction (RMSEP) is the difference in values between predicted and reference value of prediction set.

Nicolaï *et al*. [14] advised that an effective model should present a high R^2 value of prediction set and low value of errors in calibration set and prediction set, either. Nevertheless both error values should not have a high difference from each other. The calculations of RMSEC and RMSEP are described in the following equations [15]:

$$\text{RMSEC}=\sqrt{\frac{1}{\text{n}_\text{c}}\sum_{i=1}^{nc}(\hat{y}i-yi)^2}$$

$$\text{RMSEP}=\sqrt{\frac{1}{\text{n}_\text{p}}\sum_{i=1}^{np}(\hat{y}i-yi)^2}$$

where:
$\hat{y}i$:predicted value,
yi :measured value,
n^c :amount of samples in calibration set,
n^p :amount of samples in prediction set.

3. Result And Discussion

3.1. Destructive Data Analysis of Sapodilla

Water content analysis by destructive measurement was used as reference data for the development of calibration model. Any kind of measurement surely produce errors, as well as the destructive measurements. Hence, to diminish the errors, it was performed special handling to the samples. Sapodilla samples that have been irradiated by near infrared spectrometer, then as quickly as possible should be measured of it's water content at the laboratory. This is necessary to avoid the changes of internal chemical content of sapodilla. Reference data measurement of sapodilla samples are described on Table 2.

Table 2. Statistical Data of Sapodilla Samples By Destructive Method

Water Content	H_0	H_5	H_{10}
Minimum	67%	64%	63%
Maximum	74%	77%	74%
Mean	70%	72%	70%
Standard Deviation	1.5%	2.8%	2.3%

The lowest and highest value of water content are found in H_{10} as 63% and H_5 as 77% respectively. Highest mean value was found in H_5 as 72% and the lowest mean value are found in H_0 and H_{10} as 70%.

Standard deviation indicates the diversity of amount of data being investigated. Largest variation of data was found in H_5 as 2.8% and the lowest data variation in H_0 value as 1.5%.

3.2. Near-Infrared Data Analysis of Sapodilla

Data analysis of water content was measured by NIR second derivative data using multivariate data analysis as partial least square (PLS). Total samples used was 225 fruits. Each fruit was irradiated by 6 points as illustrated in Figure 1.

3.3. Water Content Assessment

In calibration set the assessment of water content used 150 samples and 75 samples for prediction set with wavelength 312-1050 nm. Lowest to highest data range in calibration set starts from 63% to 77%, while in the prediction stage ranges from 64% to 76%. The mean value of calibration was 71% and 70% for prediction. The standard deviation values of calibration was 2% and prediction was 1%, respectively. Stastical data of sapodilla used in calibration and prediction are presented on Table 3. The calibration model of water content is showed on Figure 1. Prediction model of water content is showed on Figure 2.

Table 3. Statistical Data of Sapodilla Samples Used In Calibration and Prediction Set.

Set	n	Range	Mean	Standard Deviation
Calibration	150	63% – 77%	71%	2%
Prediction	75	64% – 76%	70%	1%

Coefficient of determination of calibration set (R^2_{cal}) for assessment of water content of sapodilla was 0,71 means high (closed to 1). This defined the NIR prediction for water content was close to the reference measurement by using destructive analysis. RMSEC of calibration set generated was 0.01. Considering the RMSEC of calibration set, it showed the calibration model was built well due to the standard error value close to zero (0). It is required to perform the prediction set to check the accuracy of calibration model.

The prediction set of water content of sapodilla used different samples from calibration set which 75 samples from second derivate absorbance data (d2a) NIR and destructive mesurement. The purpose of using a different samples was to test the capability of calibration model for predicting water content of new sapodilla fruit samples. Afterwards the calibration model would be reliable for predicting new samples. Coefficient of determination of prediction set (R^2_{pred}) of water content was 0.65. The accuracy level of prediction set was determined RMSEP value. It showed that the RMSEP generated was 0.01. The RMSEP was acceptable due to close to zero. Reliability of the calibration model could be examined by how close the value of coefficient of determination of the calibration set and the prediction set. The result explained the coefficient of determination and the error value in the calibration set and the prediction set were quite close. Hence calibration model that was built could be assumed to be reliable for predicting water content of sapodilla fruit.

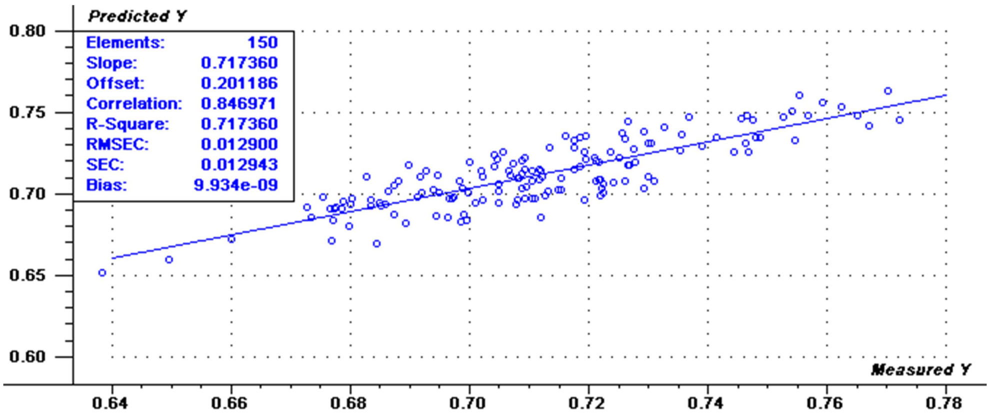

Figure 2. Calibration set of water content

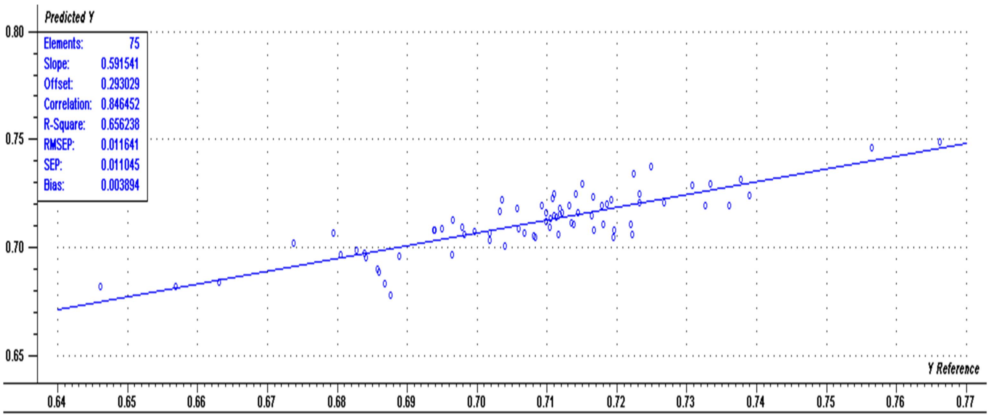

Figure 3. Prediction set of water content

4. Conclusion

Determination of intact sapodilla during storage using near-infrared spectrometer was able to measure water content value with good accuracy.

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