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Determination of Chemical Properties in *Jatropha Curcas* L. Seed IP-3P by Partial Least-Squares Regression and Near-Infrared Reflectance Spectroscopy

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***Abstract* – The objective of this study was to assessnear infrared reflectance (NIR) method for predicting chemical properties of *Jatrophacurcas* L.in form of powderas a first step for development of a non destructive method.The chemical properties of *Jatrophacurcas* L. predicted were moisture, free fatty acid (FFA), and oilcontents. The reflectance of powders were measured in the wavelengths from 1000 to 2500 nm usingNIRFlex Solids Petri Apparatus. PartialLeast Squares (PLS)method isused for calibration of NIR and chemical data. Three data pre-treatment for NIR data were studied for obtaining the best calibration, namelynormalization, first derivative Savitzky–Golay 9 points, and combination both of them.The calibration model performance were inspected by precision (standard error of calibration and coefficient of variability should be as close to zero as possible); accuracy (V-set Bias should be as close to zero as possible), regression coefficient and coefficient of determination should be as close to one as possible.Relative prediction deviation (RPD) values higher than 2.0. In the general,it was found that the correlation coefficients between the reference values and NIR predicted values were higher than 0.88 for all variables (r=0.97 for moisture content, r=0.91 for oil content and 0.88 for FFA content) indicating the robustness of calibration model. The coefficient of varians(CV) of calibration model of moisture, oil and FFA content were 5.4 %, 5.1 % and 7.1 % respectively. The RPD of calibration model of moisture, oil and FFA content were 3.9 %, 2.5 % and 2.13 %, respectively. The best calibration model of NIR for moistureand oil contents using the PLS method and the data pre-treatments of the combination by normalization between 0 to 1 and first derivative Savizky–Golay 9 points, except for FFA content was the first derivative Savitzky - Golay 9 points. The PLS factor different for each propertiesi.e.7, 4 and5for moisture, oil and FFA content, respectively. This results suggest that NIRmethod could be used to predict chemical properties of powder of *Jatropha curcas* L.**

***Keywords* – Jatrophacurcasl, Near Infrared Spectroscopy, Partial Least Square,Moisture Content, Oil Content, Free Fatty Acid.**

I. INTRODUCTION

*Jatrophacurcas*L. is a drought tropical tree and the oil from its seeds has been found useful for medicinal and veterinary purposes, as insecticide, for soap production and as a fuel substitute [1]. Moisture, free fatty acid, and oilcontent are the chemical compositions that are used as the parametersto determine the quality of *Jatropacurcas L.*seeds [2]. These parameters are very important because it will be determine the process, yield, and quality of biodiesel. *Jatrophacurcas*L. seeds havea large diversity and variability in different accessions. Besides that, a large number of seeds of the *Jatrophacurcas*L. need a rapid and easymethod to determine the chemical composition. The Soxhlet is the standard method that provides reliable and robust oil extraction. However, it is impractical for analysis of large number of samples [3].The routine procedure to determine the FFA and oil content in *Jatropacurcas L.*seed is through the conventional wet-chemical method. For preparation of the standard reagent, analysis, and expression of the result, substantial personnel time and glassware are required. Therefore, an alternative to reduce the problemis needed.Near infrared spectroscopy is a very quick method for measuring spectra from the sample, such as food, horticulture, and livestock feed with data chemical composition. Thebenefit of NIR are very fast, reduce samples preparation, non-destructive, multi determination,no pollution, and no expensive.

Near-infrared (NIR) spectroscopy is a common techniquein agriculture and the food industry [4]. The agricultural area was the first to use of NIR spectroscopy, intensively. The most recent use of NIR technology in this sector has been supporting the precision agriculture. The possibility of using NIR instruments in the crop field, collecting data in real time and correlating it with soil composition, is essential to produce the refined data necessary for precision agriculture [5]. The spectroscopic methods, combined with chemometric strategies, could represent a reliable, cheap and fast classification tool, and able to draw a complete fingerprint of a food product, describing its intrinsic quality attributes, that include the sensory attributes. In food area [6] developed multiple partial least squares (PLS) models for Free Fatty Acid (FFA) the range of 0.03–2.76% as oleic acid and for Total polar material(TPM) in the range of 7.6–48.1%. Relative prediction deviation (RPD) were 5.5 for the FFA calibration and 5.0 for the TPM calibration. Near infrared spectroscopy has already been applied for quality analysis of biodiesel fuel [7].Partial Least Squares (PLS) are generally used to set up the multivariate model and are based on two data sets (of the same objects), the chemical values and the spectra. The purpose of PLS regression is to establish a model that allows the analysis of an unknown sample [8].Near infrared reflectance(NIR) method and artificial neural networks have been applied to determine the chemical composition of *Jatrophacurcas*L. seeds [2].The results indicated that the value of RMSEP NIR-ANN 3.718%, 1.314% and 1.989% for oil content, FFA, and moisture content and the correlation coefficients0.848, 0.872, and 0.993 for oil content, FFA, and moisture content. The accuracy and precision of the models were not considered, so the other possible method should be developed.

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The purpose of this study was to determinethe chemical properties (moisture, free fatty acid, and oil contents) of *Jatropha curcas L.*IP-3P in form of powder by near infrared (NIR) and Partial Least Squares (PLS) method. *Jatrophacurcas* L. powder carried out as a first step to determine the quality of the chemical composition with non-destructive method.

II. Materials and Methods

A. Samples and Reference Methods

Jatropha curcas L.*seeds*IP-3Pwere obtained from theExperimental Farm PlantationofIndonesian Research Institute for Industrial and Beverages Crops at Pakuon Sukabumi West Java.In this study, the Jatropha samples in form of powder. The powder produced from 50 g of seed milled using a grinder then sieved. In preliminary study, used sieve sizes 16 (14 mesh, 1.18 mm) and 30 (28 mesh, 0.8 mm). The smaller size of powdered *Jatrophacurcas* L seed showed better spectra.A total of 85samplesfor measuring in NIRSand reference data.After scanned by NIRS instrument the samples were prepared to obtain reference moisture, oil and free fatty acid content data. The moisture content was determined using thermogravimetrimethod. The free fatty acid content was measured by titration using a modification of the AOCS Official Method. The acidity was expressed as percentage of total acid. The soxhlet extraction, as a standard method, was used for determination of oil content. To have an accurate determination of oil content, two measurements for each sample were run and the average of the oil content was calculated.

B. Near Infra-Red Analysis and Data Pre-treatments

Spectra were obtained using a NIR Sinstrument, NIRFlexSolidsPetriN-500 from Buchi Labortechnik AG, Flawil, Switzerland. The powdered *Jatrophacurcas* L seed scanned by near infrared with the wavelength1000-2500nmwith a spectral resolution of 4 nm. Approximately 35 g of powdered *Jatrophacurcas* L was placed in a glass petri dish and measured using diffuse reflection mode on a NIRFlexSolidsPetriN-500 spectrometer using a rotating measuring cell. Three scans for each sample of powdered *Jatrophacurcas* L were recorded at three different points by rotating the petri dish by 120^0 and a total of the 255spectrum was managed to develop calibration and validation model. The spectral and reference data were managed and pretreated with the software Nircal 5.2 [9].Approximately two thirds of the samples were used for calibrations set and one third for the validations set.The calibration set contained the extreme spectra to define the limits ofacceptance. The three spectra of the same sample remained together and designated to either the calibration or the validation set.The datapre-treatmenthas a different function for the spectrum. Normalization forreduce particle size and increasesing the value of the spectra. Normalization is typically used to obtain all data to approximately the same scale, or to obtain a more even distribution of the variances and the average values. First derivative data pre-treatmentforseparate the component into a single data so the calibration can be good. In this study, the data pre-treatmentwere used normalization between 0-1,b) first derivative Savizky-Golay 9 points, and c) the combination of normalization between 0-1 and first derivativeSavitzky-Golay9 points.

C. Calibration and Validation

Calibration models were developed and evaluated using partial least squares (PLS) regression to analyze relationships between the spectral data (x-variables) and the chemical variables (y-variables) [10] with an optimum number of PLS factors[11].Coefficient correlation (R) and coefficient determination of the calibration model calculated using equation (1) and (2). The number of factors to be used in each case was determined by the predicted residual error sum of squares (PRESS) that shows the sum of squares of deviation between predicted values (yn) and reference values (xn). Data analysis was carried out using the wavelength range from 1000 to 2500 nm.The extent of variability and distribution in calibration and validation data were measured by standard deviation (SD) and coefficient of variation (CV). The accuracyof the correlation, bias, the systematic difference between the predicted values (yn) and the reference or measured values (xn). The value of the bias should be close to zero.

$$R = \frac{\sum(X_n-\bar{X}_n)\sum(Y_n-\bar{Y}_n)}{\sqrt{\sum(X_n-\bar{X}_n)^2}\sqrt{\sum(Y_n-\bar{Y}_n)^2}} \quad (1)$$

$$R^2 = (R)^2 \quad (2)$$

The precision of calibration is represented by the standard error of calibration (SEC) and the standard error of prediction (SEP). The consistency, which is the ratio of the SEC andSEP, should be as close as possible to 100. The consistency is used to ensure that thenumber of factors selected for developing the best calibration model is optimum. The regression coefficient (expresses the relationship between the measured and the predicted values and describes the quality of quantitative calibration [12]. A value of R larger than 0.91 indicates a good correlation between reference (measured) and NIR predicted value. The coefficient of determination (R^2) shows the proportion of the variance in reference data that can be explained by the variance in the predicted data [13]. The other performance to judge the calibration model was the relative prediction deviation (RPD). Reference [14] stated RPD is a measurement of the ability of an NIRS model to predict a constituent efficiently. The SEC, SEP, bias, CV and RPD were computed by the following equations (equation 3, 4, 5, and 6).

$$SE = \sqrt{\frac{\sum(Y_n-X_n)^2}{n}} \quad (3)$$

$$Bias = \frac{1}{n} \text{ x } \sum(X_n - Y_n) \quad (4)$$

$$CV = \frac{SE}{\bar{X}_n} \text{ x } 100\% \quad (5)$$

$$RPD = \frac{SD}{SEP} \text{ x } 100\% \quad (6)$$

Where Yn : predicted value, Xn : reference value, n: number of observation, bias: total differences between predicted and reference values.

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III. Results and Discussion

A. Chemical properties and Spectra

Descriptive statistics for moisture, oil, and free fatty acid are shown in Table 1. Data showed a wide range of variation for three properties of *Jathropacurcas* L. IP_3P with values ranging from 2.61 to 6.74 % formoisture content, from 20.4to 46.82% for oil, from 0.63 to 1.24 for free fatty acids. Table 2 shown that the clustering for data used in calibration and validation samples is quite good.

Table 1: Statistical reference data of *Jatrophacurcas*L. IP-3P

Chemical properties	Mean	SD	Min	Max
Moisture content (% bb)	4.60	0.97	2.81	6.4
Free fatty acid content (%)	0.78	0.12	0.58	1.13
Oil content (%)	35.19	4.58	24.23	45.56

Table 2: The Statistics of calibration and validation data of *Jatrophacurcas*L. IP-3P

Chemical properties	Process Calibration	N	Mean	St Dev	Minimum	Maximum
Moisture content (% bb)	Kalibrasi	180	4.56	0.98	2.81	6.40
	Validasi	75	4.69	0.93	3.02	6.395
Free fatty acid content (%)	Kalibrasi	180	0.77	0.113	0.58	1.13
	Validasi	75	0.79	0.126	0.58	1.08
Fat content (%)	Kalibrasi	177	35.088	4.73	24.22	45.56
	Validasi	69	35.44	4.18	25.02	42.55

Spectra. Original Reflectance spectra are shown in Fig. 1. The shape of the original spectra wasrelatively similar, with the dominant feature being the peak around 1450 nm and 1940 arising from water absorption due to the low water content of the samples. NIR causes a small the ability to penetratesample. This is shows that a NIR spectroscopy technique in the NIR wavelength to determine the moisture content of materials can give a good data. The reflectance bands at 2200–2400 nm are due to CH stretching are free fatty acids, whereas the reflectance bands at 1215 nm, 1395 nm, 1725 nm, 1765 nm, 2310 nm, and 2323 nm are due to fatty acids. Oil content consist of C-H bond absorb at a wavelength of 1037 nm, 1620-1765 nm, and 2310 - 2323 nm [14].

Reference [15]reported that a near infrared (NIR) spectral pattern of oil contains information about fatty acid composition, because NIR absorption bands around 1600-1800 nm and 2100-2200 nm are due to the straight carbon chain and *cis* double bonds, respectively.FFA property is related to a large part of the spectrum, such as the bands due to bonded O–H, C=O stretching in ester, and C–H olefin stretch region. As reported by [4], determination of FFA in palm oil by NIR is proposed based on the C=O stretching bands that lie in the overlap region of the first overtone and the combination region (1850–2050 nm). As shown in Fig. 1, thespectrum of all samples havesimilarshape, but have different levels of reflectance. However, the differences in the level of reflectance arenot very significant due to the sample used in this study in form of powder so that it has the same particle size. Size reduction used to minimize noise.Small particle size for NIR scanning is desirable in order to provide a broad uniform surface for scanning and to minimize variation among the sub-samples selected for scanning. Spectra are quite sensitive to differences in particle size and shape [16].

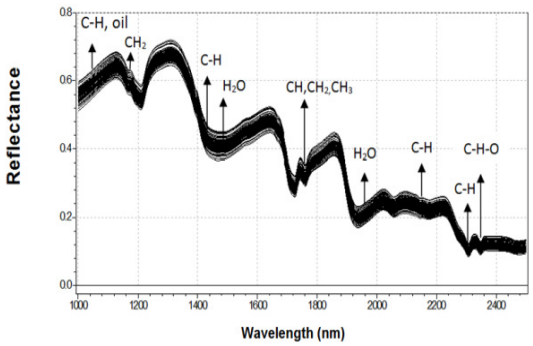

Fig.1. The mean reflectance spectrum of powdered *Jatrophacurcas* L.

B. Calibration Model for Predicting Moisture Content.

The small differences in means, ranges, and SD between the calibration set and the validation set (Table 2), demonstrated that the selected calibration set was suitable for NIRS calibration. Moisture content has a characteristic OH bond is easily absorbed by the NIR. Table 3 summarizes the calibration and validation statistics.The calibration equation of the reflectance with nodata pre-treatmentused PLS method was f(x) = 0.6456x+1.6162 with a regression coefficient (R) =0.800% and coefficient of determination (R^2) =0.646showed that this equation must be develop to reach a better calibration equation. Therefore, it is need the data pre-treatmentto improve the calibration. The NIR spectrum does not only depend on the chemical composition of samples but also on the physical characteristics of the samples, which are usually observed as the background and noise in the spectrum. The first data pre-treatment to remove noisewasused normalization between 0-1. The calibration equation result from the data pre-treatment of the reflectance spectrum by normalization between 0-1 was f(x) = 0.7247x+1.2556

with a regression coefficient (R) =0.8513 and coefficient of determination (R^2) =0.725.This result indicated poor relationship between the reference and the predicted values. A first derivative Savitzky-Golay 9 point was used to improve the calibration equation and resulting regression equation f(x)=0.9589x+0.1875 with a regression coefficient (R) =0.979 and coefficient of determination (R^2) = 0.959. The coeficient of determination (R^2)value bigger than 0.83 indicated that the robustness of the prediction of calibration model is maintained[13],whereas the coefficient of variance (CV) value still high i.e. 5.59%. This result indicated thecalibration modelneed to develop to reach better calibration performance. The combination of normalization between 0-1 and first derivative with Savitzky-Golay 9 points improved better calibration equation. The calibration equationfrom the combination datapre-treatmentwas f(x) =0.9543x+0.2084 with a regression coefficient (R) =0.977 and coefficient of determination (R^2) =0.954(Fig. 2). The correlation coefficient of calibration for moisture content was rather high, it means that calibration sample match to the value obtained by the reference method [17]. This result achieved byusing7PLS factor. It was selected based on PRESS (Predicted Residual Error Sum Square). The optimum number of PC (principal component) or factor for PLS is always given by the smallest number of PC where the PRESS function for the calibration and for the validation set is approximately equal and minimal[18]. Optimum number of factors for calibration was selected based on the PRESS, whichshould be minimized, along with the high R^2. The judging for calibration can be inspected by precision (standard error of calibration and coefficient of variability should be as close to zero as possible), accuracy (V-set Bias should be as close to zero as possible), regression coefficient should be as close to one as possible. The calibration model to predict the moisture content of *Jatrophacurcas*L. seed was quite good. The SEP,SEC, Consistency, Coefficient of variation (CV) and RPD were0.249%,0.211 % 84.75 %, 5.4 % and 3.9respectively (Table 3). The SEP value is higher than SEC value, maybe due to presence of some outliers in selected validation sample [19], moreover C-Set bias was zero and V-Set bias - 0.0299. In general, the result indicated the accuracy of the calibration model was obtained to predict the moisture content of *Jatrophacurcas*L. seed.

C. Calibration Model for Predicting Oil Content

The calibration of the method was evaluated considering the correlation between the percentages of oil content predicted by NIR and determined by the reference method. Calibrationmodel of reflectance data without data pre-treatment was f(x) = 0.4521x+19.2255 with a regression coefficient (R) =0.672 and coefficient of determination (R^2) = 0.452 and the CV = 8.49 % (Table 3). This result shown the model with no pre-treatment data thecalibration equation has poor performance. The data acquired from NIR spectrometer contain background information and noises besides sample information. In order to obtain reliable, accurate and stable calibration models, it is very

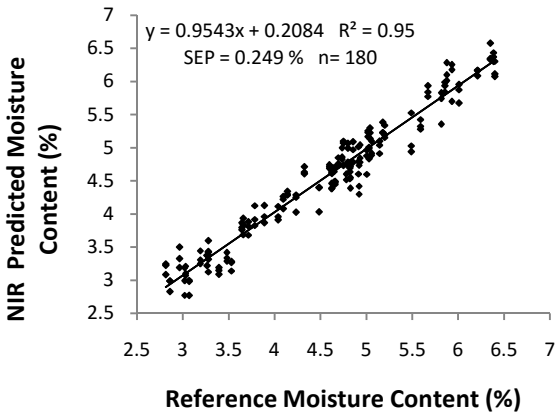

Fig.2. Plot of reference versus predicted moisture content ofthe calibrationdata set

necessary to pre-process spectral data before modeling [20]. To improve the calibration, and to remove noise, pre-treatment data by normalization between 0-1, and first derivative with Savitzky-Golay9 points was used in this research. The result showed the calibration and validation not good in performances (Table3). The correlation coefficient between the NIR with the reference data still low indicates that NIR analysis does not work and NIR spectroscopy cannot be applied in the analysis. The combination between normalization between 0-1 and first derivative with Savitzky-Golay9 points showed better values of NIR statistics calibration. Based on PRESS (predicted residual error sum of squares), 4 factors was the optimum PLS factor and needed to develop the best calibrations model for predicting fat content of Jatrophacurcas L. seed.

The calibration equationfrom the combination of data pre-treatment was f (x) = 0.8348x+5.7973 with a regression coefficient (R) 0.914and coefficient of determination (R^2) 0.835 (Fig 3). This result had shown a good prediction calibration of oil content and indicated good correlation between reference and NIR prediction of oil content of *Jatropha curcas* L.The coefficient corelation, r larger than 0.91 indicated a good correlation[13]. Coefficient of determination (R^2) indicates the percentage of the variance in the Y variable that is accounted for by the X variable. A value for R^2 between 0.82 and 0.90 reveals good prediction [21]. The values of SEC and SEP, 1.924 and 1.834, respectively and the consistency was 104.91 %. The other performance to judge the calibration model was the relative prediction deviation (RPD). As reported by [22], that generated calibration model is robust if the RPD value is between two and three it is suitable for rough screening, between three and five; model has screening potential, five and eight; model could be used in quality control analysis, above the eight; model is suitable for analytical application. In this study RPD value was 2.5. In general, this level of precision is sufficient to use NIRS as a tool for determining of oil content in *Jatrophacurcas*L. seed in the obtained range. This calibration model had better performancethan previous calibration developed by [23].

We develop the calibration by using 138 spectra for calibration and 69 spectra for validation with 4 PLS factor. Unsuccessful model in previous calibration might be due to limited number of samples. The oil content range of *Jatrophacurcas*L. seed in previous calibration smaller than the range used in this developed model (Table 1).

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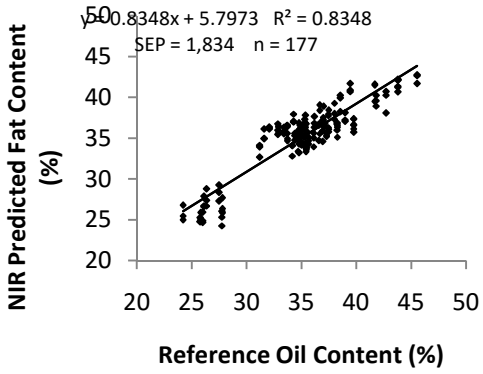

Fig.3. Plot of reference versus predicted oil content ofthe calibration data set.

Table 3: The calibrationresult for moisture, freefattyacid, and fat content

Chemical compositions/ pls factor	Statistics	No data pre-treatment	Normalization between 0-1	First derivative Savitzky-Golay 9 points	The combination of normalization between 0-1 and first derivative Savitzky-Golay 9 points
Moisture content/ 7	R (%)	0.800	0.850	0.979	0.977
	R^2 (%)	0.646	0.725	0.959	0.954
	V Set Bias (%)	0.073	-0.044	-0.280	-0.030
	Consistency (%)	103.168	87.340	77.750	84.750
	SEP (%)	0.568	0.590	0.257	0.249
	SEC (%)	0.587	0.517	0.200	0.211
	RPD	1.710	1.644	3.775	3.904
	CV (%)	12.334	12.823	5.586	5.401
Oil content /4	R (%)	0.672	0.739	0.905	0.914
	R^2 (%)	0.452	0.546	0.818	0.835
	V Set Bias (%)	0.730	-0.266	-0.172	0.211
	Consistency (%)	116.380	82.500	109.150	104.900
	SEP (%)	3.010	3.864	1.849	1.834
	SEC (%)	3.504	3.188	2.018	1.924
	RPD	1.521	1.185	2.477	2.497
	CV (%)	8.493	10.902	5.216	5.212
FFA content / 5	R (%)	0.505	0.577	0.884	0.885
	R^2 (%)	0.255	0.333	0.781	0.784
	V Set Bias (%)	0.011	0.029	-0.010	-0.004
	Consistency (%)	78.790	86.170	0.945	88.103
	SEP (%)	0.124	0.107	0.055	0.058
	SEC (%)	0.096	0.092	0.052	0.051
	RPD	0.942	1.097	2.128	2.018
	CV (%)	15.734	13.506	7.058	7.443

D. Calibration Model for Predicting Free Fatty Acid (FFA) Content

The routine procedure to determine the FFA content in palm oil, fish, and biodiesel is through the conventional wet-chemical method [4]-[24]-[25]. For preparation of the standard reagent, analysis, and expression of the result, substantial personnel,time and glassware are required. Therefore, alternative methods to reduce this problem must be developing. The reference value of FFA contents used in this study was in range 0.58 % - 1.13 % and SD 0.12 (Table 1). To develop the calibration model, we used 171spectra forcalibration and 81 spectra for validation. The calibration statistics to predict the FFA content also given in Table 3. The calibration equation reflectance data with nodata pre-treatment wasf(x) =0.2443x+0.5887. The regression coefficient (R) 0.4942 %,coefficient of determination (R^2) 0.2443%. This results shown the model was no good to predict the FFA content. The NIR spectrum does not only depend on the chemical composition of samples but also on the physical characteristics of the samples, which are usually observed as the background and noise in the spectrum [13]. Therefore, it is need the data pre-treatmentto remove noise and also to improve the calibration equation.The first data pre-treatmentwas normalization between 0-1, but the result of the calibration and validation of this pre-treatmentstill not good. We using first derivative Savitzky-Golay9 pointsdata pre-treatmentto remove background and increasespectral resolution. Reference [20], they using first derivative Savitzky-Golay data pre-treatment method and found that the peaks and volleys not very obvious in original spectra become clear.Based on PRESS, 5 factors was the optimum PLS factor and needed to develop the best calibrations model for predicting FFA content of *Jatrophacurcas*L. seed. The calibration equation result was f(x)=0.7810x+0.1706 with r=0.884and R^2=0.7810. The approximate quantitative relationship between predicted NIR and reference data was achieved (Fig. 4). As reported [21], a value for R^2between 0.66 and 0.81 indicates approximate quantitative predictions. The SEC, SEP and consistency were 0.052, 0.055 and 93.88, respectively (Table 3). The SEP and SEC value very similar but the SEP value higher than SEC. This result perhaps due to the presence of some outliers in selected validation sample [19]. In this study CV value was 7.06. The RPD was calculated and the value was 2.13. This result can be considered as good in precision to predict the FFA content of *Jatrophacurcas*L. seed. This implies that using the developed NIRS with PLS methods is possible and potential to provide quantitative measurement of the free fatty acid content of *Jatrophacurcas*L. seed.

Furthermore, to increase the calibration model, the data pre-treatment was carrying out with the combination of normalization between 0-1 and first derivativewith Savitzky-Golay9 points. The result shown similar performance of calibration equation, f(x) =0.7840x+ 0.1683 with regression coefficient (R) =0.884% and coefficient of determination (R^2)=0.784. SEP, CV and RPD value was 0.58, 7.44 and 2.018, respectively (Table 3). Although the prediction using combination ofnormalization between 0-1 and first derivativewith Savitzky-Golay9 points shown good performance, it has not been increased the calibration performance compared to using the first derivativewith Savitzky-Golay9 pointspre-treatment. It can be considered that pre-treatment data using firstderivativewith Savitzky-Golay9 pointswas more accurate for estimate of FFA content than the combination data pre-treatment.

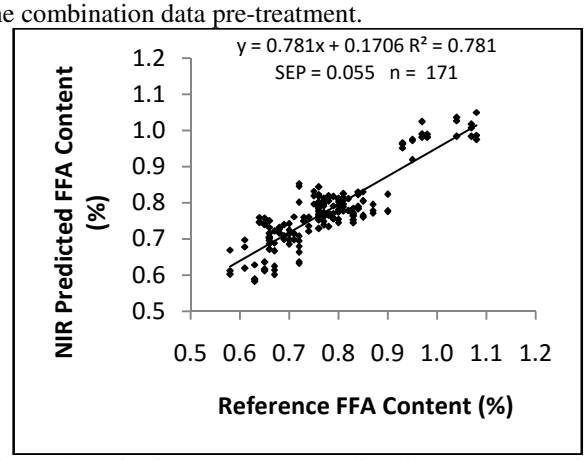

Fig.4. Plot of reference versus predicted FFA content ofthe calibration data set

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AUTHOR'S PROFILE

Lady C.E. Ch. Lengkey

Was Born in Manado, North Sulawesi, East Indonesia on October 11. PhD student in School Of Graduate Studies of Bogor Agricultural University, inAgricultural Engineering Sciences.

Education backgorund:

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Non degree program in postharvest technology and cooling technique at King Mongkut University of Technology in Thornburi-Thailand. 2006.

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She is a University Lecturer in faculty of Agriculture in Sam Ratulangi Universityin Manado North Sulawesi. Postharvest technology was her field in research until 2009. Active in Colaboration Program between 5 university in East Indonesia and Texas A&M University in postharvest technology 2002-2006. Secretary of Agricultural engineering study program held on 2000- 2003. She was a coordinator of TPSDP (Technological and profesional skill development project) in Agricultural engineering Study Programin University of Sam Ratulangi Manado, 2004-2008. As a secretary of postharvest laboratory , 1996-2006, and became a head of Postharvest laboratory in department of agricultural technology UNSRAT, 2006 – 2009. Since 2009 – now as a Ph.D student in School of Graduate Studies at Bogor Agricultural University.

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Education backgorund:

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He is an University Lecturer in Bogor Agricultural University, and has expirience in lecture:

1. Thermodynamic and Heat Transfer.
2. Physical Properties of Agricultural Products
3. Post harvest Engineering
4. Nondestructive Method for Quality Evaluation of Agricultural Products

His expertise :

1. Design and Automation of Food and Agricultural Process Machinery.
2. Non-destructive Measurement of Food and Agricultural Products
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Job Experience :

1985 - 2004:Lecturer of Bogor Agricultural University (IPB)

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He had morethan 20 articles already publishin International journal, and some of those paper list below:

International Publications:

1. Budiastra, I W., Y. Ikeda, T.Nishizu. : Optical Methods for Quality Evaluation of Fruits (Part 1), Journal JSAM Vol. 60 No. 2, 117-128, 1998.
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3. Budiastra, I W., Y. Ikeda, T.Nishizu. : Optical Methods for Quality Evaluation of Fruits (Part III), Journal of JSAM Vol. 60 No. 4, 63-71, 1998.
4. Dadi R. Maspanger, Hadi K. Purwadaria, I Wayan Budiastra and

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5. J Juansah, IW Budiastra, K Dahlan, K Boro Seminar. 2012. The Prospect of Electrical Impedance Spectroscopy as Non-destructive Evaluation of Citrus Fruits Acidity. International Journal of Emerging Technology and Advanced Engineering 2 (11)

Book:

1. Purwadaria, Hadi K., I Wayan Budiastra, Suroso, I Wayan Astika, and D. R. Heldman. 2006. Low Cost IT for Developing Countries, in CIGR Handbook of Agricultural Engineering Volume VI Information Technology. Edited by CIGR--The International Commission of Agricultural Engineering; Chapter 9, pp. 501-523. Editor, Axel Munack. St. Joseph, Michigan, USA: ASABE.

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professor of Computer Technology in the Department of Agricultural Engineering, Faculty of Agricultural Technology (FATETA) and the Department of Computer Science, Faculty of Mathematics and Natural Sciences (FAMIPA), IPB. Born in Jember, west Java on November 18, 1959. Completing his studies at IPB strata S1 in 1983, and the strata S2 and S3 in the Faculty of Computer Science University of New Brunswick Canada in 1989 and 1993. Occupied areas of research include *Information Engineering, Software Engineering, Intelligent Systems, Distance Learning, Internetworking, Computer-Based Instrumentation and Control Systems*. Since completing his doctoral studies, got the mandate to be the Chairman of the Department of Agriculture, IPB (1997-2000), Chairman of the Graduate Studies Program IPB Agricultural Engineering Sciences (2000-2003), Head of Section (Lab) Ergotron (2008-present), Head of Library IPB (2003-2007), and Director Of IPB Communications And Information Systems (2007-present). Involved in the design and implementation team formation IPB Department of Computer Science, Master of Computer IPB, Program Management for Library Information Technology IPB, opening a PhD in Line IPB Agricultural Engineering Research Science and Engineering Department of clump formation in IPB.

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Education Background

	S1	S2	S3
University	IPB	NC State University, USA	Cornell University, USA
Field	Agronomy	Horticulture	Horticulture, Minor Plant Physiology and Breeding
Period	1979-1983	1987-1988	1989-1992

There are 39 articles publication in nasional journal in the last 5 years and also 39 articles presented on various confference.

Books written in Bahasa Indonesia

No	Title	Year	Number of page	Publisher
1.	Bioteknologi Untuk Pemuliaan Tanaman	2011	250	IPB Press

Policy Paper or Book

No.	Title	Year	Place
1	Indonesian Biodiversity Strategy and Action Plan: National Document	2003-2020	Indonesia
2	PedomanPelaksanaanPengujianKeamanan HayatiProdukBioteknologiPertanianHasil RekayasaGenetik	2000	Indonesia

Prof. Purwoko is a Member of Biosafety Technical Team, National Biosafety Committee 1997-2011 and Assessor BAN-PT (University Acreditation Board) 2007-now and he had honors list below:

Honors

No.	Name	Awarding Person/Institution	Tahun
1.	SatyaLencanaKaryaSatya 20 years	President RI	2008
2.	102 Prospective Innovation 2010	Minister of Research and Technology	2010