

Estimation of Sensory Analysis Cupping Test Arabica Coffee Using NIR Spectroscopy

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Abstract. Flavors have become the most important coffee quality parameters now day, many coffee consuming countries require certain taste scores for the coffee to be ordered, the currently used cupping method of appraisal is the method designed by The Specialty Coffee Association Of America (SCAA), from several previous studies was found that Near-Infrared Spectroscopy (NIRS) can be used to detect chemical composition of certain materials including those associated with flavor so it is possible also to be applied to coffee powder. The aim of this research is to get correlation between NIRS spectrum with cupping scoring by tester, then look at the possibility of testing coffee taste sensors using NIRS spectrum. The coffee samples were taken from various places, altitudes and postharvest handling methods, then the samples were prepared following the SCAA protocol, for sensory analysis was done in two ways, with the expert tester and with the NIRS test. The calibration between both found that Without pretreatment using PLS get RMSE cross validation 6.14, using Multiplicative Scatter Correction spectra obtained RMSE cross validation 5.43, the best RMSE cross-validation was 1.73 achieved by de-trending correction, NIRS can be used to predict the score of cupping.

1. Background

Coffee has become a popular drink and consumed all over the world, just as coffee grapes have a distinctive flavor for each producing area so as to have their own fans for a particular taste. The ordering of coffee by the current consumer country has been based on the quality of the taste so that the better it feels the greater the market demand and the expensive.

The method of determining flavor quality commonly used in many countries is the SCAA method, the grade of quality tastes differentiated by direct tasting coffee that has been brewed by certified testers, its tasting method has been standardized by SCAA to eliminate other factors that influence taste, its method called cupping. Cupping scores are strongly influenced by the geographic place where coffee is grown, fertilization during planting and protective plant density resulting in the chemical composition of the resulting coffee beans. Research on several agricultural commodities has been found that chemical composition some agricultural commodities can be detected by using NIRS, in cocoa [14], Gambier [13]. The same approach is also expected to be applied to coffee cupping that will replace tasting method using the human sensory organ, the grade of coffee cupping is classified as table 1.



Table 1. Classification of quality issued by SCAA

Total Score Quality Classification		
90 – 100	Outstanding	Specialty
85 – 89.99	Excellent	
80 – 84.99	Very good	
< 80	Below Specialty Quality	Not Specialty

The aim of this research is to get correlation between NIRS spectra with cupping scoring by tester, then look at the possibility of testing coffee taste sensors using NIRS spectra

2. Methods

2.1. Sample preparation

Coffee beans taken directly from the Gayo highlands by random sampling of 50 samples in 50 locations with uniform height of planting and varieties so as to obtain samples with varying cupping quality, then the sample of coffee is prepared, Preparation of coffee samples begins with roast following the procedures issued by SCAA [11] include :

- The sample should be roasted within 24 hours of cupping and allowed to rest for at least 8 hours.
- The roast profile should be a light to light-medium roast, measured via the M- Basic (Gourmet) Agtron scale of approximately 58 on whole bean and 63 on the ground, +/- 1 point (55-60 on the standard scale or Agtron/SCAA Roast tile #55).
- The roast should be completed in no less than 8 minutes and no more than 12 minutes. Scorching or tipping should not be apparent.
- The sample should be immediately air-cooled (no water quenching). When they reach room temperature (app. 75° F or 20° C), completed samples should then be stored in airtight containers or non-permeable bags until cupping to minimize exposure to air and prevent contamination.
- Samples should be stored in a cool dark place, but not refrigerated or frozen.

The ready-made coffee samples were then divided into two, each 100 grams, partly used to perform cupping sensory analysis while others were used for their NIRS testing as shown in figure 1.

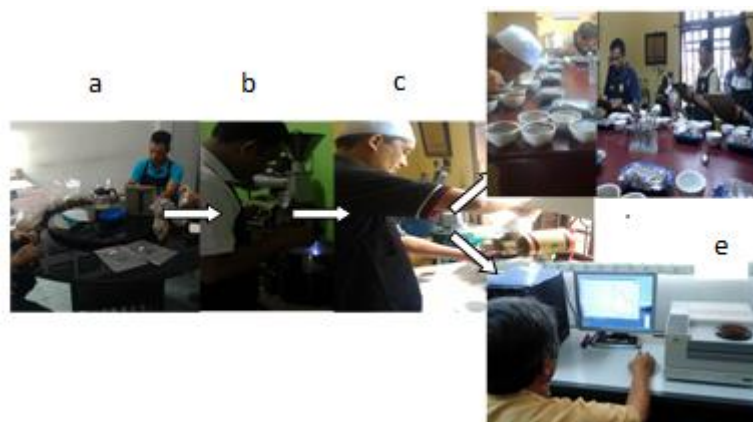


Figure 1. The flow of a coffee sample process is done by a. labeling, b roasting, c grinding, sensory analysis done by d. expert cupper and e. with NIRS

2.2. *Cupping score analysis*

Before the analysis of sensory roasted coffee first milled maximum of 30 minutes before brewing, the size of the coffee powder used for cupping test is to pass through a 20 mesh screen size. The number of cups used for cupping analysis of each sample is 5 cups.

The analysis of cupping score is done by involving 5 experts cupper (the name for coffee drinkers), in the test procedure issued by SCAA [11] the cupping activity or taste test of a taster has to face several cups of coffee and taste it in certain ways. One of the purposes of cupping is to know the difference between the various cups of coffee based on the quality of taste and aroma. The aroma can be detected in two ways, namely smell the aroma when coffee is still a powder and shortly after brewed with hot water. When coffee is still a powder, can also smell the level of acidity (acidity). Next, by tasting the coffee, cupper can know the flavor or taste of coffee varies. The taste of each coffee is certainly different from each other, starting only felt one character that stands out in a complex sense. All that happens because of several factors such as the genetic coffee tree, the process of planting, postharvest process, until the roaster process. Then the body, the viscosity with different weights and the last after taste, the impression of the taste of the coffee whether it will quickly disappear or not. Through cupping can be seen that each original coffee has the characteristics and uniqueness according to the origin of the coffee area.

2.3. *Measurement of the NIRS spectra*

The measurement of the spectra of the coffee powder is done by using a solid Buchi NIRFlex N-500 spectrophotometer by placing the sample into a petri dish, as shown in Fig. 1 next the sample is scanned three times at different positions. Spectrophotometer operation and near-infrared spectrum data collection were performed with NIR ware 1.2 software [3] at room temperature. The spectrum data was collected by reflectance measurements of the samples with a 0.4 nm data interval on a scale of 1000-2500 nm as was done by Scholz [12]. The spectra generated by each sample is averaged which is then used to construct the calibration model and stored as the reflectance value (R).

The measurement principle of the Buchi NIRFlex N-500 solid spectrophotometer as shown in figure 2 of the manual book. The process of measuring the spectrum begins by emitting a wave or NIR ray to optical 1 and then proceeding to mirror 1, light barrier and forwarded to the sample perpendicularly. When the light has reached the sample, the molecular bonds in the material will vibrate at the same frequency as the transmitted NIR wave, then wave absorption occurs. Waves absorbed by some materials are reflected back and transmitted to mirror 2, next to optics 2 to be forwarded to the detector. The detector will record the resulting spectrum which is then forwarded to the computer for chemometric acquisition and analysis.

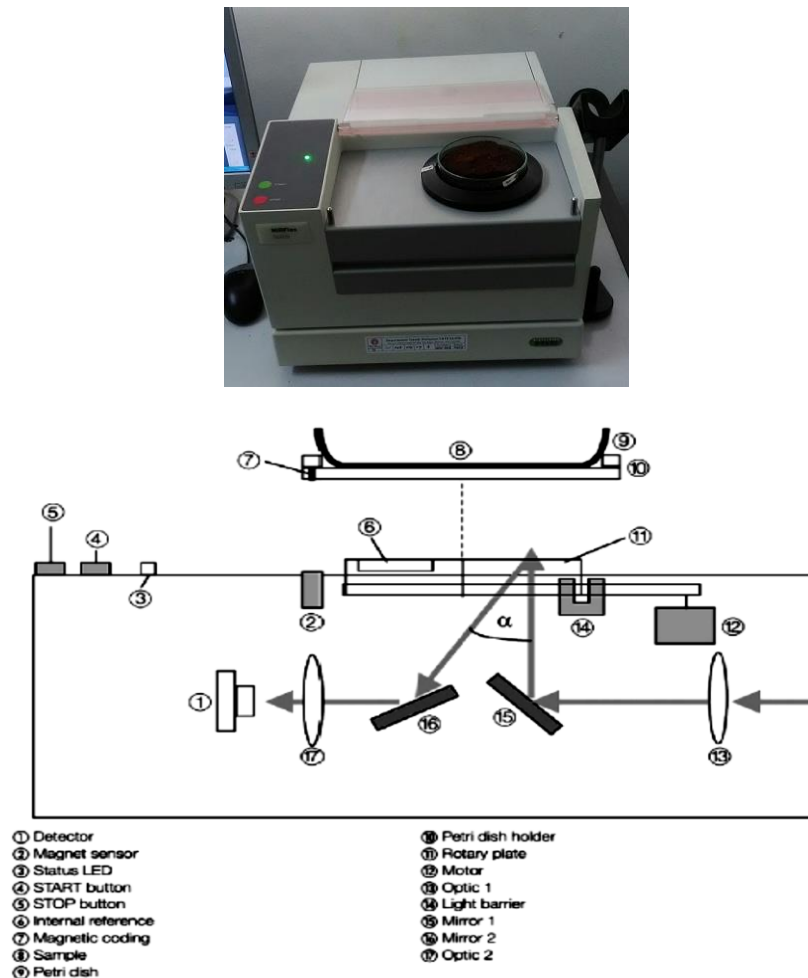


Figure 2. Measurement of near infrared spectra using spectrophotometer and functional principle of spectrophotometer (Buchi Labortechnik AG, 2007)

2.4. NIRS data pretreatment

The uses The Unscrambler®X version 10.3 The spectra is corrected with two data pretreatments, namely the normalization represented by Multiplicative Scatter Correction (MSC) and the transformation group represented by De-Trending (DT).

Pretreated spectra were calibrated using Partial Least Squares (PLS) which will be compared with the results of cupping test conducted by expert cupper. PLS is one of the most popular methods for multivariate calibration of NIR spectral data. PLS retrieve (NIR spectral data) X and Y (attribute quality desired) matrix consider when developing model to find latent variable in X which will best predict latent variable in Y. PLS maximize covariance between X and Y. In this case, the convergence of system for minimum residual errors is often achieved in fewer factors. PLS also leads to a reduction in the number of latent variables [6] [4].

3. Results

3.1. Cupping score

Cupping is done by certified expert testers so that the value of cupping is tested in accordance with consumer demand. The cupping values obtained by the Gayo arabica coffee sample test vary from 67.75 as the lowest to 85.25, the cupping score above 80 is considered as specialty coffee by SCAA.

3.2. NIRS spectrum

NIRS spectrum was then tested for PLS calibration to obtain correlations between NIRS spectra and cupping values, the results obtained can still be corrected with spectral correction using MSC and DT, the baseline spectrum and spectrum correction can be seen in figure 3.

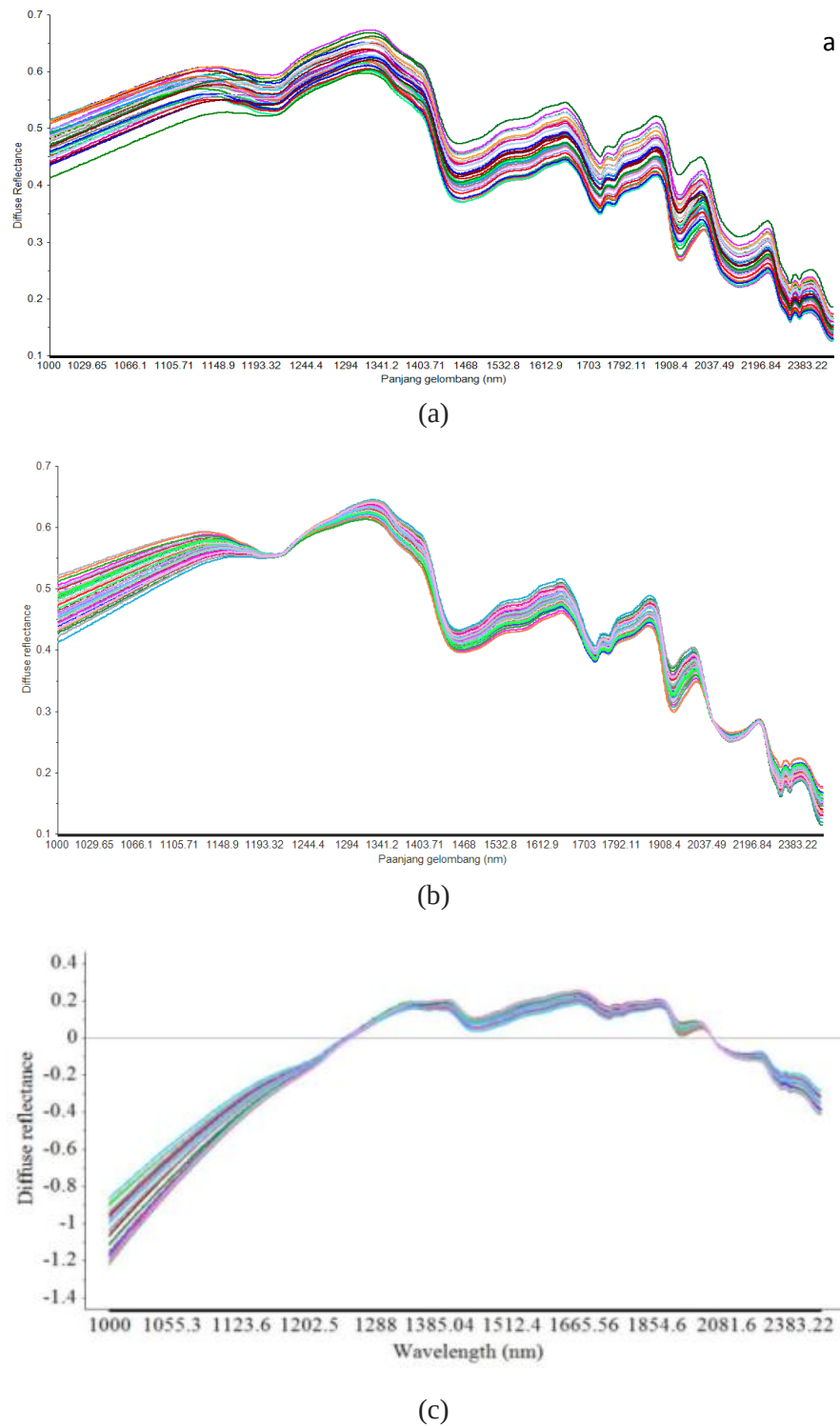


Figure 3. Absorbance spectra for coffee powder obtained from (a) raw data and, (b) MSC, (c) DT data

3.3. Predict cupping score

The basic spectra of coffee powder show the presence of several chemical components in coffee such as chlorogenic acid, caffeine as shown in figure 3. The dominant wavelength is seen at 1390 nm - 1436nm and in 1917nm - 1962nm after plotted to figure 4 shows close to the acid group component. The cupping score is influenced by the chemical composition present in the coffee powder while the chemical composition present in the coffee powder will affect the absorption of tested NIRS.

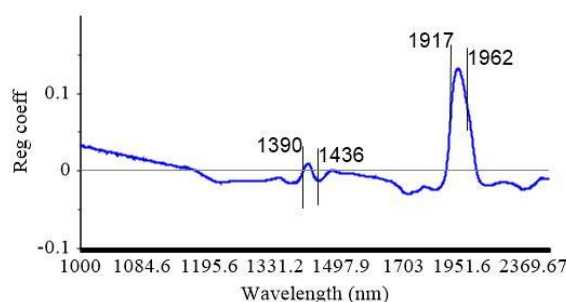


Figure 4. Loading plot analysis results on coffee

The result of prediction of PLS without pretreatment yields good r value that is 0.68. While the RMSEC and SEC errors are small, well below the SD data value. Furthermore, if viewed from the value of RPD, it is still above two. According to Nicolai [9] the value of RPD within 2-3 indicates that the model includes good model performance.

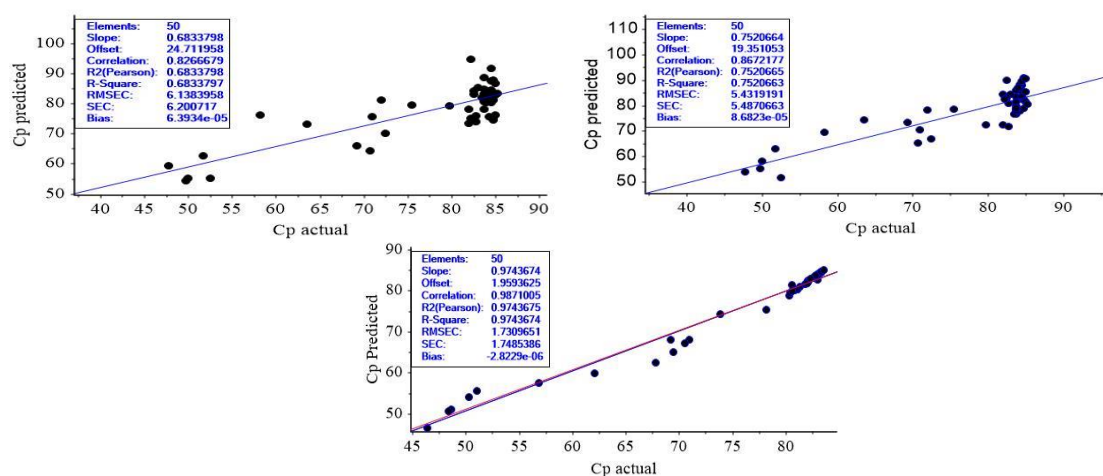


Figure 5. Cross validation for a basic spectrum, b correction with MSC and c correction with DT with cupping value using PLS)

The prediction of cupping score better results with corrected spectrum as shown in figure 5 cross-validation made on the basic spectrum get the value of R^2 0.68 while after corrected its spectrum using MSC yield value R^2 0.752 while using DT get better 0.97. For the RMSEC value for using the basic spectrum of 6.14, the smaller the MSC correction used to obtain the value of 5.43 and with the correction DT value of 1.73 means that the prediction of the score of gayo coffee cupping better results using NIRS spectrum that has been corrected with DT.

4. Conclusions

Cupping analysis can be done by reducing human involvement in sensory analysis by using NIRS spectra, the best result from cupping analysis using NIRS obtained on the corrected spectra using De-Trending (DT) and PLS calibration, it can be seen from the result of cross-validation resulting in very small RMSEC 1.73

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