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The Navel Orange Sugar and Acidity Quantitative Prediction Model Optimization Research by Second Generation Wavelet Transform

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Abstract

The author researches the impact of the second generation wavelet transform spectrometer data preprocessing navel orange sugar content and acidity Partial Least Squares (PLS) quantitative accuracy of the prediction model. This paper also collects the spectral date of one hundred navel oranges by visible/near-infrared diffuse reflectance detection technology and establishes the navel orange sugar content and acidity PLS prediction model using the sixty navel oranges as the establishing samples. The author contrasts changes of navel orange sugar content and acidity PLS prediction model because the spectral date of navel oranges are processed by the second generation wavelet transform, Finally conclusion: the second generation wavelet transform processing navel orange spectral data can improve the predictive ability of the sugar content and acidity PLS quantitative analysis models.

Keywords: *near infrared spectrum, second generation wavelet transform, partial least square, navel orange, acidity, sugar content*

1. Introduction

Navel orange tastes good, full of juice without seed, good quality, bright color, and contains all kinds of nutrients,which are human need. In addition to focusing on the external quality of navel orange, for example size, color and shape, consumers pay more attention to the sugar, acidity, vitamin content and taste, which are the internal quality indicators . Sugar and acidity is an important indicator of navel orange, sugar and acidity largely depends on the amount and types of fruit sugar and organic acids,etc. So the research of the navel orange sugar and acidity by the internal quality of rapid, accurate and non-destructive detection method has far-reaching significance.

With the development of computer and electronic science and technology and the physical and chemical metrology, near-infrared spectroscopy technology development is rapid in recent years, it has more advantages, such as: quick analysis speed quickly, less sample pretreatment, green pollution-free and non-destructive, so it has become a hot research. Domestic and foreign researchers have done a lot of research work in the analyzed internal fruit quality indicators. Moghimi (2010) [1] used near-infrared spectroscopy forecast the SSC and PH of kiwi, analyzed the establish model prediction's effect by using different pretreatment methods; He Yong (2006) [2] used 325nm-1075nm near-infrared spectroscopy to predict the quality of the different bayberry base on methods of principal component analysis and neural network. Niepeng Cheng, Yang Yan (2010) [3] used principal component analysis and combines Bayesian linear discriminant and nectar forward neural network prediction model, comparative analysis of the accuracy of prediction models, the conclusion is using visible and near infrared technology for honey fast classification is feasible; Liu Yande (2012) [4] used reverse interval partial least squares method, genetic algorithm and continuous projection algorithm, built the near-infrared spectroscopy partial least squares regression model of apple soluble solids.

The experimental collect spectral data of the navel orange through diffuse reflectance near-infrared spectroscopy detection technology, because the output signal of spectral data in the collection terminal is affected by harmonics or each harmonic, voltage waveform will be mixed with more interference and noise, it will appear glitches spike, it's phase also will have a larger movement, in order to improve the accuracy and reliability of prediction models,

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comprehensively analysis of domestic and foreign scholars on fruit spectral preprocessing methods. This design uses the second generation wavelet transform for the spectral data preprocessing of navel orange, and then create orange's sugar and acidity content of partial least squares (PLS) quantitative prediction model [5-7], and comparative analysis the changes of performance between before and after the PLS prediction model using second generation wavelet algorithm .

2. Materials and Methods of Measurement

2.1. Material's Selection and Classification

Experimental samples contained 100 Ganzhou navel orange were purchased from supermarket in Nanchang, then culled the samples, which eroded by pests, damaged or shaped oddly. After collected navel orange samples,turned them number randomly, and then placed in a constant temperature chamber with 25℃ in 12 hours, the day that the experimental data measured must be same with the day of navel orange collected. Specific requirements of classification categories as shown in the following table:

Table 1. Measuring Classification of Samples

	group1 calibration set	group 2 sugar prediction set	group 3 acidity prediction set
sample selection method	number 1-60	number 61-80	number 81-100
number of samples	60	20	20
collected spectra	equatorial parts of uniform three-point	equatorial parts of uniform three-point	equatorial parts of uniform three-point
detection navel orange	sugar and acidity throughout the navel orange	sugar of the whole orange	acidity of the whole orange

2.2. Selection of Spectrometer Experiment and the Method of Spectral Acquisition

Experiments used LS-1 type tungsten halogen light source, TCD1304AP linear detectors, portable spectrometer USB4000 to collect the spectral data of navel oranges, the orange spectrum's data analysed through the overture software to and set the scanning conditions of samples: integration time is 50ms, smooth width is two pixels, the band selected in the range of 400-1400nm. By near-infrared spectroscopy diffuse reflectance detection technique, collected 10 points spectral data from the three measurement points on equatorial parts for the study of 100 orange , and then averaged 30 the spectral data of the samples, the each number is the each navel orange's spectral data.

2.3. Sugar and Acidity Physicochemical Methods of Measurement

Using a handheld glucose meter WYT-4 type in accordance with the national standard GB12295-90 to measure the sugar of group 1 and group 3 samples. Using handheld PH meter PHSJ-4A type according to the national standard GB/T 5009 1-2003 GB/T 12456-90 to measure the acidity of orange from group 1 and group 3 samples. Sugar and acidity measurement requirements for continuous measurement 6 times as a whole averaged sugar and acidity values.

2.4. Spectral Data Preprocessing Methods

Because in addition to the original spectrum signal contained information related to the chemical structure of the material, but also contained signal noise generated from many confounding factors, the wavelet transform can show the nature of non-stationary signals in time domain and frequency domain better, thus removing the these interference of signals used wavelet transform. Constructor of second generation wavelet transform algorithm enhances the generation of wavelet transform, the speed of wavelet algorithm enables faster. The basic idea of the method is constructed by the conventional wavelet filter, decomposed the basic building blocks, completed the wavelet transformation by stepping sequentially, it can be summarized as: resolution, prediction and updating.

(1) Decomposition can be inert wavelet transform, the original signal $X(n)$ decomposed into odd and even number, the sample were set as follows:

$$X_a(n)=\{X(2n), n \in Z\} \tag{1}$$

$$X_b(n)=\{X(2n+1), n \in Z\} \tag{2}$$

(2) Forecast: there is a certain correlation between the original samples of each signal, the coefficient $X_a(n)$ used to predict $X_b(n)$,the prediction operator P generated , namely:

$$d_n = X_b(n) - P(X_a(n)) \tag{3}$$

(3) Update: In order to reduce the aliasing effects of the wavelet transform and preserve the original $X_a(n)$ characteristics of certain frequencies, used an operator set A to produce better data c_n , it can be expressed as:

$$c_n = X_a(n) + A(d_n) \tag{4}$$

Second generation wavelet reconstruction process is the reverse process of decomposition, that is anti-update and prediction and decomposition. Reconstruction and decomposition of expression is the same, just need to change the sign and order. As shown below schematic block diagram of decomposition and reconstruction:

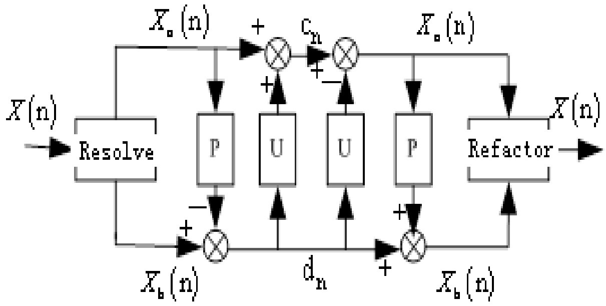

Figure 1. Second Generation Wavelet Reconstruction and Schematic Diagram of the Principle of Decomposition

2.5. Predictive Modeling and Evaluation of Parameter

By using stoichiometry software unscrambler8.0 and matlab2007 tools for data processing, the experiment using a linear model of partial least squares (PLS) method to establish a quantitative prediction model for the sugar and acidity of navel orange. Reinstituted the PLS quantitative prediction model of sugar and acidity content of orange using second generation wavelet transform preprocessing spectroscopy data, Comparative analysis using the second generation wavelet transform of spectral data preprocessing before and after the navel orange sugar and acidity PLS quantitative prediction model performance changes. The performance of the model evaluated by modeling the correlation coefficient, modeling the root mean square error, model prediction correlation coefficient and root mean square error of model prediction. The higher correlation coefficient model, modeling the smaller root mean square error and the root mean square prediction error, the stronger the ability to predict model.

3. Experimental Results and Analysis
3.1. The Effect of Navel Orange Sugar PLS Model by Second Generation Wavelet Spectral Data Preprocessing

According to the method mentioned in section 1.2 acquisition correction and 2 set of prediction sets of navel orange spectral data, in section 1.3 standard physical and chemical measurement method for determining correction and 2 set of prediction sets actual sugar value of the navel orange, establish a quantitative prediction model PLS of the sugar content of the orange, then used the prediction model to predict 20 navel orange's sugar of 2 group; using the second generation wavelet transform for navel orange spectral data preprocessing, to build navel orange sugar PLS quantitative prediction model, then used 20 navel orange's of 2 group to predict the sugar. As shown in Figure 2, Figure 3, it is the discrete points distribution of sugar navel orange percentage of predicted and actual before and after the second generation wavelet transform:

Analysis two charts shows that the original orange brix PLS model and optimization of second generation wavelet correlation coefficient orange brix PLS model, standard deviation correction of the model, the prediction model of root mean square error values as shown in table:

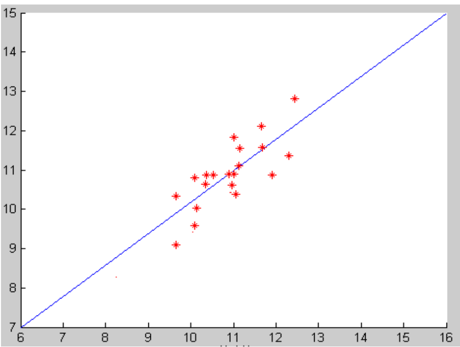

Figure 2. The Brix PLS Model of Original Navel Orange

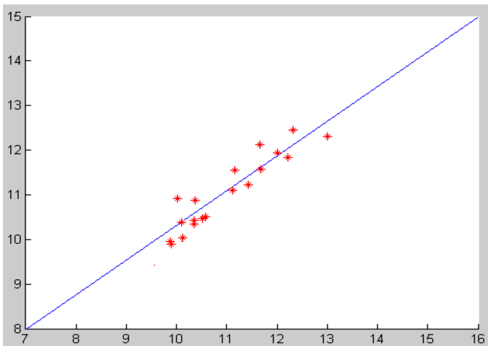

Figure 3. The Brix PLS Model of Navel Orange after Second Generation Wavelet Pretreatment

Analysis two charts shows that the original orange brix PLS model and optimization of second generation wavelet correlation coefficient orange brix PLS model, standard deviation correction of the model, the prediction model of root mean square error values as shown in table:

Table 2. The Analysis Results of the Original and Ssecond Generation Wavelet Optimization Navel Orange Brix Partial Least Squares (PLS) Mmethod Model

	Number	The correlation coefficient of model	Correction standard deviation of model	Standard deviation of prediction model
PLS model of original Brix	20	90.34	0.763	0.806
PLS model of optimization Brix	20	94.56	0.696	0.725

It can be seen that the spectral data with navel orange after the second generation wavelet transform preprocessing sugar partial least squares (PLS) ,quantitative analysis model of the correlation coefficient increased, the standard deviation is reduced somewhat, the second generation wavelet transform of spectral data pretreatment can improve the prediction ability of navel oranges sugar PLS model.

3.2. The Second Generation Wavelet Spectra Data Pretreatment Effects on the Navel Orange Acidity PLS Model

According to the method mentioned in section 1.2, collected the spectral data of prediction navel orange in collection group 3, using standard physical and chemical measurement method of section 1.3 for determining correction and group 3 prediction sets the actual acidity of the navel orange, navel orange acidity PLS quantitative prediction model is established, then use prediction model to predict the acidity of the 20 navel orange in third group; used the second generation wavelet transform for navel orange spectral data preprocessing, build the navel orange acidity PLS quantitative prediction model, then using models to predict 3 groups that the acidity of the 20 navel orange. In Figure 4, Figure 5, it is the second generation wavelet transform for navel orange spectral data preprocessing before and after the acidity of discrete points distribution of the percentage of predicted value and actual value:

Analysis the two charts shows that, the original navel orange acidity PLS model and the second generation wavelet correlation coefficient of the optimized navel orange acidity PLS model, the standard deviation of a calibration model, the prediction model of root mean square error values as shown in table:

By this table, it can been seen that take the second generation wavelet transform of navel orange was founded after the spectra data pretreatment acidity partial least squares (PLS) quantitative analysis model of the correlation coefficient increased, the standard deviation is lower a little, With the second generation wavelet transform of spectral data preprocessing navel orange acidity PLS model improved accuracy and reliability.

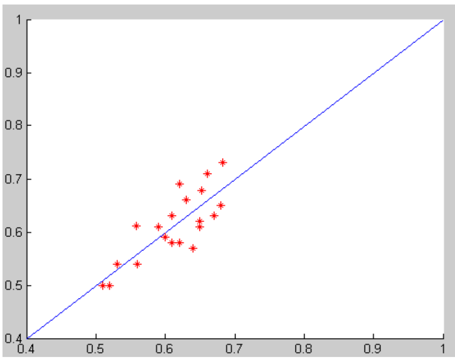

Figure 4. The Acidity PLS Model of Original Navel Orange

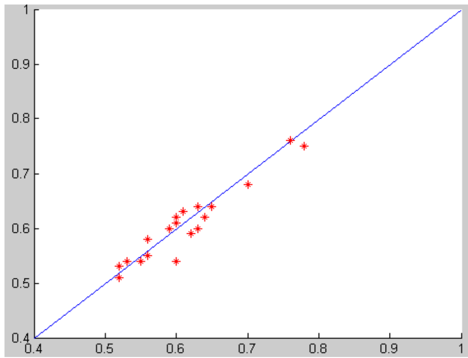

Figure 5. The Acidity PLS Model of Navel Orange after Second Generation Wavelet Pretreatment

Table 3. The Analysis Results of the Original and Second Generation Wavelet Optimization Navel Orange Acidity Partial Least Ssquares (PLS) Method Model

	Number of samples	The correlation coefficient model	Correction model standard deviation	Standard deviation prediction model
PLS model of original Brix	20	89.78	0.842	0.863
PLS model of optimization Brix	20	92.18	0.691	0.738

4. Conclusion

In this study, used a portable spectrum instrument, used near infrared diffuse reflection spectrum detection technology to acquired the navel orange spectral data, elaborated the basic principle of the second generation wavelet transform, using the second generation wavelet transform of spectral data preprocessing, comparative analysis it is concluded that after the second generation wavelet spectral data preprocessing sugar and acidity of navel orange PLS model predictive ability is improved. The optimized model effectively eliminates the instrumentation, measurement condition, the influence of sample status for spectral acquisition, and by using optimization model is established in navel orange sugar and acidity of partial least squares analysis model.Experiments show that the optimized second generation wavelet transform navel orange sugar and acidity analysis model has good prediction ability, For navel orange sugar and acidity accurately forecast provides a means of fast nondestructive detection.

Acknowledgements

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