Application of NIR Analytical Technique in Green Tea’s Quality Control

Hong-Bo Yang, Zhan-Bin Li, Guang-Lin Song and Hong Tan

ABSTRACT

To better control green tea’s quality, brand-name green tea was chosen (green tea with one bud) as the research subject in this study. With the combination of chemical quantitation value for concentrations of tea’s water extract, Near Infrared Reflectance Spectroscopy combined with partial least squares (NIRS-PLS) was used to build a quantitative analysis model for water extract. As shown in results, the Correction Correlation Coefficient ($R_c$) value of water extract is 0.9547, and the values of Root Mean Square Error of Prediction (RMSEP) is 1.18. Therefore, this method can be used to control the quality of tea in its production. It also accelerates the application and popularization of NIRS analytical technique in tea industry. Furthermore, it attaches great important to the development of tea industry.

Keywords: NIRS; Green tea; Quality control; Application

1. Introduction

China is famous for producing tea. As far as tea plantation is concerned, China covers the area of 38690 mu by the end of 2013. However, Chinese brand-name green tea markets are in big mess. The prominent problem is that some high-quality tea commodities are mixed with poor quality ones, which is not only harmful to consumers’ benefits, but also bad for protecting Chinese tea brands \cite{1}. At present, the sensory evaluation is applied to judge the specific tea quality through its shape, liquor color, aroma, flavor and the infused leaves. And among all these five evaluating indicators, flavor is considered as the main evaluating indicator. The traditional assessment method of tea is the combination of sensory evaluation and chemical quantitative method. As for sensory evaluation, it is greatly affected by human factors and the objectivity of its result will be affected as well. On the other hand, the chemical quantitative method is accurate to assess tea quality, but it costs too much time in its complicated analytical procedures. As a result, its testing cost is increasing

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in turn. This kind of method is bad for quick monitoring and blending of tea quality. Near Infrared Spectroscopy (NIRS) analytical technique enjoys the advantages of low cost, fast speed and good reproducibility\(^2\). Near Infrared Spectroscopy (NIRS) analytical technique has been used by scholars both at home and abroad to quantitatively analyze the concentrations of caffeine\(^3\), free amino acid\(^4\), tea polyphenol (TP)\(^5,6\), protein, water extract and water\(^7\), but the Near Infrared Spectroscopy (NIR) analytical technique is seldom applied in the application of tea quality control. In this study, we have selected 50 lots of brand-name green tea in certain place, and used caffeine, free amino acid, tea polyphenol (TP), water extract and water as physicochemical testing data. With the combination of NIR scanning analysis, we have applied Partial Least Square (PLS) to analyze intense multicollinearity multivariable data, and set up a relevant variable model. Afterwards, this model has been used to quantitatively analyze the concentrations of water extract, water extract must be controlled strictly. The quality control of famous green tea was carried out by this index. The method of controlling tea quality attaches great important to boosting rapid development of tea industry, accelerating tea enterprises to be international, and expanding its influence as well.

2. Materials and methods

2.1 Sample collection

Five famous green tea producing areas in Guizhou Province were chose as the sampling areas. They are Guiding, Duyun, Kaili, Zunyi and Bijie, respectively. The sample of this study is Maojian tea with one bud. 12 sampling lots are selected from each sampling area, altogether there are 60 sampling lots. Every sampling lot is divided into chemical quantitative sample and NIR sample. Among all these 60 samples, 50 are calibration samples and the rest 10 ones are verification samples.

2.2 Chemical analysis of 5 components

The method of measuring water extract sample in this study is accordance to the National Standards of the People's Republic of China (GB/T 8305-2013). The results are presented in table 1.

<table>
<thead>
<tr>
<th>components</th>
<th>minimum value</th>
<th>maximum value</th>
<th>average value</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>water extract</td>
<td>32.51</td>
<td>51.10</td>
<td>44.52</td>
<td>1.18</td>
</tr>
</tbody>
</table>

2.3 Sensory evaluation

According to GB/T 23776-2009, five provincial evaluators are responsible for green tea’s sensory evaluation, which includes the following five factors, such as shape, liquor color, aroma, flavor and the infused leaves. 60 sample lots are given evaluating scores according to the above five factors. During the course of evaluation, we have found that four tea samples are not green teas with one bud, so they are removed from sampling green tea while setting up model, and the rest 46 samples are used for model.
2.4 Spectrum collection

The equipment used in experiment is Nicolet Antaris II Fourier transform near-infrared spectroscopy, which is manufactured by Thermo Fisher Scientific. Parameters of experiment are as follows: the spectrum scanning data range: 10000~4000 cm\(^{-1}\); the resolution: 8cm\(^{-1}\); the number of scan: 64 times; collecting type: diffuse reflection mode. Before the experiment, spectrograph is turned on to warm up for half an hour, and the integrating sphere diffuse reflection module is allocated at the same time. The Result 3.0 software is used as spectral analysis software to collect spectrogram, and TQ8.0 quantitative analysis software is applied to build model. The InGaAs detector is used to analyze model, because it enjoys very high sensitivity to near-infrared light. And its inbuilt background is automatic collection. The beam splitter is CaF2.

During the course of testing, the temperature and humidity indoors should be basically kept the same. Place sample into sample cup and press it hardly. Sample is not necessary to be made into powder. The integrating sphere diffuse reflection mode is used to scan NIR for collecting data. During the process of data-collecting, sample cup must be kept spinning to avoid deviation caused by samples’ nonuniformity. Every sample is filled and scanned for three times, and the average spectrum of three times is used to build model. The original spectrum of samples is presented in figure 1.

![Figure 1. Original spectrum of samples.](image)

3. Quantitative analysis

3.1 Setting up quantitative analysis model

During the course of building model, the most popular PLS has been applied to process data, and spectrums used for building model are processed with first-order, second-order differential and Norris smooth preprocessing. The evaluating indicators of modeling results include Rc, RMSEC, Rp and RMSEP. In our study, we predict model’s performance according to the values of Rp and RMSEP, and we find that the model’s predicting performance is the best if the value of Rp increasingly becomes larger and the value of RMSEP increasingly gets smaller. After model is optimized, the quantitative analysis model for tea’s water extract components is built, which is presented in figure 2, and the NIR model for green tea’s water extract components’ difference is presented in figure 3.
3.2 Verification of quantitative analysis model

To verify NIR quantitative analysis model’s predicting precision, ten verification samples have been chosen to predict water extract components. The evaluating indicators are presented in table 2.

<table>
<thead>
<tr>
<th>components</th>
<th>Corr. Coeff.</th>
<th>RMSEC</th>
<th>RMSEP</th>
<th>difference</th>
<th>prominent components number</th>
</tr>
</thead>
<tbody>
<tr>
<td>water extract</td>
<td>0.8863 ~ 0.9547</td>
<td>1.18</td>
<td>1.48</td>
<td>-4 ~ 3</td>
<td>9</td>
</tr>
</tbody>
</table>

The Rp of different indicators is 0.8863. The RMSEC is 1.18, the RMSEP is 1.48, which are acceptable. Therefore, this indicator testing model enjoys the advantages of no damage to samples, being pollution-free, less man-made interference and high-efficiency, which is the priority for tea enterprises to reduce production cost.

4. Conclusions

In this study, we have selected the brand-name green teas in Guizhou Province as testing samples, and the chemical quantitative analysis has been conducted to test the water extract component. Quantitative analysis model for green tea’s water extract has been built by applying the method of partial least squares regression. Testing results are as follows: The Rp of different indicators is 0.8863. The RMSEC is 1.18, the RMSEP is 1.48. The independent verification samples have been used to verify the model, and the relative analytical deviations are less than 3, which indicates a good calibration result and it can be used in actual testing.
As shown in the results, if we strictly control the value of water extract, the green tea’s quality shall be controlled. With the combination of scholars’ evaluating results, the concentration of water extract is not less than 38%. So it is reasonable to analyze concentrations of tea’s water extract components by using NIR diffuse reflection mode. This method can be used to give a quick test for tea’s water extract components, and properly guide green tea’s production and quality. Besides, the method attaches great important to boosting rapid development of tea industry, accelerating tea enterprises to be international, and expanding its influence as well. But in the practical experiment, it needs to increase the amount of modeling samples to get model upgraded and optimized. Thus, the model’s accuracy and stability will be improved.

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References