DIFFERENT ASPECTS OF NON-DESTRUCTIVE ANALYSIS OF LEAF TEAS

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INTRODUCTION

Camellia sinensis L. is a perennial leafy crop. All varieties of tea are produced from the tea plants. The well-grown plants provide high-quality tea shoots. which vary with tea cultivars and the environmental conditions. such as the type of soil and altitude and climate of the growing area. FT-near-infrared spectroscopy (FT-NIRS) is a rapid and non-invasive analytical tool coupled with various chemometric methods. has been applied for the quality assessment of different type of teas. This process involves the recording of spectral data. their pre-processing. the assignment of the characteristic absorption bands. followed by pattern recognition methods and by development of prediction models after the determination of different physical and chemical properties. In this study. commercially available leaf teas with various oxidation states and geographical origins were examined using FT-NIR spectral data. Our aims were to investigate the effects of oxidation states and geographical origin of samples on NIR spectra and to explore the spectral diversity in the data set using chemometrics.

MATERIALS

In this study, 75 commercially available leaf tea samples were analyzed in their original form. The samples included **white** (4), **green** (15), **matcha** (2), **oolong** (14), **Pu-erh** (14), **dark** (2) and **black** (22) teas.

There is also a diverse composition in terms of the region of growing origin, with samples from **Taiwan** (10), **Japan** (8), **Nepal** (8), **Sri Lanka** (6), **India** (4), **South Korea** (2) and **Kenya** (1), but most of the teas were from different provinces of **China** (36).

METHODS

- ✓ **recording of the spectra by using Bruker MPA Multipurpose FT-NIR Analyzer** (Bruker, Ettlingen, Germany)
  - diffuse reflectance mode
  - rotating cuvette
  - resolution 16 cm^{-1}; scanning speed 10kHz
- ✓ **chemometric evaluation of spectral data**
  - spectral pre-treatment methods – SNV, MSC, derivatives
  - *Principal component analysis* (PCA) – to screen spectral outliers; for pattern recognition
  - *Linear discriminant analysis* (LDA) – classification by oxidation state
  - ***Software***: OPUS 7.2; Unscrambler X 10.4; Statistica 8.0

RESULTS AND DISCUSSION

The spectral range of 12500-9000 cm^{-1} was excluded from the evaluation due to significant differences in color, shape and size of tea leaves. **Figure 1** shows the average spectra of the seven types of tea analyzed. The bottom spectrum belongs to **matcha teas**, which showed very well the sensitivity of NIRS to variations in particle size. Unlike the others, these samples were ground to a powder.

In addition, the **spectrum of white teas** was also associated with lower absorbance values, which could be due to the fact that white teas are mainly made from buds, which are covered with resin to protect them from frost.

The reduction of light scattering due to the physical properties of the samples can be achieved by transforming the spectra. **Vector normalization (SNV)** was used to eliminate differences due to scattering. **Figure 2** shows that the most significant differences were observed for matcha and dark teas, but the spectral characteristics of the different types are generally similar.

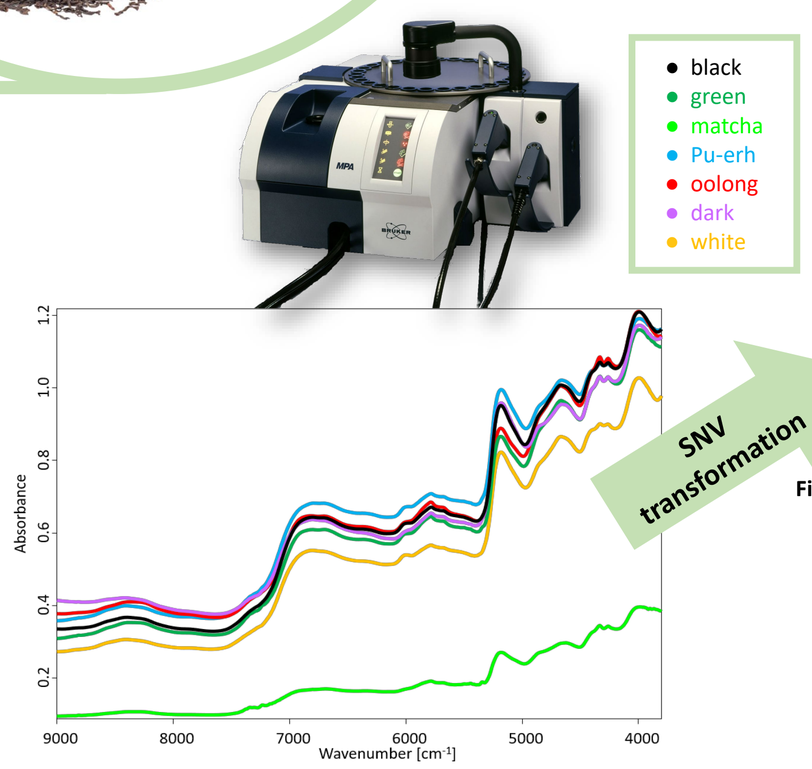

Figure 1. The average spectra of seven types of tea samples

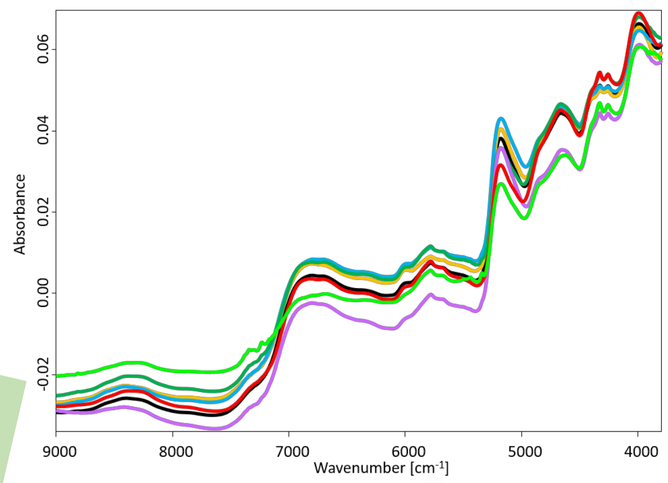

Figure 2. The SNV pretreated average spectra of seven types of tea samples

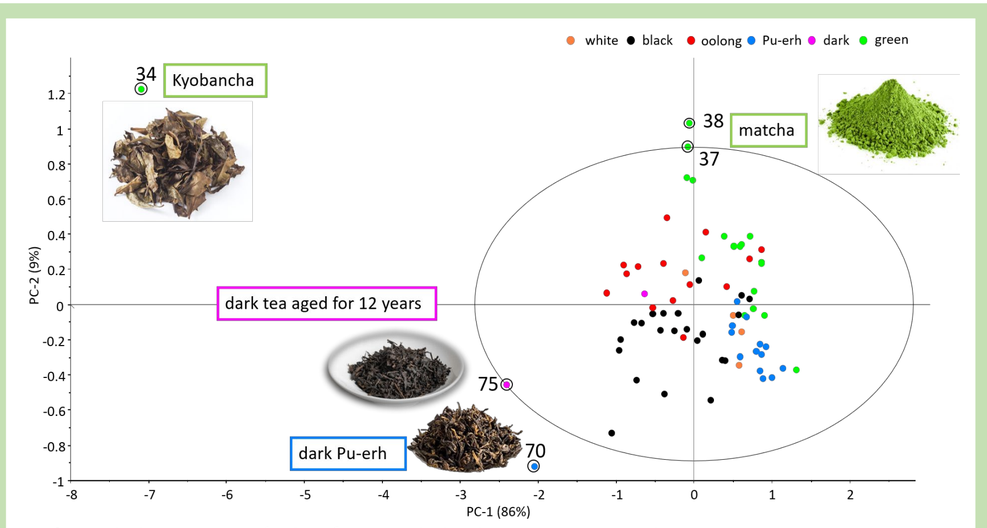

Figure 3. Scores plot of PCA after multiplicative scatter correction spectra pre-treatment

PCA is a widely used data reduction method that can be applied for pattern recognition, in addition to detecting spectral outliers by taking into account the F-residual and Hotelling-T^2 values. The scores plot shows the best results obtained using **MSC data preprocessing**. Based on the results, the first three principal components determine **98% of the variance of the data**.

There were five true **spectral outliers**: the two matcha teas; the Kyobancha green tea (sample 34), which is a roasted and not rolled tea. In addition, sample 70 dark Pu-erh, post-matured tea and the dark tea matured for 12 years proved to be spectral outliers. These samples were excluded from further analysis.

The **Figure 3** clearly shows that the spectra of the teas form relatively distinct groups, depending on their fermentation state. However, no clear separation can be observed from the PCA results.

Based on the results of the LDA (**Figure 4**), the classification of the samples is possible according to their fermentation level and their growing origin. According to the classification matrices, the accuracy of separation was 95.39% and 86.05% respectively.

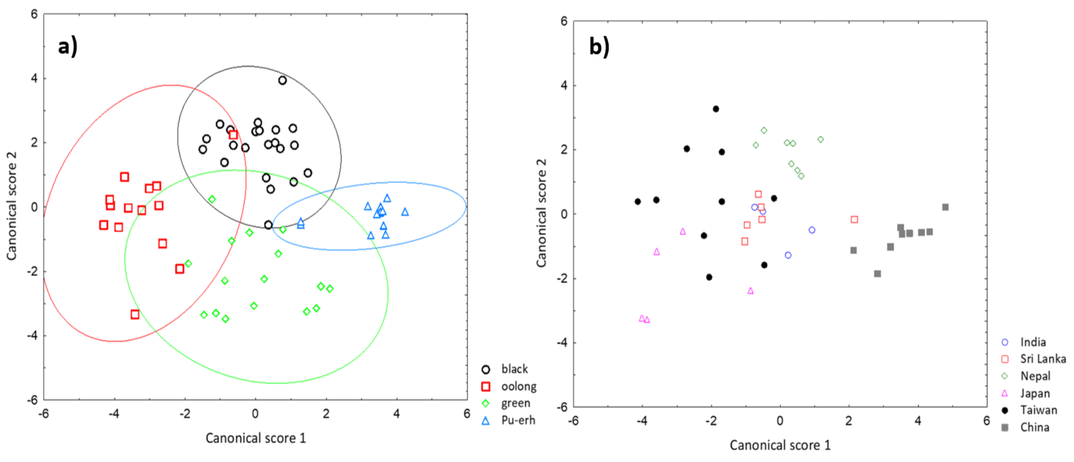

Figure 4. Results of LDA after multiplicative scatter correction spectra pre-treatment: type (a); growing origin (b)

CONCLUSIONS

- additional samples are needed to test leaf tea made using a special procedure
- the use of spectrum transformations is essential to reduce variations in the appearance of leaf teas
- NIRS offers an excellent opportunity to classify tea samples according to their fermentation levels and growing origin

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