

Abstract

Sucrose is a widely used food ingredient. There are two main sources that sucrose can be obtained. While sugar cane is dominating 80% of the world market, 20% of sucrose is produced by using sugar beet. Although beet and cane sugar both are sucrose based, differentiation of the source of sucrose can be very difficult by chemical methods. Plant source and production processes may give different results when inspected by various spectroscopic methods like Isotope ratio-mass spectrometry (IRMS), nuclear magnetic resonance (NMR) spectroscopy and different types of optical spectroscopy (UV-VIS-NIR) even tough sucrose molecules are same. Differential Scanning Calorimeter has also been used for that purpose. In this study sucrose samples from both sources and nine different countries were measured for potential use of spectrophotometric techniques. Absorbances of 25% (w/w) sucrose water solutions were measured in the region 200-1380 nm and differences in spectral signatures were observed in 200-600 nm region. For statistical data analysis of obtained spectra, principal component analysis (PCA) was used. As a result of this preliminary work, it was shown that the representation of the measured spectra in the three-dimensional space of the principal components makes it possible to differentiate sources of sucrose.

Introduction

Sugar is one the unique multifunctional ingredient (taste, fermentation substrate, texture, structure, conservation and color) for food industry. An important actor for the confectionary sector, sucrose, can be produced from both sugar cane and sugar beet. Although, cane sugar and beet sugar are completely sucrose based, there can arise some differences due to the plant and production processes which they are obtained.

The presence of polysaccharides in sugar beet and cane juices causes diverse negative effects during sugar manufacture like increase in viscosity, blockage in the processing line, pump and filters, or change in crystallization behavior (Abdel-Rahman, 2007). Therefore, it is really important to understand the source of the sugar present in the market. Since cane sugar and beet sugar are completely sucrose based, it can be quite difficult to detect the source of the sugar by chemical methods.

Spectroscopy is rapid analytical method has been used in many food applications including rice authenticity, wine maturation and chocolate production (Khodasevich et al., 2010; Tarkošová & Čopíková, 2000; Teye, Amuah, McGrath, & Elliott, 2019). Spectroscopic methods can be used for determining the sucrose content in chocolate mass (da Costa Filho, 2009). Therefore, beet and cane sugar identification seems to be an interesting application to be examined by spectroscopy. Spectroscopic techniques produce spectrum that provides lots of information which can be exploited using multivariate mathematics and statistic analysis. Principle component analysis is one of the statistical methods used for explorative data analysis, outlier detection, graphical clustering and classification. In this study it is aimed to investigate the ability of spectrophotometric methods on differentiation of beet and cane sugar.



Materials and Methods

Sucrose samples obtained from both sugar cane and sugar beet were collected from different countries. 15 different sucrose samples were examined for this study.



For the measurements, 25% (w/w) sugar solutions were prepared. Absorbance spectra of sucrose solutions were measured by double-beam scanning spectrophotometer Shimadzu UV-3101 in 200–1380 nm spectral range with 1 nm resolution. Measurements were carried out in replicates (4–10 depending on the sample amount).

Principle component analysis (PCA) for the samples were performed with the MATLAB software.

Results

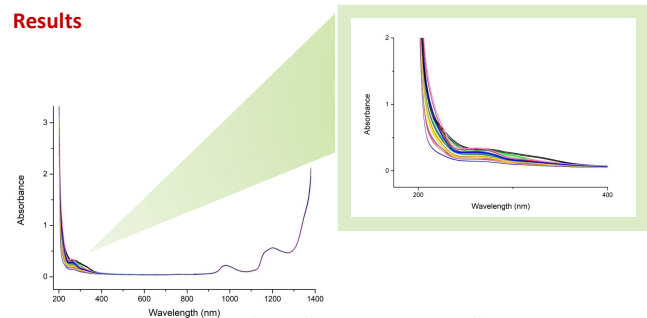


Figure 1. Spectra of 15 samples from different countries and different sources

A quick look at the collected spectra shows that the visual information can be differentiated in Ultra Violet (UV) region. PCA was carried out to find number of components to represent the data set. Results showed that two component explains 99% of the total variance of spectra (Figure 2).

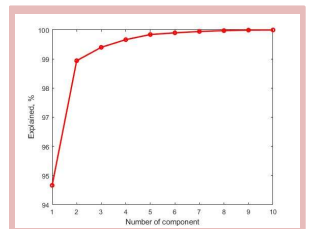


Figure 2. Dependence of the explained variance on the number of components

Each class is shown with different color for a better visualization (Figure 3). Results showed that source of unknown samples can be determined. In this study, it can be deduced that the unknown samples are cane sugar.

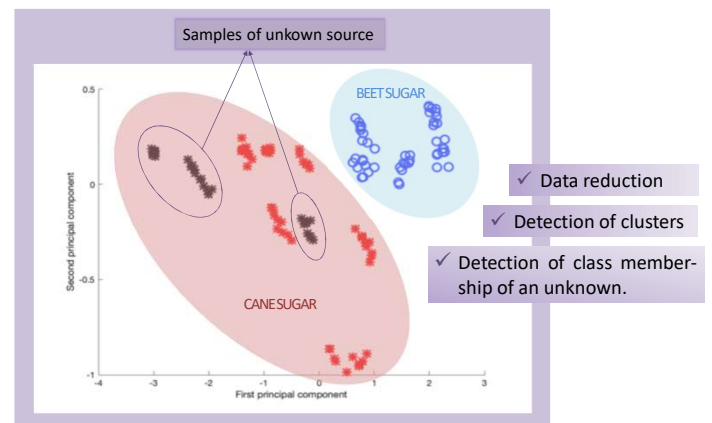


Figure 3. Score plot for spectra of 15 samples.

Acknowledgments



This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement No 101008228. Results reflects only the author's view and that the Agency is not responsible for any use that may be made of the information it contains.

References

- Abdel-Rahman, E. A. (2007). Investigations on the influence of dextran during beet sugar production with special focus on crystal growth and morphology, 109.
- da Costa Filho, P. A. (2009). Rapid determination of sucrose in chocolate mass using near infrared spectroscopy. *Analytica Chimica Acta*, 632(2), 206–211. <https://doi.org/10.1016/j.aca.2008.10.049>
- Esbensen, K. H., & Geladi, P. (2009). Principal Component Analysis: Concept, Geometrical Interpretation, Mathematical Background, Algorithms, History, Practice. *Comprehensive Chemometrics*, 2, 211–226. <https://doi.org/10.1016/B978-0-444-52701-1.00043-0>
- Khodasevich, M. A., Trofimova, D. V., & Nezalova, E. I. (2010). Principal component analysis of UV-VIS-NIR transmission spectra of Moldavian matured wine distillates. *LAT 2010: International Conference on Lasers, Applications, and Technologies*, 7994f(February 2011), 7994f. <https://doi.org/10.1117/12.881593>
- Tarkošová, J., & Čopíková, J. (2000). Fourier transform near infrared spectroscopy applied to analysis of chocolate. *Journal of Near Infrared Spectroscopy*, 8(4), 251–257. <https://doi.org/10.1255/jnirs.285>
- Teye, E., Amuah, C. L. Y., McGrath, T., & Elliott, C. (2019). Innovative and rapid analysis for rice authenticity using hand-held NIR spectrometry and chemometrics. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 217, 147–154. <https://doi.org/10.1016/j.saa.2019.03.085>