Use of Hyperspectral Imaging to Determine Protein Content in Sugar Beet Leaves

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Abstract

Today, valuation of byproducts is a quite important area in food industry. Effective use of discarded food parts which are considered as wastes, is beneficial for both customers and producers. It was found out that sugar beet leaves can be a good plant protein alternative and it can be a potential substitute for milk, soy and meat proteins. Protein content of the beet leaves could be affected from many factors and it is usually determined by chemical methods. Nondestructive methods that could help to determine protein content on field could be great to be used by beet sugar producers. Hyperspectral Imaging (HSI) technique could be a perfect tool for that purpose. HSI is a nondestructive and rapid spectra analysis method which gives opportunity to work with nonhomogeneous samples. HSI can cover three regions (UV-Vis-NIR) of the electromagnetic spectrum, which can be very informative on natural substance analysis for both qualitative and quantitative perspective. In this study, three different leaf samples from sugar beet were collected and their image was acquired by using a Vis-NIR hyperspectral camera covering the wavelengths from 400 nm to 1000 nm. Differences between leaf samples were observed for both visible and NIR region. This preliminary work with the integration of further calibrations and data analysis techniques shows HSI method can be used to analyze protein content of sugar beet leaves.

Introduction

Nowadays, food sustainability is an important subject that attracts attentions worldwide. To obtain sustainability, amount of by-product wastes should be decreased and evaluation of those products should be done effectively.

In confectionary area, beet sugar is one of the most important materials and overall 20% of world's sugar is produced by using sugar beet. Sugar beet leaves can be counted as one of the by-products of beet sugar production because leaves either discarded as waste or are given to animals to feed. It was proven that sugar beet leaves contain good value proteins that can be used as sustainable protein source and can be potentially used as a substitute for milk, soy and meat proteins (Kiskini, Vissers, Vincken, Gruppen & Wierenga, 2016).

Hyperspectral Imaging (HSI) is a new non-destructive, quick analysis method which does not need sample preparation. It gives opportunity to investigate non-homogenic samples with its ability to contain both spectral and spatial information (Qin and Lu 2008).

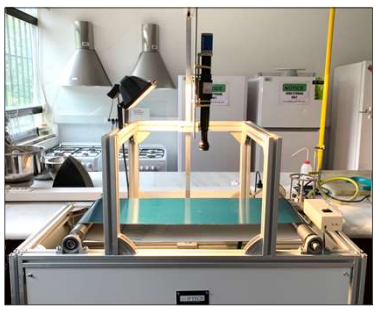
Purpose of this preliminary work is to analyze sugar beet leaves for their protein content and to show potential usage of HSI system as a quick protein content analysis tool.

Methods and Materials

Sugar beet leaves were provided from Kayseri Şeker A.Ş and then randomly three of them were selected for HSI image acquisition. A line scan (pushbroom) hyperspectral system was used in this work. System consists of an imaging spectrometer (MS MacroSystem, Nederland) which covers the wavelengths from 400 nm to 1000 nm, an objective lens and a 14bit CCD (charge-coupled device) high quantum efficient, high resolution camera. For the line movement, a custom design conveyor belt (IFTECH, Ankara) was used. As a light source 500W tungsten halogen lamp was mounted on the conveyor system with the 45^0 angle. Data were recorded with a distance of approximately 30cm from the lens. For data analysis Matlab-2021a (The MathWorks, Inc., Natick, MA, USA) was used. As the approach, 'method of calculating mean reflectance' which is a simple method for scattering profile characterization was used (Lu 2007). Using the following formula, relative mean reflectance was calculated;

$$\bar{R} = \frac{\sum_{i=1}^{N}(R_{s,i} - R_{d,i})}{\sum_{i=1}^{N}(R_{w,i} - R_{d,i})}$$

where R_s is reflectance of sample, R_d is dark reference, R_w is white reference, N is the total number of pixels in the region of interest.



Results

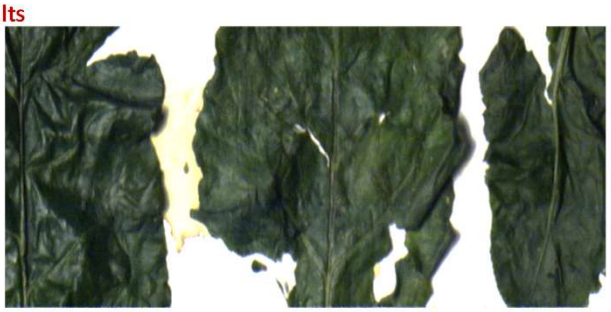


Figure 1. RGB colored HSI image of three leaf samples.

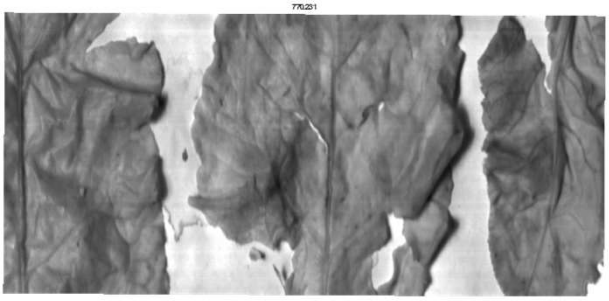


Figure 2. Monochoromatic Image of leaf samples taken at 770nm.

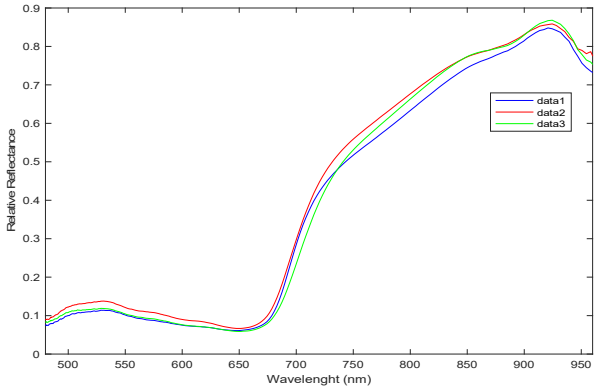


Figure 3. Relative mean reflectance spectra of sugar beet leaves.
*data 1-2-3 represent leaf 1-2-3 respectively from right to left.

Differences in reflectance values were observed in both visible and NIR regions, NIR region is informative about C-H and O-H bonds which are primary structures of organic compounds such as proteins. Also visible wavelengths could give some correlated information. Thus protein content comparison between leaves can be potentially obtained by using differences in spectral signatures.

References

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