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Colour and water content detection of sweet cherry by portable spectrometer

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Summary: Based on the most recent data, the average amount of sweet cherry produced in Hungary is around 10-12 thousand tons. Therefore fast and effective method is important for sweet cherry fruit quality analyses. The aim of the study was to examine the applicability of reflectance measurements for sweet cherry fruit quality analyses. In our experiment five cherry species (Vera, Cristalina, Germersdorfi, Noir de Mechet, Canada Giant) were examined in order to measure the spectral differences between species. Further more, spectral alteration was examined between different health and maturity status of the fruits in the case of a specified, the Germesdorfi species. The four new indices are appropriate tools for cherry quality analysis. Thus reflectance measurements can also support more precise and automated fruit selections. The methods for the differentiation of species could also be viable at a concerned habitat; however, the climate, habitat and soil conditions strongly affect the yield quality. Concerning the fast determination of water content, WBI could be a reliable method for the assessment

Key words: sweet cherry, spectrometer, reflectance measurements, fruit indices

Introduction

The total sweet cherry production of the world ranges between 1.4 and 1.6 million tons. Regarding the growing area, Europe has a leading role as more than 50% of sweet cherry is produced here.

The Hungarian sweet and sour cherry breeding has been going on since1950. In the frame of this programme are 13 released and 1 candidate sweet cherry varieties, and 9 released and 2 candidate sour cherry varieties. Sweet cherry varieties in the National Variety List are the following: 'Margit' (1987),'Linda' (1988), 'Katalin' (1989), 'Alex'(1997), 'Kavics' (1999), 'Vera (2002), 'Rita'(2004), 'Petrus (2007), 'Paulus'(2007), 'Aida' (2007), 'Carmen (2007) 'Tünde'(2008), 'Sándor'(2008) (*Apostol,* 2011).

The total area of new orchards planted between 1998 and 2005 with governmental support is 750 ha, out of which the intensive orchards with a plant density above 1000 trees/ha make up for only 3.3%. Unfortunately, in most orchards the "semi-intensive" spacings of 7 x 5 m and 6 x 4 m were applied. In recent years, the cultivars planted on the largest areas were (in decreasing order): cv. 'Katalin', clones of cv. 'Germersdorfi', cvs, 'Linda', 'Kordia', 'Bigarreau Burlat', 'Szomolyai fekete', 'Van' and 'Margit'. In addition to these, the following foreign cultivars were also planted by the Hungarian producers: cvs. 'Sunburst', 'Stella', 'Regina', 'Valerij Cskalov', 'Sylvia', 'Sweetheart' and 'Krupnoplodnaja' (*Thurzó,* 2008).

Based on the most recent data, the average amount of sweet cherry produced in Hungary is around 10–12 thousand tons. Therefore fast and effective method is important for sweet cherry fruit quality analyses. One of the possible methods for quality analysis is the reflectance measurement of the fruits.

Materials and methods

The aim of the study was to examine the applicability of reflectance measurements for sweet cherry fruit quality analyses. In our experiment five cherry species (Vera, Cristalina, Germersdorfi, Noir de Mechet, Canada Giant were examined in order to measure the spectral differences between species. Further more, spectral alteration was examined between different health and maturity status of the fruits in the case of a specified, the Germesdorfi species. Out of every sweet cherry species 25 fruit samples were measured in three repetitions.

The reflectance spectra were measured by a hyperspectral (0.55 nm spectral resolutions) AvaSpec 2048 spectrometer within 400–1000 nm wavelength interval. The AvaSpec 2048 system consists of a spectrometer, a fiber optic and a halogen light source, and a spectral sampling box *(Figure 1.).*

The fiber optic has two connections; one is for the spectrometer, and one is for the light source. The light source ensures the permanent light intensity in the whole measurement range. The sampling box is insulated so the sampling is not disturbed by any external light.

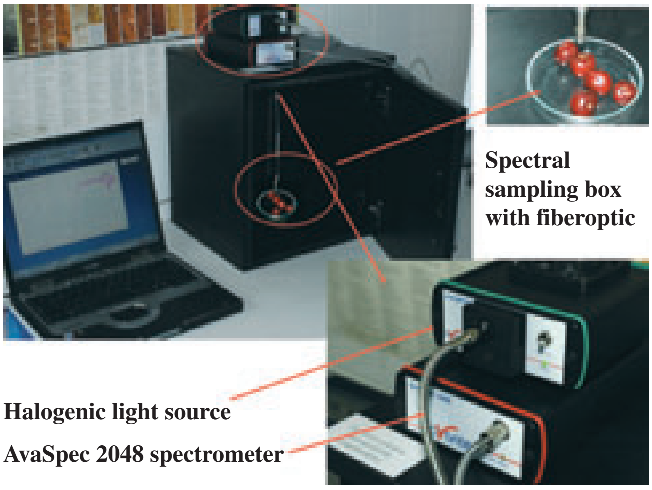

Figure 1. The AvaSpec 2048 spectrometer

Before the spectral measurement the spectrometer had to be calibrated. For the calibration white and dark reference measurement is needed. The calibration was made by a special calibration reference unit. For reflection measurements WS-2 reference tiles was used for diffuse reflection The WS-2 white reference tile is made out of a white diffuse PTFE (polytetrafluoroethylene) based material, meeting the highest demands with regard to high grade diffuse reflectance.

Several parameters were examined based on the spectra. The color, maturity and health status was analysed in the yellow –red (570–730) wavelength interval, where a significant sigmoid growth of reflectance appears. Besides the reflectance differences, fruit indices were calculated for a proper determination of the mentioned parameters. Since vegetation indices, which are sensitive to the chlorophyll content (*Burai* et al., 2009), show similar sigmoid growth in the red-NIR zone, thus the determination of fruit indices were based on the algorithms of the Normalized Difference Vegetation Index (NDVI), the Simple Ratio Index (SRI) and the Red edge Position (REP). Differences between relative water content of the fruits were also assessed in the near infra red (NIR) zone between 900–970 nm by the Water Band Index (WBI). WBI is a reflectance measurement that is sensitive to changes in canopy water status. As the water content of vegetation canopies increase, the strength of the absorption around 970 nm increases relative to that of 900 nm. WBI is defined by the following equitation: WBI=$\delta_{900}/\delta_{970}$ (Champagne et al. 2001). The dry material content of the fruits was also measured by drying them till the weight of fruits became constant.

Results and discussions

The characteristics of the reflectance curves of each fruit species are caused by the large amount of absorption of anthocyanin content at 450–570 nm wavelength intervals. On the other hand, reaching the red interval the reflectance of healthy cherry fruits are raising markedly at 700 nm due to the red color *(Figure 2.)*. Though the shapes of the spectral curves are tend to be similar, there are differences among species in intensity and the yellow –red (570–730) wavelength interval.

There are much more spectral differences between fruits regarding the ripe and health status. Healthy and ripe fruits

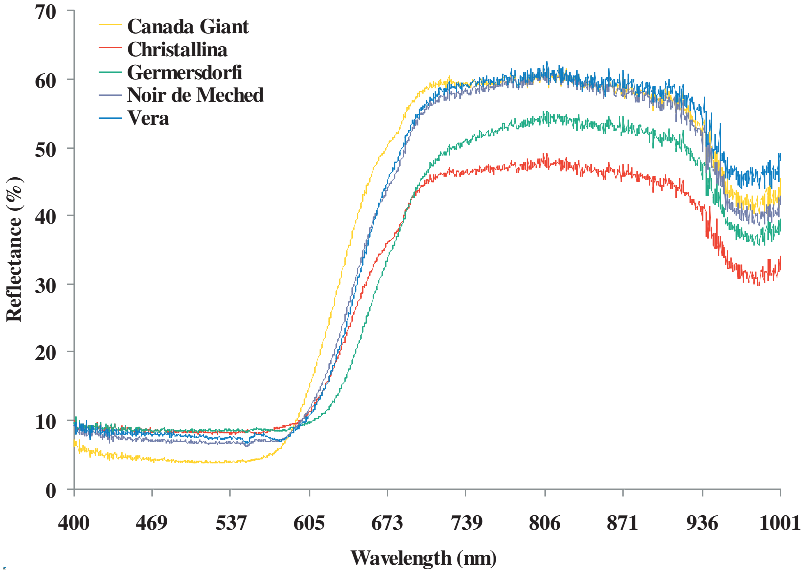

Figure 2. Spectral properties of different cherry fruits

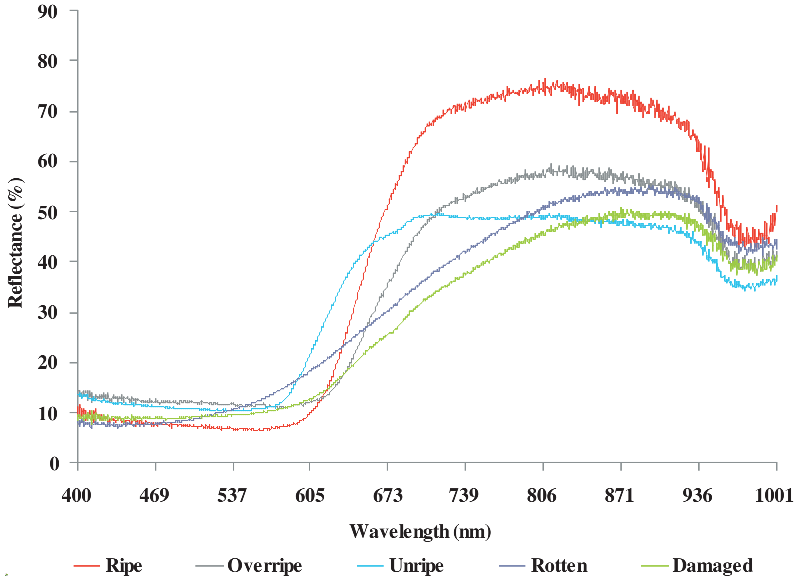

Figure 3. Spectral properties of cherry fruits regarding the ripe and health status

shows the highest reflectance (%) in the red and NIR spectral interval, since the amount of anthocianin is probably the highest, and there is no damage which could case oxidation of these flavonoids *(Figure 3.)*. Due to the damages and other diseases (*Monilia*) brownish oxidation occurred in fruits, and the anthocyanin content is definitely decreased. Therefore the reflectance in the red interval is lower and there is no rapid sigmoid increase between yellow red interval. Due to unripe had less anthocyanin but more karotinoids (yellowish colour), and the effect of starting oxidation processes effects in overripe fruits, low reflectance accured in red- NIR

Besides the reflectance values, four new fruit indices was created in order to examine the differences numerically. The Simple Ratio Yellow Index (SRYI) were calculated based on the reflectance value in yellow (R_{yellow}) and red (R_{red}) wavelength:

$$SRYI = R_{yellow}/R_{red}$$

Normalized Red-Yellow Index (NRYI) was based on the algorythm of NDVI, and calculated as follows:

$$NRYI=\frac{R_{yellow}/R_{red}}{R_{yellow}/R_{red}}$$

Both SRYI and NRYI values show that the rotten has the lowest and the ripe has the highest value which describes the anthocyanin content change as well as the health status of the fruits. Regarding species, the redder was the fruit of a species the higher was the indices value. Therefore these indices should be appropriate for health analysis and for differentiate species based on the redness of flavonoids.

Yellow Edge Position (YEP) was also created and calculated based on REP (Jung et al., 2006). YEP is narrow band index which shows the inflection point of the sigmoid curve. The results suggest that the place of the inflection point depends on the redness of the fruit. If the fruit is free from damages and diseases, the redder was the fruit the higher was the YEP value and probably also the anthocyanin content. Lower reflectance and slow sigmoid increase in wide wavelength interval resulted higher YEP values in the case of overipe, rotten and damaged fruits *(Figure 5.)*. Yellow-Red Area; (YRA: the area below the sigmoid curve, between 570–730 nm) was also calculated, which results less reliable data for health and maturity status.

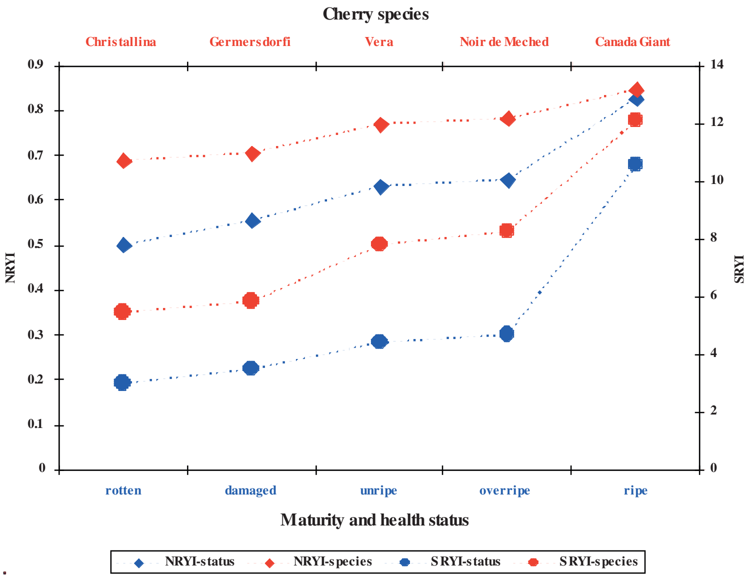

Figure 4. SRYI and NRYI values of cherry fruits

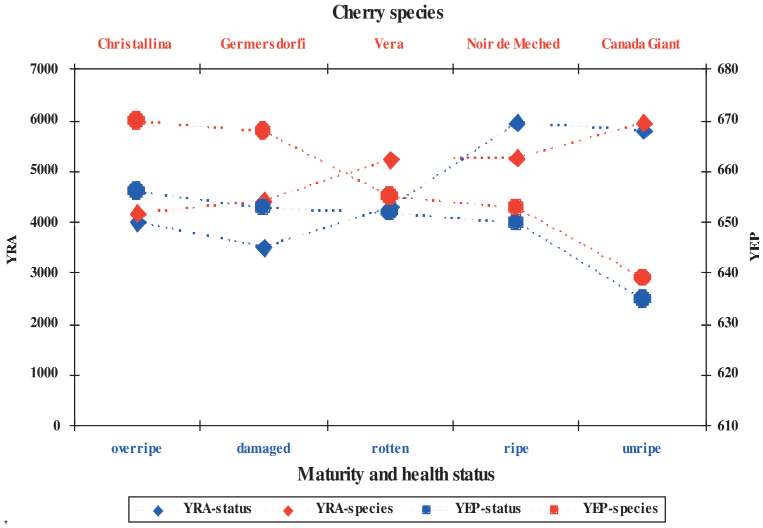

Figure 5. YRA and YEP values of cherry fruits

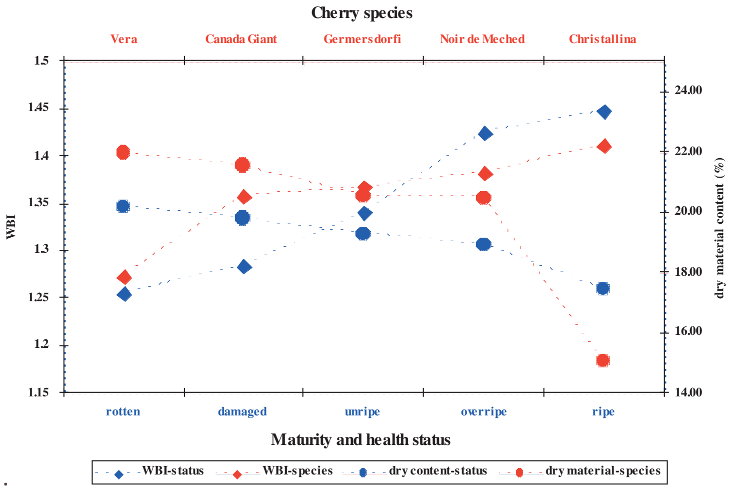

Figure 6. Relationship between dry material content and WBI

The water content of fruits was determined by WBI, and also the dry material content was measured to evaluate the applicability of WBI in the case of fruits. Since there is good, negative correlation (R=-0.72) between WBI and dry material content WBI could be a reliable method for assessing the water content, thus the dry material content of the cherry fruits.

Conclusion

The four new indices are appropriate tools for cherry quality analysis. Thus reflectance measurements can also support more precise and automated fruit selections. The methods for the differentiation of species could also be viable at a concerned habitat; however, the climate, habitat and soil conditions strongly affect the yield quality. Concerning the fast determination of water content, WBI could be a reliable method for the assessment

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