Implementation of the "Seeing Through Layers" (STL) method for Apples Categorizing

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Abstract

The aim of this research is to apply "Seeing through layers" method (STL method) in virtual peeling of apples. The final results have been compared to those of the physically peeled fruit and a conclusion has been made concerning the utility of the method for apples' classification according to their internal transmittance.

Key words: *seeing through layers, stl, apples, internal transmittance*

Introduction

This publication describes the method "Seeing Through Layers" (STL) for assessment of apples by internal and external quality. After obtaining the NIR - data set of apples, each apple has been evaluated organoleptically. Models for virtual peeling have been created and tested. The accuracy of V-models was analyzed. Apples were virtually peeled for pr5ooving the authentication of the method for predicting the inner transmittance of the apples. Taking into consideration the fact that the method accurately predicts internal transmittance, it is logical conclude that there is higher accuracy of sorting virtually peeled apples than the accuracy of sorting not peeled apples.

Material and methods

Referent evaluation and classification

For assessing of apples' selling maturity it has been used a descriptive scale in which the consumer's score is given exclusively of signs of internal quality - savour and related structure.

Categories (grades) of maturity:

C1. Complete consumption maturity - gentle, pleasantly crunchy structure, juicy flesh; harmonic (balanced), typical for the sort taste, typical for the sort aroma.

C2. Intermediate maturity - crispy, but rather rigid structure, satisfactory juiciness, taste is not harmonious with dominant acidity, flavour is less pronounced.

C3. Harvesting maturity - the flesh was too firm to firm, the structure is rough, flavour characteristics are undeveloped, the taste is too sour and sweetness is insufficient, the aroma is lacking.

C4. Overripeness - structure is greasy to farinaceous, loss of juiciness of the fruit, taste is unharmonious, insipid and overly sweet, and acidity is low to almost disappear. Apples in this class are considered as defective and unfit for consumption (i.e. low, not satisfying qualities).

Here we should mark that fruits with other types of defects have been not assessed for consumer maturity, as they are substandard according to all international regulations.

272 apples of three varieties of apples (Starkrimson, Melrose and Granny Smith) were classified organoleptically. Fruits were with different colour of skin! There weren't any unripe fruit in the set of apples - class C3. Studied fruits were brought to the class C1 (ripe) and C2 (intermediate ripe) or C4 (with farinaceous structure). The purpose for classification by spectral data was:

a) recognizing both class C1 and class C2 from class C4
b) recognizing class C1 from class C2 by the degree of maturity

Three sets of data were created. One set of data represents the optical density of natural peeled fruits, P (peeled). The second set of data consists of the results for optical density of the fruit that are not peeled, labelled with W (whole). The third data set includes results the optical density of the flesh calculated by STL method using model M6D6Ro [2,3]. These data are labelled with V (Virtually peeled).
For each of the sets (P, W, and V) averaged spectra were calculated for classes C1, C2, C3 and C4. In advance for each class the average spectra have been analyzed in terms of differences between these spectra. Discriminant analysis was performed of data for the optical density of objects classified organoleptically. There has been no smoothing or normalization of the spectra and second derivative or other functions have been not used. The graphics of average spectra for classes C1, C2, C3 and C4 for the sets P, W and V are shown in Figures 1 to 4.

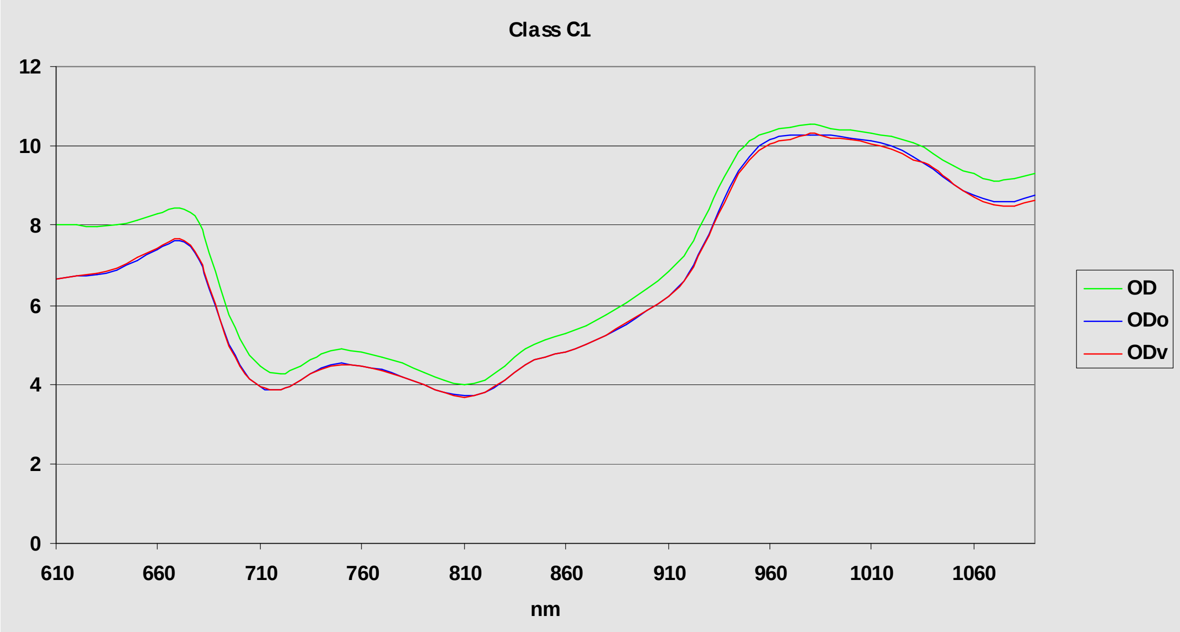

Figure 1 Average optical density of whole apples (OD), physically peeled apples (ODo) and virtually peeled apples (ODv) for Class C1.

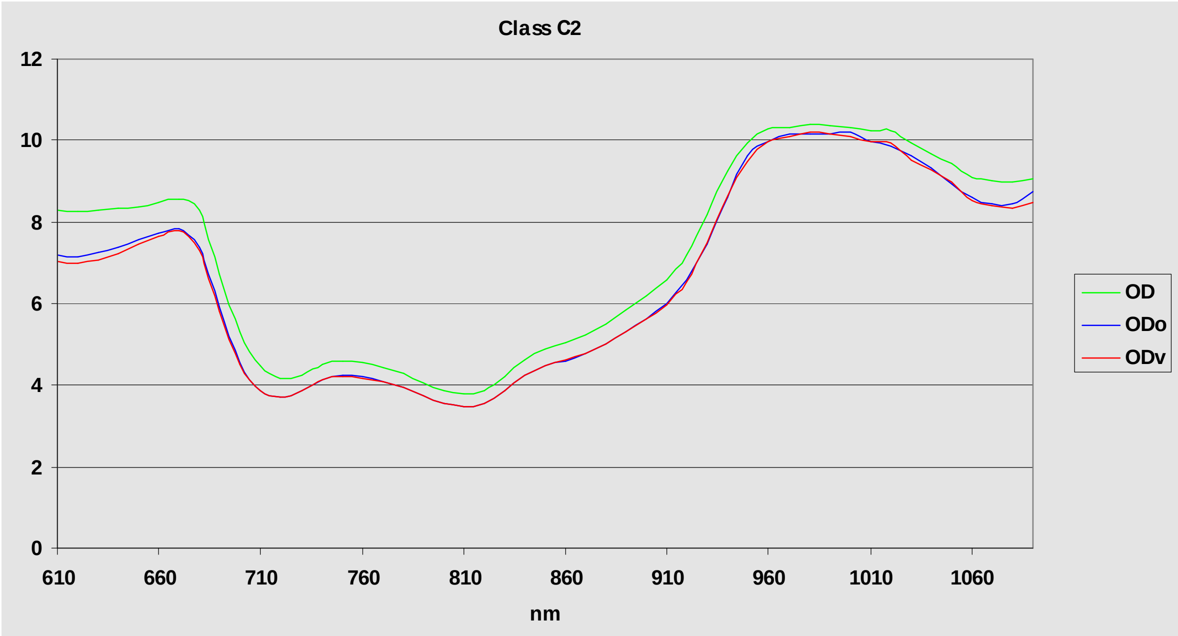

Figure 2 Average optical density of whole apples (OD), physically peeled apples (ODo) and virtually peeled apples (ODv) for Class C2.

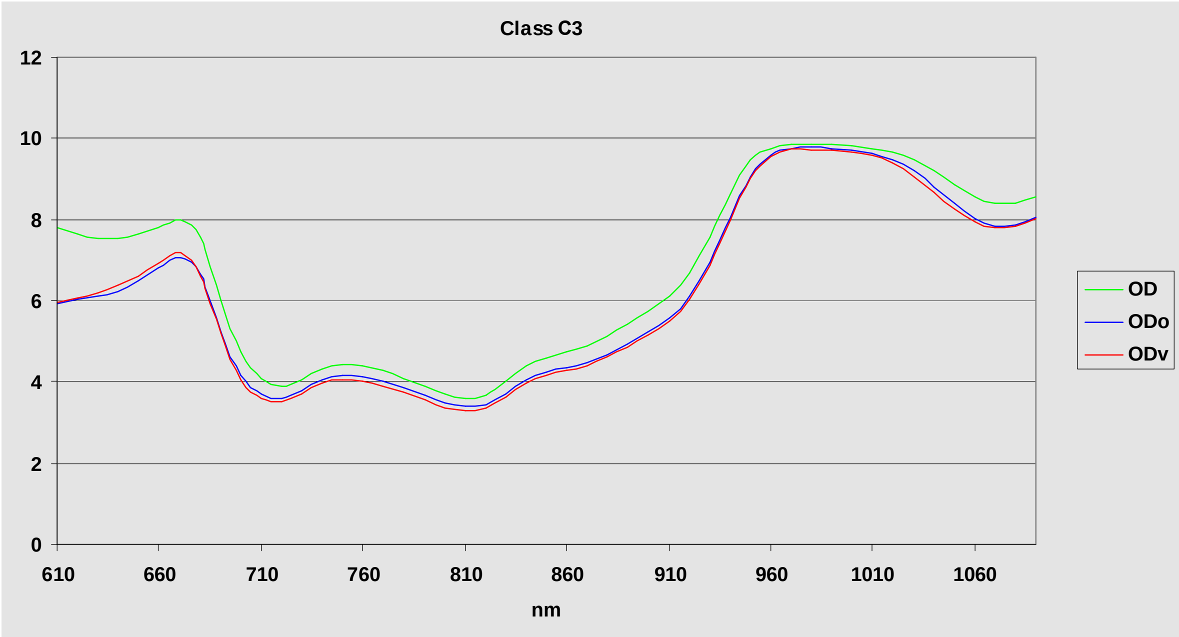

Figure 3 Average optical density of whole apples (OD), physically peeled apples (ODo) and virtually peeled apples (ODv) for Class C3.

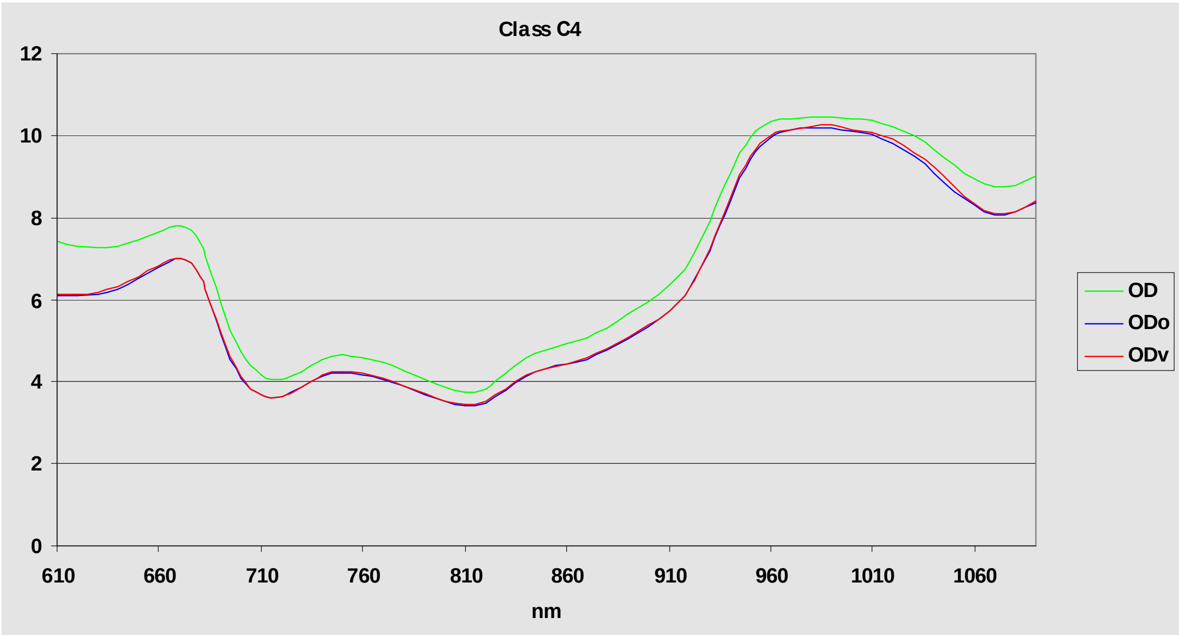

Figure 4 Average optical density of whole apples (OD), physically peeled apples (ODo) and virtually peeled apples (ODv) for Class C4.

Results and Discussion

Here are presented the NIR wavelengths, selected for distinguishing the different apple and results of the classification according the selected wavelengths.

In Tables 1 and 3 are shown the selected wavelengths for recognition, while Tables 2 and 4 provide an opportunity to compare the accuracy of classification by the degree of maturity with the three sets of data - P, W and V.

Table 1 Selected wavelengths for distinguishing between the Classes (1 and 2) and Class 4 for the different data sets P, W and V

Set P, peeled fruit	*Set W, whole fruit*	*Set V, virtually peeled fruit*
630	*670*	*630*
680	*680*	*670*
740	*790*	*710*
780	*810*	*740*
840	*840*	*830*
1070	*880*	*1080*

Table 2 Relevant part of apples referred to the correct Class (1 and 2) or Class 4 using an equation based on 6 selected wavelengths.

	Set P, peeled fruit	*Set W, whole fruit*	*Set V, virtually peeled fruit*
Calibration	*77.7%*	*75.9%*	*83.0%*
Validation	*75.9%*	*71.4%*	*79.5%*

Table 3 Selected wavelengths for distinguishing between Class 1 and Class 2 for the different data sets P, W and V

Set P, peeled fruit	*Set W, whole fruit*	*Set V, virtually peeled fruit*
610	*710*	*610*
630	*750*	*630*
750	*790*	*660*
880	*810*	*750*
910	*1050*	*810*
1090	*610*	*1050*

Table 4 Relevant part of apples referred to the correct Class 1 or Class 2 using an equation based on 6 selected wavelengths.

	Set P, peeled fruit	*Set W, whole fruit*	*Set V, virtually peeled fruit*
Calibration	*76.5%*	*76.8%*	*70.2%*
Validation	*75.4%*	*75.7%*	*68.4%*

Conclusion

After the separation of Class 1 and 2 of Class 4 (Table 2) it is observed that a higher accuracy classification of peeled apples has been in achieved than in the case of not peeled, i.e. after peeling the apples the defects stand out more clearly and the classification is easier. Interesting is the fact that virtual peeling achieves even better accuracy than the physical peeling. This may be due to the fact that different wavelengths have been used for classification of the different Sets P, W and V, i.e. each wavelength has a different degree of informativeness for the quality of apple. Selected values of the wavelengths in Tables 1 and 3 are among the best, but not the only ones which can be used.

In Table 4 is noticeable that peeling the apples does not increase the accuracy of the division of Class 1 Class 2, i.e. accuracy in this case is highest when the apples are classified when they are not peeled.

This may be due to the fact that for the distinction between Class 1 Class 2 is necessary to take information from the superficial layer of skin, i.e. spectrum of the surface layer also contains information about the degree of defectiveness.

These are only preliminary results from a study of an initial applying of STL method for apples. Research in this area will be continued in the future.

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