Analysis of citrus peel for non-destructive determination of fruit composition by reflectance Vis/NIR spectroscopy

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Introduction and Literature Review

- *Reflectance Vis/NIR spectroscopy is one of the applicable non-destructive methods for measuring quality attributes of fruits and vegetables that has been quite popular with researchers:*

Produce	Measured Attribute	Reference
Apple	*SSC*	*(Peirs et al., 2003)*
Apricot	*SSC, TA, Firmness*	*(Camps & Christen, 2009)*
Citrus	*SSC, TA, pH;* *SSC, pH*	*(Cayuela, 2008);* *(Gómez et al., 2006)*
Pear	*SSC, Firmness*	*(Liu et al., 2008)*
Tomato	*SSC, TA;* *SSC, pH, Firmness*	*(Flores et al., 2009);* *(Shao et al., 2007)*

Introduction and Literature Review

- *The peel is part of the light path which can affect the spectrum.*

- *Reports indicate that good results can be obtained in the fruits with a thin peel using reflectance NIR spectroscopy. However, it is very difficult to determine the composition in a thick fruit such as citrus using this method.*

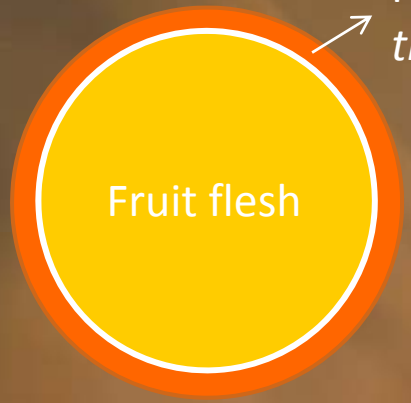
Research objectives

- *Analysis and interpretation of reflectance spectra of citrus including orange and lime (both intact and peeled fruits) using Vis/NIR spectroscopy.*

- *Utilizing an empirical model to analyze and interpret the spectrum of citrus peel in terms of the main absorbance peaks as well as to study the effect of the peel in non-destructive Vis/NIR measurements.*

Materials and Methods

- ***Theory***



$T_{total}=T_{peel}T_{flesh}T_{peel}$

Where T_{total} is the overall transmittance from the intact fruit; T_{peel} is the transmittance of the peel; and T_{flesh} is the transmittance of the flesh (peeled fruit). T_{peel} is used twice because the incident light crosses the peel twice during transmittance.

Moreover, transmittance can be quantified using Beer's law: $A=\varepsilon . d . y =\log (1/T)$, where A is absorbance; ε is absorptivity; d is the optical path length; and y is sample concentration.

Materials and Methods

Theory

According to Beer's law and the empirical model which expresses dependency between log (*1/T*) and log (*1/R*), it can follow as:

$$A_{total}=log(1/R_{total})=log(1/R_{peel})+log(1/R_{flesh})+log(1/R_{peel})$$

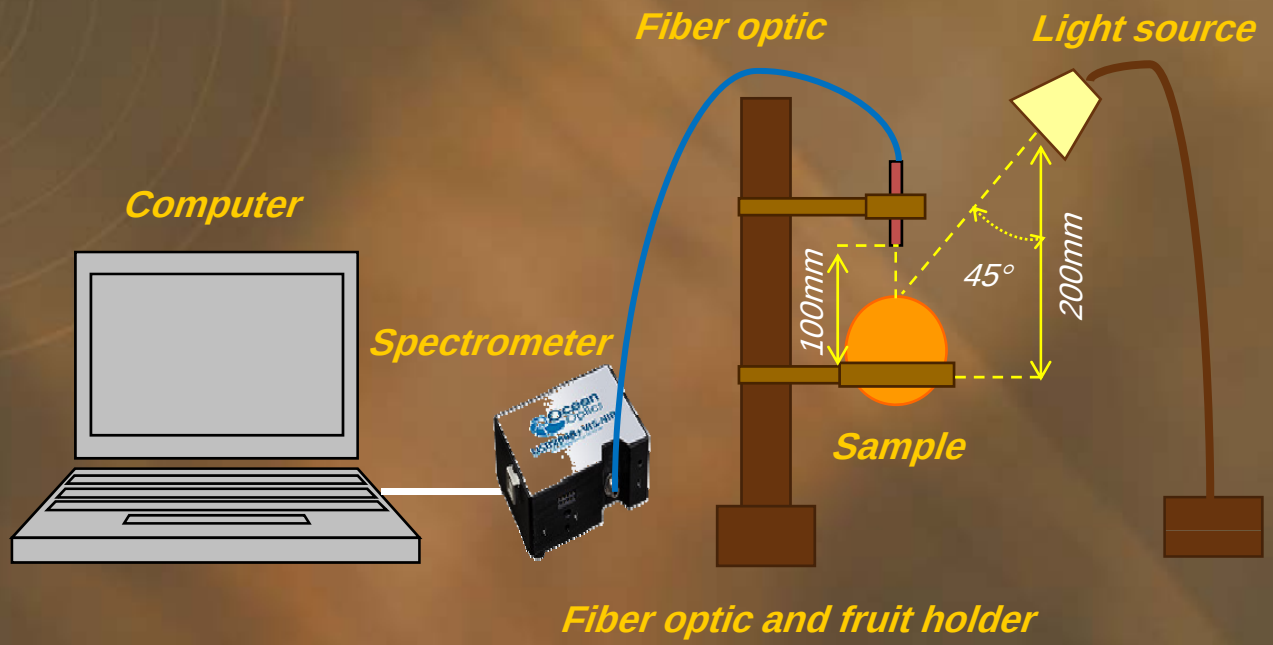
Where, A_{total} *and* R_{total} are overall absorbance and reflectance of the intact fruit, respectively; R_{peel} is the reflectance of the peel; R_{flesh} is the reflectance of the peeled fruit.

It is hypothesized that the peel thickness is constant and its composition is homogeneous for samples of one and the same variety. Therefore, the peel plays the role of an absorbent filter when the light penetrates into the fruit. However, it does not affect the light when it crosses the peel for the second time because the light has once been filtered before with the same filter (it is hypothesized that the absorbed wavelengths by the peel are quite omitted). Thus:

$$log(1/R_{peel})=log(1/R_{total})-log(1/R_{flesh})$$

Materials and Methods

- **Setup**



Materials and Methods

- ***Spectra Acquisition***

For each sample, reflectance spectra at three positions around equatorial locations (approximately 120 °) and 5 scans at each position were collected by OOIBase32 software (Oceanoptics Inc., USA).

Next, the mean spectrum was calculated from a total of 15 scans for each fruit.

Then, all the samples were peeled and the spectroscopy tests were reported for the whole fruit flesh.

Materials and Methods

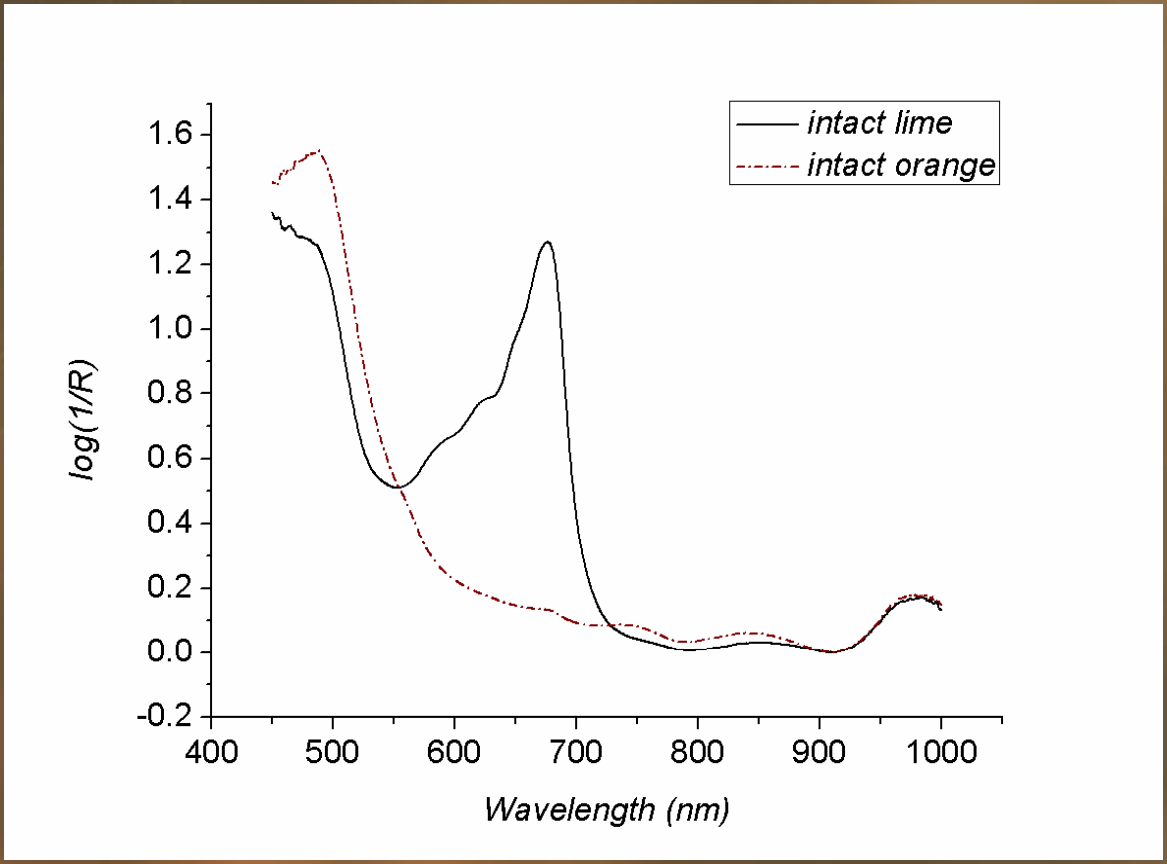
- ***Spectra Preprocessing***

Overall reflectance spectra of each type of fruit (both intact and peeled) were converted to log (1/R).

The spectra were pre-processed using first derivative to increase spectral resolution.

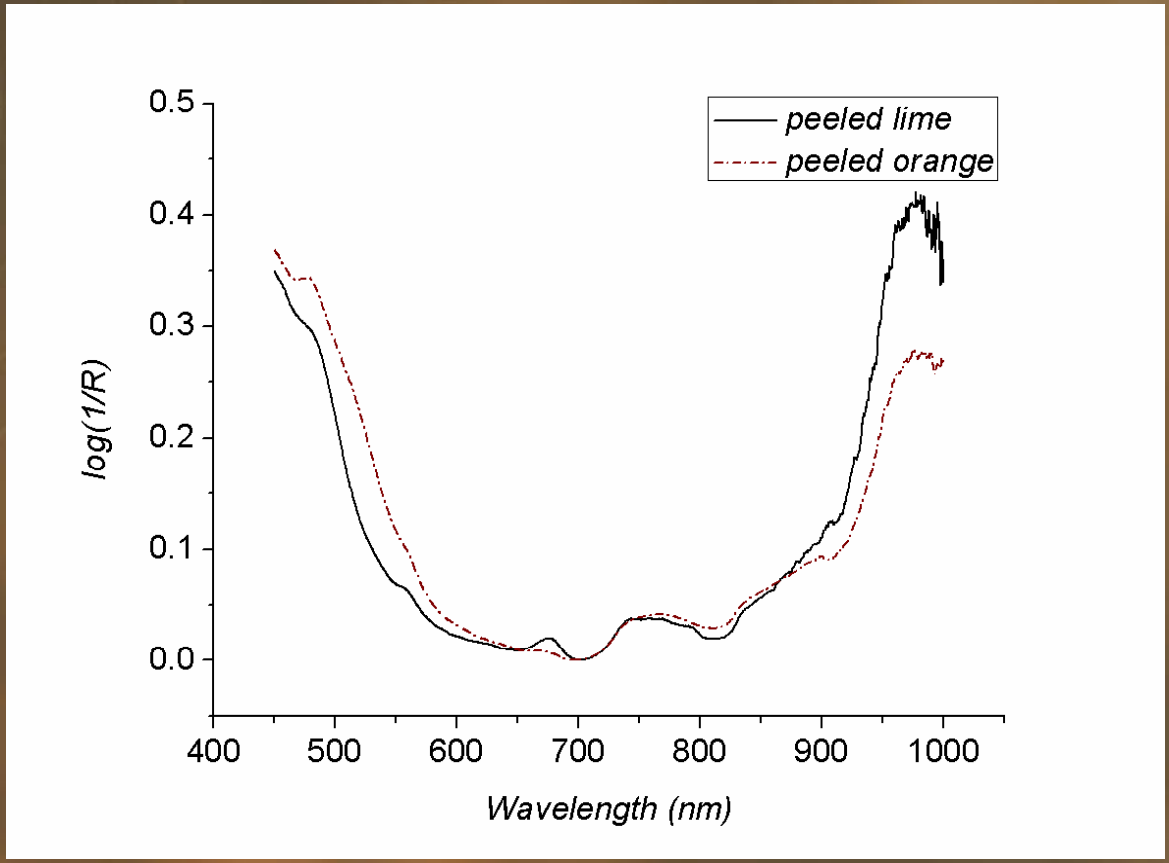
The OriginPro 8 (OriginLab Corporation, USA) software was used for analysis of all spectra.

Results and Discussion



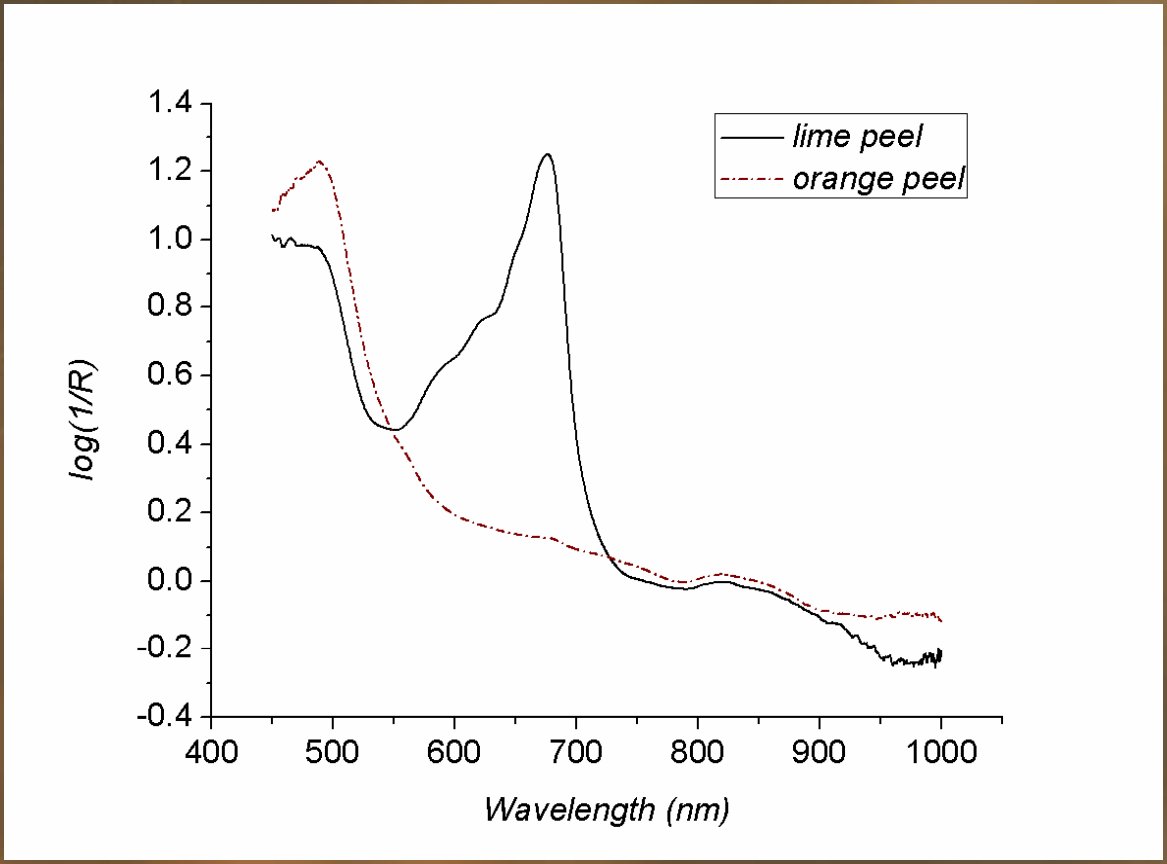
Mean absorbance spectra of intact citrus

Results and Discussion



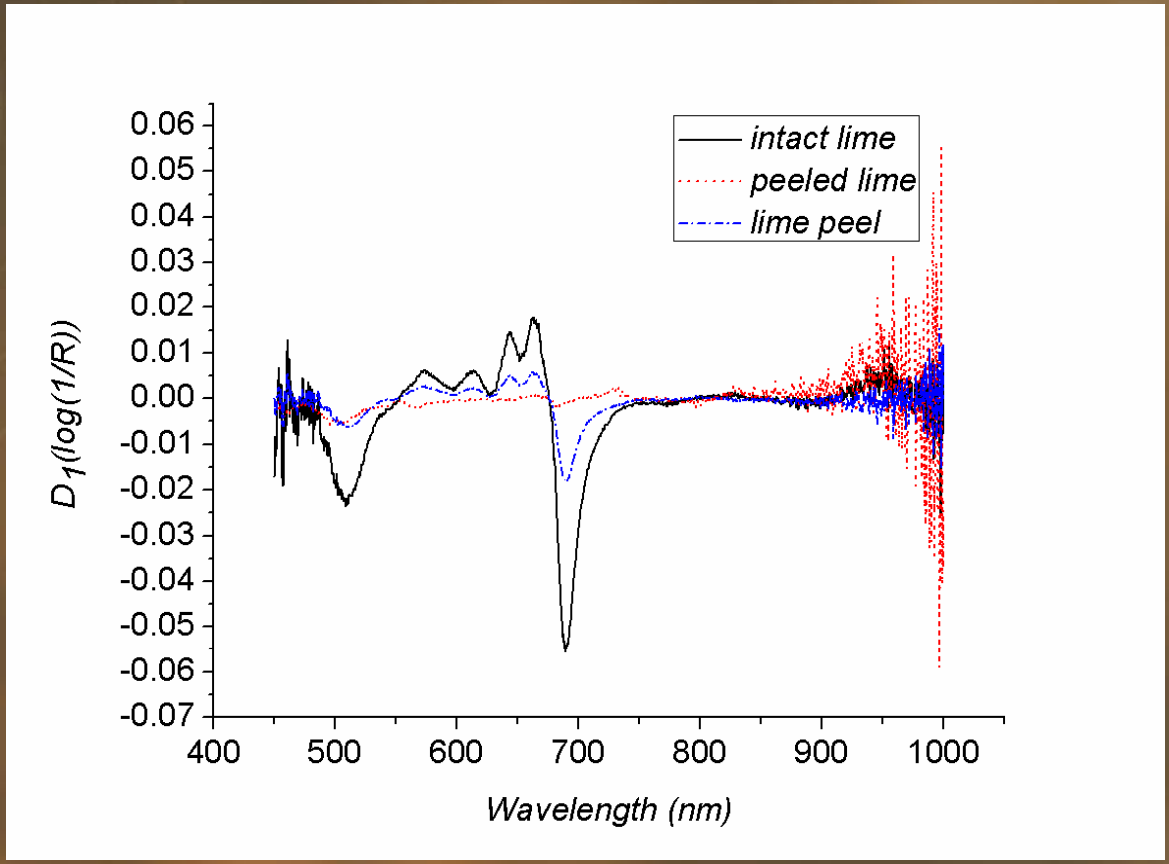
Mean absorbance spectra of peeled citrus

Results and Discussion



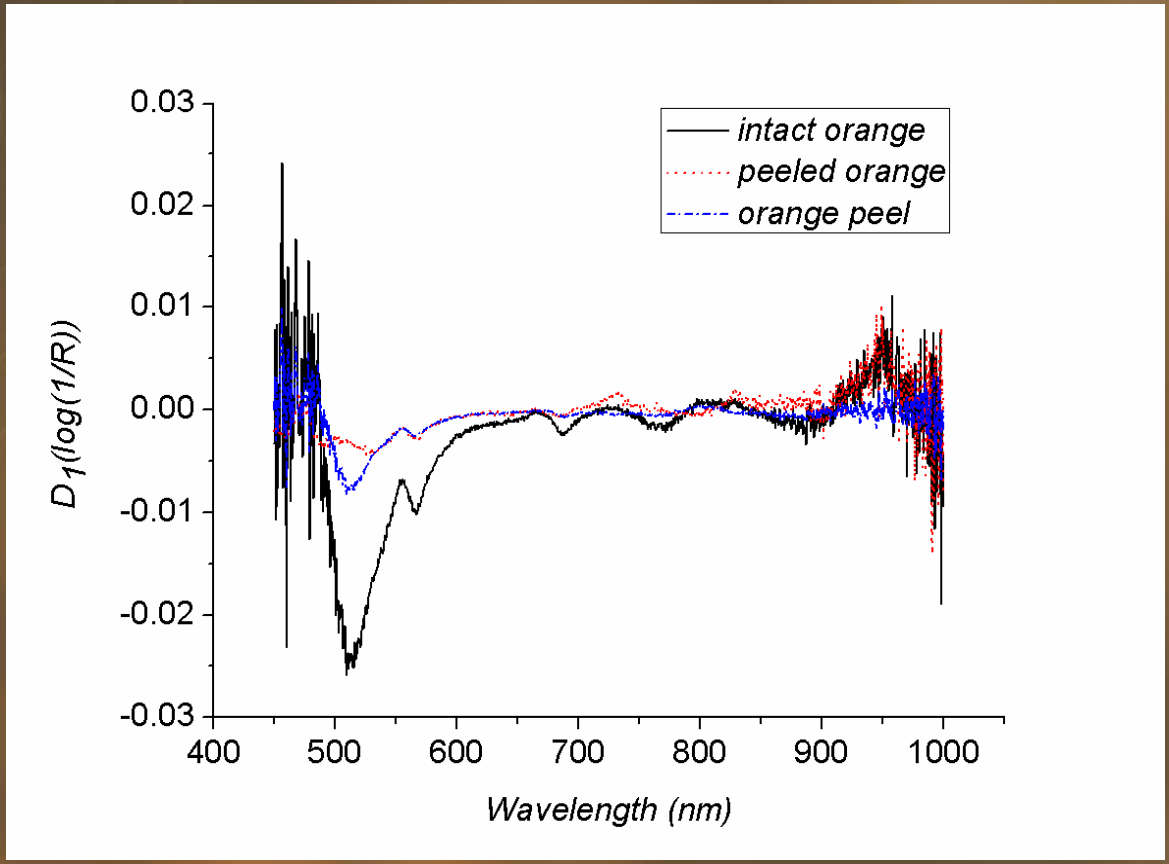
Absorbance spectra of citrus peel

Results and Discussion



First derivative of the absorbance spectrum of intact lime, peeled lime, and lime peel

Results and Discussion



First derivative of the absorbance spectrum of intact orange, peeled orange, and orange peel

Results and Discussion

The main peaks on the spectra of intact, peeled, and the peel of fruits

Main peaks	Intact lime	Peeled lime	Lime peel	Intact orange	Peeled orange	Orange peel	Related absorbance and vibrated bonds
470-490	485	475	485	487	477	488	Pigments
670-680	676	676	676	672	672	672	chlorophyll
730-750	-	742	-	736	750	-	3^{th}overtone of O-H, 4^{th} overtones of C-H, CH_2 and CH_3
810-850	847	840	820	839	840	817	3^{th}overtones of C-H, CH_2, and CH_3
960-990	976	977	985	986	977	985	2^{ed} overtones of O-H and NH_2

Conclusions

✓ *The main absorbance peaks on the spectra of both intact and peeled fruits were the same and relevant to pigments or the overtones of O-H and C-H functional groups.*

✓ *The difference between the main absorbance peaks for the spectra of the peel, intact, and peeled citrus were only observed in the visible region. However, there were no considerable differences in the overall shape and main peaks of the spectra in the NIR region.*

✓ *The effect of chemical composition of the peel can be ignored in non-destructive spectroscopy of intact citrus.*

Thank You For The Attention

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