Non-Destructive Identification of Woolly Peaches combining Mechanical Impact Response and NIR Spectroscopy
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Introduction
Woolliness (mealiness in other fruits) is a negative attribute of peach sensory texture that is a physiological disorder associated with inadequate cold storage. It is characterised by lack of crispness and juiciness without variation in the tissue water content (Harker and Hallet, 1992). Many attempts have been made to develop destructive instrumental procedures to detect mealiness and woolliness. Non-destructive procedures attempted include using nuclear magnetic resonance (Sonego *et al.*, 1995). However, this technique has economical limitations and is not practical at present. Non-destructive impact tests and NIR are non-destructive techniques which have been used to assess internal characteristics of fruits (Chen and Sun, 1991).
The objective of this study was to develop a novel non-destructive procedure to identify woolly peaches by combining impact and NIR approaches.

Methods
Early soft flesh peaches (cv. *Maycrest*) were used for this study in a randomised factorial design of 10 fruits per sample. The total number of peaches was 270). The experimental factors were: 3 ripeness stages (low, intermediate and high ripeness), 2 storage temperatures (+1° and +5°C) and 5 storage periods (at harvest and weekly for a period of 1 month).
The tests carried out were: Near infrared spectroscopy: 900-1.400 nm, wavelength increment of 10 nm, Monolight spectrophotometer; Non-destructive vertical impact: 50 g instrumented steel rod and 4 cm height; and Destructive tests: Magness-Taylor penetration on whole fruit , confined compression and shear rupture tests on cylindrical peach probes, with a Universal Mechanical Test Device (Texture Analyser XT2; SMS IMC).

Results
A reference destructive procedure was compared to a new non-destructive procedure.
Woolly peach identification using the destructive reference procedure
This method was based on a non-supervised classification according to the parameters obtained by the destructive tests. In a first step, segregation into two mechanical categories, crispy/firm/hard and soft, was carried out. Then, within the soft group, a segregation into three juicy categories was performed. Fruits classified as soft together with low juiciness were identified as woolly fruits.
Study of textural characteristics by non-destructive impact
A pool of five impact parameters were used to segregate between crispy/firm/hard fruits and soft fruits by Forward Stepwise discriminant analysis. The total percentage of properly classified fruits achieved with this procedure was 80 %.

Study of juiciness by NIR spectroscopy
Nine variables were selected by Forward Stepwise discriminant analysis from a pool of 60 wavelengths that correspond to the second derivative of the spectra to classify fruits in the three juiciness categories established with the destructive procedure. These variables corresponded to the 900-1400 nm range, where water shows several absorbing bands. The total percentage of properly classified fruit lay around 72%. Only 4 fruits (0.015 %) were misclassified as high juicy when belonging to low juiciness category. No fruits were misclassified as low juicy when belonging to high juicy category .

Identification of woolly peaches combining impact and NIR techniques
Parallel to the destructive reference procedure, non-destructive identification of woolly peaches corresponded to fruits which are non-crispy, non-firm, soft and non-juicy. Peaches classified as soft by non-destructive impact and simultaneously as low juicy by NIR spectroscopy were identified as woolly peaches. When comparing the non-destructive classification to the destructive reference procedure, 80% of correctly classified fruits was achieved. That is, 211 of 265 individual fruits. *Figure* 1 and 2, show the segregation of the two extreme textural categories (crispy-firm-hard *vs.* woolly) for the destructive and non destructive procedures respectively. Slight differences in woolliness onset (border individuals) may be the cause for misclassification, although further study should be performed in this direction.
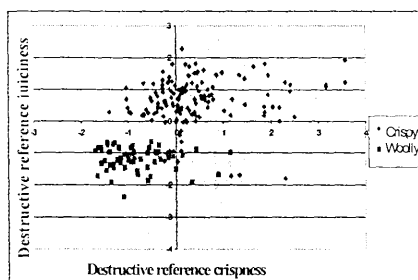

Figure 1. Representation of the two extreme textural categories (crispy/firm/hard vs. woolly) according to the standarised destructive juiciness and crispness parameters.
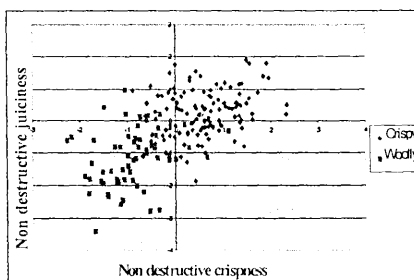
Figure 2. Representation of the two extreme textural categories (crispy/firm/hard vs. woolly) according to the standarised non -destructive parameters (roots from the discriminant analysis) for individual fruit values.

References
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Sonego L; Ben-Arie R; Raynal J, and Pech JC. Biochemical and physical evaluation of textural characteristics of nectarines exhibiting woolly breakdown: NMR imaging, X-ray computed tomography and pectin composition. *Postharvest Biology and Technology*. 1995; 5(3):187-198.