New version of a laboratory impact device for firmness sensing of fruits.

(00-PH-036)

B. Diezma*, L. Flores, J. Diez, M. Ruiz-Altisent, P. Barreiro, A. Marañón
Physical Properties Laboratory. Rural Engineering Department. Polytechnic University of Madrid. e-mail: labpropfis2@iru.etsia.upm.es

Introduction

Results of previous studies conducted by different researchers have shown that impact techniques can be used to evaluate firmness (Delwiche et al., 1989; Delwiche et al.; 1996; Jarén et al., 1992; Ruiz Altisent et al., 1996). To impact the fruit with a small spherical impactor of known mass and radius of curvature and measure the acceleration of the impactor is a technique described by Chen et al. (1985) and used by several researchers for sensing fruit firmness (Jarén et al., 1992; Correa et al.; 1992). The advantages of this method vs. a force sensor that measures the force as a function of time is that the measured impact-acceleration response is independent of the fruit mass and is less sensitive to the variation in the radius of curvature of the fruit (Chen et al., 1996).

Ruiz Altisent et al. (1993) developed and used a 50 g impactor with a 19 mm diameter spherical tip, dropping from different height for fruits (apples, pears, avocados, melons, peaches ...). Another impact device for firmness sensing of fruits was developed by Chen and Ruiz Altisent (1996). They designed and fabricated an experimental low-mass impact sensor for high-speed sensing of fruit firmness. The impactor consisted of a semi-spherical impacting tip attached to the end (near the centre of percussion) of a pivoting arm. Impact is done by swinging the impactor to collide with the fruit. It has been implemented for on-line use. In both devices a small accelerometer is mounted behind the impacting tip. Lateral impactor and vertical impactor have been used in laboratory and the results from non-destructive impact tests have contributed to standardise methods to measure fruit firmness: Barreiro (1992) compared impact parameters and results of Magness-Taylor penetration tests for apples, pears, apricots and peaches; Agulheiro (1994) studied the behaviour of the impact parameters during seven weeks of cold storage of two melon varieties; Ortiz (1998) used low energy impact and NIR procedures to segregate non crispy, non firm and soft peaches. Steinmetz (1996) compared various non-destructive firmness sensors, based on sound, impact and micro-deformation.

Objectives

- To establish a calibration procedure of a low-mass impact sensor for firmness sensing of fruits
- To evaluate its actual accuracy
- To develop new system software and hardware to obtain a device enable to be easily used and configured by the user

Equipment description

The new equipment consist of three elements:

An external conditioning amplifier that adapts and amplifies the signal to measure and manage the electromechanics.

- An internal ISA PC board Computer Boards CIO-DAS08, up to 40 kHz sampling rate, 8 multiplexed analog inputs, 24 digital in/out connections and 12 bits A/D converter.
- A Windows95/98/NT software that allows the user to control the process as well as record all the measurements made.

Materials and methods

Hardware and software systems to develop the impact device:

- Tektronix 468 Digital Storage Oscilloscope, power supplies, signal generators, multimeters, Windows 95/98/NT, Borland C++ 2.0, Microsoft Visual C++ 5.0, personal computers, ISA PC board CIO-DAS08, etc.

Several impact tests were made to evaluate the repeatability, sensitivity and robustness of the system, to calibrate the signal and to obtain protocols of experiments to determine fruit firmness categories:

- Tests with a rubber ball: impacts from different distances (lateral impactor) and heights (vertical impactor)
- Tests with different fruits (apple, pear, peach and apricot)
- Tests with different program configurations to establish the best testing procedure for each fruit

Results

The new system external electronics increase the data resolution up to 12 bits decreasing the error and allowing an easier way to calibrate the system. It also strongly increases the signal noise relation. The accuracy has been increased with de new system.

On the other hand the new window based interface allows the user a fast and easy way to manage the data and control the measurement process by the use of scroll bars, a board configuration window. It also gives the user direct information about acceleration, velocity, deformation, energy, etc. Different files are created by the program to store data providing an easy way to use with Microsoft Excel or Corel QuattroPro. Data analysis is being carried out.

References

Chen, P., S. Tang and S. Chen. 1985. Instrument for testing the response of fruit to impact. American Society of Agricultural Engineers Paper Number 75-3537

Chen, P., M. Ruiz-Altisent , and P.Barreiro. 1996. Effects of impacting mass on firmness sensing of fruits. Transactions of the ASAE 39(3):1019-1023

Chen, P., and M. Ruiz-Altisent. 1996. A low-mass impact sensor for on-line firmness sensing of fruits. Paper 96-F-003. Presented at AgEng96, Madrid, Spain. Sept. 22-26, 1996

Chen, P., and Y. Tjan. 1998. A real-time impact sensing system for on-line firmness sensing of fruits. Paper 98-F-006. Presented at AgEng98, Oslo

Steinmetz, V., Crochon M., Bellon-Maurel, V., García Fernández, J.L., Barreiro, P., Verstreken, L. 1996. Sensors for fruit firmness assessment: comparison and fusion. Journal of Agricultural Engineering Research, 64(1), 15-28

Acknowledgements

The funding of this work has been covered by concerted action ASTEQ FAIR5 CT97-3516.