NON-DESTRUCTIVE METHODS TO EVALUATE THE PHYSICAL-CHEMICAL PROPERTIES OF FRUITS AND VEGETABLES

METODE NEDISTRUCTIVE PENTRU EVALUAREA PROPRIETĂȚILOR FIZICE ŞI CHIMICE A FRUCTELOR ŞI LEGUMELOR

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Abstract. *The mechanization, automation and IT adaptation of the machines and installations for sorting / calibration of vegetables and fruits asked for the inclusion in the specific conditioning flow of some OPISCAN devices able to appreciate the shape, weight, colour, specific warmth, elasticity and firmness of the products that are on the conveyor's belt.*

Complex IT programmes allow, on account of the primary data, to identify and separate (sort) the products by species, maturation degree, covering colour, size, weight or other criteria so as to insure a commercial uniformity.

Rezumat. *Mecanizarea, automatizarea şi informatizarea maşinilor sau instalațiilor de sortare/calibrare pentru legume şi fructe a impus includerea pe fluxul de condiționare specific a unor dispozitive OPISCAN în măsură să aprecieze forma, greutatea, culoarea, căldura specifică, elasticitatea şi fermitatea produselor care se află pe banda transportoare.*

Programe informatice complexe permit pe baza datelor primare să identifice şi să separe (sorteze) produsele pe specii, soiuri, grad de maturare, culoare acoperitoare, mărime, greutate sau alte criterii, în vederea asigurării unei uniformități comerciale.

To appreciate the quality of fruits they use visual and analytical criteria. While the criteria of the visual type (shape, size, color, noticing of certain flaws etc) are non-destructive, the destructive analytical criteria appeal to methods that imply the mincing, boiling and filtering so as to determine the contents of soluble sugars and starch, acidity and firmness etc.

At present the non-destructive methods become more and more spread. The non-destructive control of the internal quality may be used to determine operatively the samples on the valorization flow of products, to appreciate their quality at delivery or to evaluate some technologies in process of homologation. A use that has already asserted itself is the non-destructive determination of the sugar contents especially on the English market (in France, Italy, Spain, Great Britain and Israel). The Great Britain is mentioned for its significant investments in this field focusing on the trading of the high quality products, first of those with an advanced state of ripening.

The NIR check up for the firmness of mature fruits (kiwi, avocado, mango etc) makes possible the valorization at a maximum extent of the sugar contents and aims at an applicability in numerous domains (gluten determination, fodder quality, pharmaceutical industry, oil industry, plastics).

Bourgeois, Hellene (2002) highlights the possibilities of NIR (Near Infra Red = spectrometry in near infrared) to measure rapidly and non-destructively the sugar contents of fruits. The method is already an instrument adapted at the conditioning mechanical / electronic flow and functions in real time (instantaneous determination with an instantaneous data processing). There are also portable systems that allow determination on plantations so as to evaluate the culture technologies, the harvest date, the maturity state of the fruits preserved and the moment of their marketing. It is fit for the fruits with a thin epicarp (apples, pears, grapes, peaches, some melons) and applies more difficultly to those with a thick skin (2).

Vaysse, P. (2002) notices that a device of recent conception, meurtimeter measures the sensitivity to fruit damaging registering the percentage of fruits damaged (meurtris) after they were submitted to a fall from certain heights precisely established.

An instrument for testing the calibration installations is the instrumental sphere that registers shocks in three dimensions to which fruits are submitted during conditioning. The sphere PMS 60 (a compression) made from deformable rubber has a silicone oven that measures the sums of the forces to which it is submitted. The values are stored in the internal memory and are unloaded as some information (values expressed in Newton = $kg/m/s^2$) in the terminal of a computer. After initiating and launching of measuring, the sphere is put on the bottom of a packing in the absolute similar conditions to any fruit of its dimensions. They may determine in this way the critical points that may cause mechanical deteriorations in fruits in the three phases of a transport (loading, transport, storage) (21).

Costa, G. and collab. (2004) elaborated a NIRS calibration model based on determination effectuated beforehand that were correlated with the values of absorbance at a certain specific wave length for two apricot breeds Bergarouge and Goldrich. They noticed that the soluble dry substance (^{0}Bx), firmness (kg/cm^2) and dry extract (%) could be anticipated (indirectly evaluated) with a standard deviation acceptable as compared to the real values (5).

Kim and collab. (2005) used fluorescence induced in a multi-spectral manner to determine the contamination of apples with certain pollutants. They could identify a significant result in the aspect of 690 nm, where there is a difference between the uncontaminated samples and the contaminated ones (12).

Wulf, J. S. and collab. (2005) used the spectroscopy of fluorescence induced by laser (LIFS) as a non-destructive determination to establish the changes of the pigments contents from apples and carrots. The samples were excited by short laser pulses emitted at 337 nm and registered as spectral fluorescence directly on the surface of products at wave lengths between 350 and 820 nm.(25).

In parallel they measured the polyphenols contents of apples by liquid-chromatography of high performance. They noticed that the intensity modifications of the fluorescence in the range of wave length blue-green may be attributed to the variations in polyphenolic contents of fruits. The degradation of chlorophyll becomes also visible during storage in the red fluorescence of apple fruits (25).

Johnson D. S. and collab. (2005) tested the possibility of use of some acoustic determinations to evaluate the firmness of apples. They used apple samples different in texture and manner of conservation in various ways coming from two cultivars. The acoustic firmness was measured using an AFS unit (AWETA BV) in parallel with a penetrometer Lloyd LRX specifically adjusted. The measurements were made for three times.

For Cox there is a good relation between the penetrometric readings and the sensorial values (crispiness) and a less good correlation for Gala. At Cox there was a strong correlation between the acoustic firmness and the penetrometric readings and no correlation for Gala. The increase of the humidity losses at the Cox apples determined the increase of the sensorial values for crispiness and firmness but the index of acoustic firmness showed an opposite trend indicating that the turgidity of tissues is a contradictory factor in the acoustic measuring of the apple firmness (11).

Landahl, S. and collab. (2005) consider that the product texture may be evaluated as the elastic properties of tissues and firmness. The authors want to demonstrate the possibility of some technical non-destructive devices of impulse – acoustic response to determine the internal flaws of apples and the acoustic techniques if they depend on the biochemical changes from the cell walls in apples.

The apples were treated with microwaves to obtain fruits with internal flaws. They were measured by the classical lab equipment and the acoustic technique of impulse- response and the results were compared before and after the microwave treatment. With the classical equipment they did not find any differences between the treated and untreated fruits with microwaves. By the acoustic technique of impulse- response they found very significant differences between the untreated fruits and the ones treated with microwaves (13).

Eccher Zerbini, P. and collab (2005) In a preliminary testing of nectarines, the absorption coefficient at 670 nm measured at harvest was correlated with the fruit maturity and the softening after harvest. The purpose of the research was to model by TRS measured in harvest, the softening of nectarines during valorization. The softening during valorization after the cold keeping was modeled by a non-linear regression following a logistic model depending on the absorbance at 670 nm at harvest and in the period with 20^0C (R^2=0,85). The results of the previous tests ere confirmed integrally. Using this model and absorbance at 670 nm at harvest, it is possible to pre-eliminate the softening rate at 20^0C of the fruits studied necessary for a better trading (7).

Echeverria, G and collab. (2005) evaluated for the Fuji apples the effects of different storage conditions, the storage duration and valorization by measuring the production of volatile substances, tests of sensorial acceptability and determinations with an „electronic nose”. The production of volatile substances was measured by means of a chromatograph gas and alternatively with an „electronic nose” and the acceptability of apples was measured by specific means (8). The PCA (Principal Component Analysis) model contains data for all fruits, at harvest and after storage showing that it is possible to identify fruits recently harvested and after different storage variants. On the other hand PCA on the production of volatile substances, the sensorial acceptability and the EN signals specific to all fruits allow a good differentiation between the fruits stored in the two types of controlled atmosphere with an acceptable variability coefficient (8).

Symoneaux, R. and collab. (2005) – mention that in a previous paper they studied the impact of the harvest date on the quality of apples by taking into consideration the correlations among the acoustic measurements (the coefficient compactness–density) and the sensorial evaluation. The studies were continued in the same manner for the different maturation levels and subsequently completed with the impact of conservation on the apple quality. They effectuated acoustic, sensorial and instrumental measurements on different apple breeds. They confirmed a high correlation between the acoustic measurements and the textural ones. The compactness proved to be a non-destructive parameter good to measure the apple texture. The correlation between the sensorial and instrumental measurements was also studied (18).

Vanoli, M. and collab. (2005) A non-destructive method TRS (Time – Resolved Reflectance) measures separately the two optical properties of absorption and dispersion in the depth of 1-2 cm from the apples pulp. The absorption coefficient measured at 630 nm by TRS evaluates the apple quality at harvest and after storage. The absorption coefficient at 630 nm was significantly higher at the first apples harvested. The apples with a higher absorbance at 630 nm had a less fruit mass as well as a more reduced percentage of colored fruits both at harvest and after storage. The fruits classified as super-maturated by TRS had a more reduced titrable acidity at harvest and higher soluble dry substance after storage. At the sensorial analyses these fruits were significantly sweeter, more flavored and more pleasant. We may conclude that TRS may be used to select apples after their maturation degree and to separate the fruits of different qualities from the same origin (20).

Casalonga, Sabine (2005) presents a prototype of flavor nanocaptor based on individual olfactory receptors called “artificial nose” with applications in security, defense, health and agro-alimentary field. The theoretical support is constituted by the discovery of the olfactory receptors and the great gene family that codify them (R. Axel and Linda Bucek Nobel prize for physiology and medicine in 2004).

By imitating the olfactory system of animals that may identify thousands of smells with a very high sensitivity, the electronic nose may be effective in the agro-alimentary field for the control of quality and food security. The European project SPOT – NOSED developing an olfactory biosensor based on the electrical properties of the specific receptors is functional (3).

Zanella A. and collab. (2005, 2006) study the extent in which the results of the conventional lab analyses correlate with the results of some innovating procedures. They present the robot Pimprenelle that determines automatically (but destructively) weight, the soluble dry substance, pulp firmness, titrable acidity and the juice contents (23).

The non-destructive apples in close infrared regarding the appreciation of transmittance to a sorting line with a higher speed than 4 apples/second (λ= 650-970 nm) by irradiation of the entire fruit, used a source with luminous intensity of 12 x 100W. They noticed that at the NIRS determinations effectuated (firmness and soluble dry substance) the results obtained were comparable and non-differentiated statistically from the classical lab determinations (destructive) (24).

Bargain, Veronique (2006) evaluates the last aspects regarding the non-destructive control of the internal quality of fruits. The producers (Greefa, MAF Roda, Aweta, Sinclair, Sacmi, Sorma – Compac, Setop etc) of sorting – calibration installations managed to inset on the flow models of NIR equipment able to determine the sugar contents, acidity, dry substance, oils, internal scald, vitrescence. (1).

The Setop company specialized in the calibration of melons discovered a new NIR method to determine non-destructively the firmness for melons and water melons. Other producers (Greefa, Sinclair etc) achieved a non-destructive impact method that evaluates products on account of elasticity. The company Aweta homologated a CAF device (Capteur Acoustique de Fermete) that strikes non-destructively the product and listens to the acoustic echo resulted according to firmness, succulence, freshness and internal structure. All the systems enumerated may be installed in line at the calibration installation with an execution speed from 1 to 10 fruits per second (1).

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