Bernd Herold, Michael Weiner, Ingo Truppel and Martin Geyer, Potsdam-Bornim

Quality Determination of Agricultural Produce by Measuring the Surface Microprofile

Gloss and roughness are frequently used to subjectively evaluate the surface quality of fresh fruit and vegetables. However, a technical definition of these properties does not exist for uneven surfaces, i.e. objective determination is difficult. Traditionally, quantitative measurements of surface microprofiles are done by using mechanical sensing methods. Recently developed non-contacting optical methods can be used to analyse the surface microprofile of susceptible horticultural products.

Dr. Bernd Herold and Dipl.-Ing. Ingo Truppel are staff of department, and Dr. Martin Geyer is head of department “horticultural engineering” of Institute of Agricultural Engineering Bornim e.V., Max-Eyth-Allee 100, 14469 Potsdam (Scientific director: Prof. Dr.-Ing. Jürgen Zaske); e-mail: *bherold@atb-potsdam.de*.
Mr. Michael Weiner is student of the Humboldt university at Berlin and is working at Institute of Agricultural Engineering Bornim e.V during his diploma thesis.

Keywords

Microtopography, surface quality, fruit, gloss, roughness

Literature

Books are identified by •

[1] *Dietz, C. und M. Jurca*: Eine Alternative zum Laser - Ein Weißlicht-Messverfahren dringt in den Sub-µm-Bereich ein. Sensormagazin, (1997), H. 4
[2] • *Klein, G.* Einführung in die DIN-Normen. B.G. Teubner, Stuttgart Leipzig; Beuth Verlag, Berlin Wien Zürich, 1997
[3] *Lipshitz, H., M. Gridger and G. Derman*: On the relationships between topography and gloss. Tappi Journal, (1990), pp. 237-245

The quality of fruit and vegetables is perceived by the consumer at first by means of its external appearance. In this context, surface properties like gloss or roughness are very important. The external appearance of the surface of a horticultural product surface will be controlled on the one side by grower’s intention, but on the other side to a high extent by the post-harvest handling technique. Micro-topographic measurements can be used to quantify these quality properties and their changes, and to evaluate the effect of post-harvest handling. Traditionally, the micro-profile of surfaces is determined by means of contacting mechanical scanning technique. These technique is routinely used for industrial application e.g. for even surfaces in metal processing (DIN EN ISO 11562 and 4287). Because horticultural products are susceptible to mechanical stress, non-contact scanning techniques based on optical principle are preferred.

Non-contact scanning technique based on principle of chromatic coding

This paper presents a scanning technique based on the wavelength depending coding of the measured distance (*Fig. 1*) [1]. The sensor consists of an optical probe and a signal processing unit including a halogen lamp as source of white light. By means of a glass-fibre, the light of the halogen lamp is guided to the optical probe. There is a lens to focus the light in coaxial way onto the surface whose distance is to be measured. Because of the chromatic aberration of the lens, the focal length varies with the wavelength. The wavelengths of light with focus on the surface are predominantly reflected to the optical probe and enter again the glass-fibre. This reflected part of light is guided to the signal processing unit and measured by a spectrograph. The spectral signature of measured light shows a pronounced peak whose spectral position is used to determine the distance from the surface.

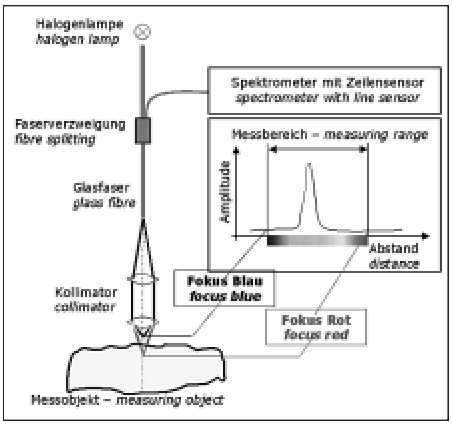


Fig. 1: Principle of wavelength dependent distance measurements

The measuring unit for surface topography Type NEMESIS (manufactured by Precitec Optronik, formerly JURCA) (*Fig. 2*) was used for the tests. It consists of a cushioned heavy portal with two linearly driven precision stages for placing and mov-

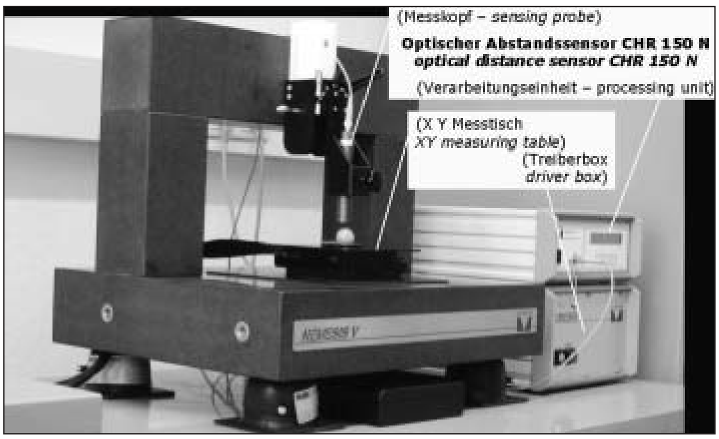


Fig. 2: Total view of the topography system NEMESIS

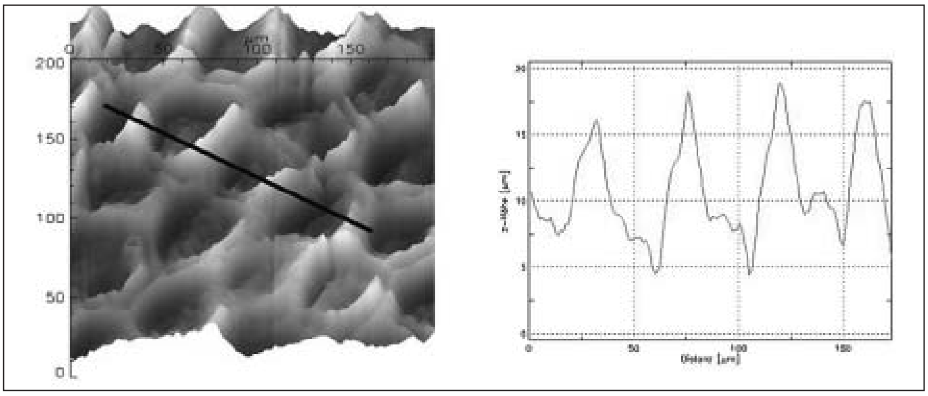


Fig. 3: Microtopographic measurement of tomato surface; a) 3D-view of measured surface (200 µm • 200 µm, lateral resolution 1 µm); b) view of the altitude profile along a diagonal line over the tomato surface

ing the measuring object in horizontal plane. A driver box controls the precision stages. By means of the measuring unit, surfaces can be scanned with minimum resolution of 1 µm in horizontal plane. An optical sensor Type CHR 150 N (measuring range of 300 µm, resolution 10 nm) is placed on the portal above the precision stages and used to measure the distances in vertical axis. Before the measurement it is adjusted about 5 mm above the measuring surface. The controlling of measurements and the evaluation of measured data is done by PC. The measurement of an area of 0,25 mm • 0,25 mm with lateral resolution of 1 µm at the maximum scanning rate of 1000 Hz takes about one minute.

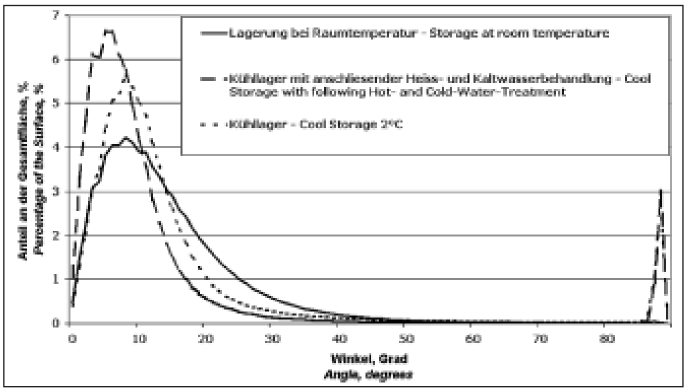
Micro-topography on horticultural products

Horticultural products have specific properties with particular requirements for micro-topographic measurements.

The freshness of highly perishable products like lettuce decreases rapidly. Accordingly, the surface properties change. Because of the relatively small light reflectivity of lettuce leaf, slow scanning rates between 100 and 300 Hz are required in order to obtain meaningful data. Under the above mentioned conditions, a measurement takes several minutes, i.e. it is difficult to carry out reproducible measurements.

A crucial problem is the scanning of objects with dimensions close to the resolution, e.g. if there is a tiny hair with diameter of about 1 µm on the leaf surface.

Fig. 4: Facet angle distribution on sweet cherries after different treatments



During the measuring run, the product is stepwise moved synchronously with the distance measurement. No additional relative movement and vibration are acceptable. Small proper motions can cause appreciable measuring errors and have to be restricted widely by careful affixing the object on the precision stage.

Several measurements were carried out with tomato and cherry fruits, whose surface has a waxy layer with distinct gloss. A 3D view on the tomato fruit surface with decided cell structure is shown in *Figure 3a*. In this example, the contour along a straight line over the surface shows vertical peaks up to 14 µm height in a distance of about 50 µm according to the cell diameter (*Fig. 3b*).

Evaluation of surface profile

There exist standardised parameters to determine the surface roughness related to 2D profiles. A well-established parameter is the arithmetic mean value of roughness Ra that accords with the height of a rectangle of length as long as the entire measuring section and of area equal to the sum of the areas enclosed between roughness profile and mid-line [2].

In order to describe the gloss properties, a model according to Lipshitz et al. [3] is used. For this purpose, the surface under investigation is dissected in small elements (facets). Three adjacent scanning points of the topographic measurement respectively are considered to span a facet. The orientation of all the facets is determined and related to the average surface plane. The expected gloss properties are characterised by means of the average facet (orientation) angle as well as the width of the distribution of the facet angles.

Micro-topographic parameters were determined at several tomatoes from different storage conditions (*Table 1*). Considering these parameters and the water loss, the results of this test did not show clear tendencies.

The other test with sweet cherries cv. 'Kordia' has been carried out in order to determine the effect of different post-harvest treatments on the micro-topography. Three groups of cherries were used, the first with 16 fruits and the others each with 10 fruits. Before the measurement, the first one was held at room temperature, and the both others were held at cool condition and then immersed in water, one of them in hot and the other in cold water. The distribution characteristics of the facet angles of the three test conditions differ (*Fig. 4*). The widest distribution characteristics was found for the group held at room temperature. To what extent these parameters are suited for evaluation of the physiological state or the retail quality of the product, could not sufficiently be elucidated yet.

Storage condition	open, ventilated	open	closed, ventilated	closed
Water loss, %	5.45	3.64	1.88	1.78
sRa, µm, λc=28.571 µm*)	1.474	1.571	1.216	1.802
Average facet angle, °	20	22	17	23

*) λc is the boundary filter wavelength to separate longwave signal parts [2]

Table 1: Tomato parameters from different storage variants