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

Colour measurement and ripeness determination for apples

Colouring and degree of ripeness are important trading quality aspects with apples. The fruit's colouring is variety-specific. With many varieties, this is influenced through the intensification of the red basic skin colour. To a large extent the basic colour correlates with the degree of ripeness.

Demand from the trade is for batches which are of an even quality, a target which is only achievable through objective and reliable testing methods. Monolithic miniature spectronomy allows colour and ripeness to be cost-efficiently controlled.

Dr Martin Geyer is manager of the "Technology in Horticulture" department at the Institut für Agrartechnik Bornim e. V., Max-Eyth-Allee 100, 14469 Potsdam (scientific director: Prof. Dr.-Ing. Jürgen Zaske); Dr. Bernd Herold and Dipl.-Ing. Ingo Truppel are members of the scientific staff of this department, e-mail: bherold@atb-potsdam.de

Keywords

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Improved market opportunities for fresh fruit and vegetables can, above all, be achieved through striving for higher quality. For this aim it is necessary to specify more closely the quality demands. The EU quality standards for apples applicable to the trade concern themselves, up until now, only with quantitative demands as to size of fruit, measurement of external quality faults and with variety-specific red skin colour graduation. Additionally, the consumers want ripe fruit consistent in appearance and quality. It is also important on the farm at harvest time to classify as far as possible apples according to their degree of ripeness as this simplifies the management of storage, preparation and marketing processes. In order that these market demands can be better met, growers will aim in the future for on-farm ways of classifying interior quality (firmness, sugar content) [1].

The definition of colour, especially through evaluation according to the proportion of red-coloured fruit surface is, in the main, technically solved as far as grading for market is concerned. With colour cameras, several RGB photographs per fruit are taken on the conveyor belt and evaluated by computer. Grading according to size and colour then follows through variety-specific evaluation programs. The mechanical grading cannot, however, be compared directly with traditional manual sorting without some reservations. The results of comparative trials show that manual classification and mechanised evaluation of RGB photographs based on variety-specific characteristics according to EU quality standards, more or less differ greatly [2]. In order to achieve mechanical grading which can match manual classification it appears that research and development work is still necessary.

Definition of colour pigments

The colouring of the fruit is caused by colour pigments which are on the one hand genetically based and on the other are dependant on physiological changes during fruit development and ripening. In the evaluation of the colour characteristics, different aspects have to be considered. In order to describe the colour impression of the fruit surface as perceived by humans the measured colour values are transformed in the L*a*b*- colour space[3]. The L*a*b*- colour values are mainly matched to subjective perception and can be directly defined with the help of commercial measurement equipment. With scientific trials mostly the spectral light reflectance or light transmission is evaluated.

In the following, results from spectral and colorimetric measurements on apples will be introduced which have been realised at the IFR, Norwich as part of the communal EU action ASTEQ (Artificial Sensory Techniques for Evaluating Quality). The investigations took place on apples of the sorts "Jonagold" (J) and "Cox's Orange Pippins" (C). The fruit was supplied by the Institute of

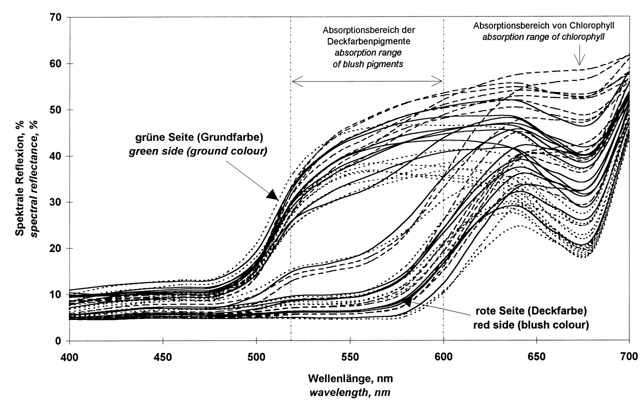

Fig. 1: Spectral reflectance curves of fruits of cv. „Cox's Orange Pippin" (..... non-ripe, __ ripe, _ _ overripe)

	Original groups	Classification NR	R	OR	Total
Number	NR	30	2	0	32
	R	3	26	3	32
	OR	0	3	29	32
%	NR	93,8	6,3	0,0	100,0
	R	9,4	81,3	9,4	100,0
	OR	0,0	9,4	90,6	100,0

Table 1: Classification of apples cv. "Jonagold" and "Cox's Orange Pippin" through spectral reflectance data according to ripeness classification (NR – non-ripe, R – ripe, OR – overripe)

Agricultural Technology of the Catholic University of Leuven. The apples were fully developed and, through different storage times and appropriate climatisation, could be divided into three ripeness classes: not yet ripe for eating (NR), ripe for consumption (R) and overripe (OR).

The measurements took place with the help of a portable Minolta spectrophotometer type CM-503i. The equipment works by being laid on the fruit surface with one hand and, following the pressing of a button, capturing in a matter of seconds the light reflection (including the shine) of a surface area of 33 mm diameter in the wavelength area of 400 to 700 nm. Internal colorimetric key values are then calculated from the spectral data and displayed or printed out.

The presence of chlorophyll as a criterium of ripeness within the measured reflectance spectrum (*Fig. 1*) can be estimated according to the specific reflectance minimum at a wave length of 680 nm (high reflection = ripe, low reflection = unripe). The pigments responsible for the red ground colour (anthocyane and others) are identifiable through reduced light reflectance in the wavelength area from 520 to 600 nm. The values show a high variability which is due to the influence of the pre-harvest conditions (sunshine, fertilising).

Evaluation according to ripeness

The differentiation of the three ripeness grades was investigated with the help of a discriminatory analysis (SPSS). Taking into account the total reflection spectrum in the analysis of from 400 to 700 nm, 91.7% of the "Cox's Orange Pippin" apples and 89.6% of the variety "Jonagold" could be correctly classified . Taking both varieties together, a correct classification of 88.5% was achieved (*Table 1*). According to the reflection values from just three chosen wavelengths, a further classification with 86.5% correctness was achieved for the apples of both varieties.

For comparison, the L*a*b* colour values were drawn up for differentiation. *Figure 2* reflects the ease of separation of the ripeness grades through the a* and b* values. Taking into account the three colorimetric key values L*, a* and b*, the discriminatory analysis resulted in unsuitable results for two different light types (D65 – daylight, A – artificial "bulb" light) in each case. In the case of D65 light 80.2% of the apples (in each case both varieties), and with A light 78.1% were correctly classified.

Outlook

The results recommend the use of spectrometerical measuring techniques for determining colour and ripeness . In that cost-effective industrially-produced monolithic miniature spectrometers will be available on the market in the coming years, it is expected that, for agricultural and horticultural use too, there will be increasing employment of this technology.

Preview

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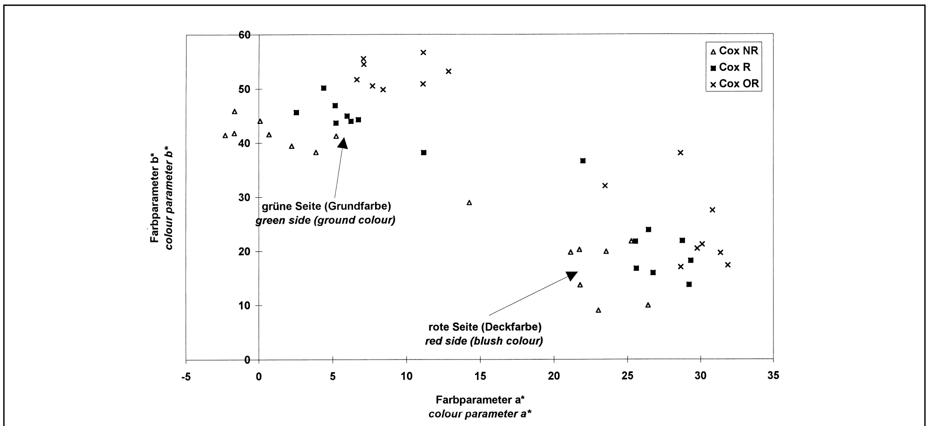

Fig. 2: Colour parameters of fruits of cv. „Cox's Orange Pippin" (NR – non-ripe, R – ripe, OR – overripe)

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