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Destruction-free determination of the glassiness of bulb onions

For several years, glassiness has been an increasing problem in the storage of bulb onions. It generally affects the outer, fleshy rings and manifests itself in the watery appearance of the affected areas of the onions after they have been cut open. Since heavily glassy bulb onions are susceptible to microbial infection and must be classified as unsuitable for commercial sale, there is a great need for checks. Spectral-optical parameters for the examination of onions have been studied in order to investigate a promising, destruction-free principle as an alternative to very time-consuming manual quality control.

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Keywords

Bulb onion, objective quality determination, glassiness, spectral optical signature

Bulb onions react sensitively to temperature stress and mechanical load. They tolerate slight freezing up to -3 °C because they can fully resorb the frozen cell water when thawed. However, they may not be moved in frozen condition because this may cause bruises, which lead to rotting. Freezing damage manifests itself as glassiness and watery spots with a greyish shine [1]. Storage glassiness occurs after changing, moist weather conditions [2].

For commercial sale, bulb onions must be supplied in perfect quality [3]. Onions are considered unacceptable if the two outer, fleshy rings are entirely or partially glassy (*fig. 1*) or have soft spots. In order to determine glassiness, onions not only have to be analyzed externally, but they must also be examined based on internal characteristics. Thus far, this requires that the onions be peeled or cut and evaluated. However, this method is very time-consuming and causes additional waste.

The goal of experimental studies should be a destruction-free technical detection principle, which provides information about the degree of glassiness of the bulb onions. This detection principle should work fast enough that it can be employed for the control of a sorting system.

Material and Methods

For the studies, two series of experiments with bulb onions from the production of storage- and marketing operations were carried out in the spring of 2002. For this purpose, evaluators selected samples of sound onions and onions which were suspected to be glassy after external, destruction-free assessment (*table 1*). Both samples were kept cool and examined in the laboratory one day after sampling in order to avoid the possible atrophy of glassiness.

At two spots opposed on the largest circumference, the onions were marked with a pen. At these spots, objective measurements were carried out. With the aid of a spectral glass-fibre photometer (company Tec5, Oberursel), partial light transmission was measured in the wavelength range from 400 to 1,100 nm [4].

During the spectral-photometric measurement, the glass-fibre probe was firmly applied to the onion surface (*fig. 2*). On the front side of the glass-fibre probe, two light fibres terminate. The light emitting fibre radiates the light of a halogen lamp into the tissue. The light-receiving fibre, which is situated 10 mm away from the light emitter, collects part of the light scattered and reflected in the interior of the onion. The characteristics of the cell tissue passed by the light rays influence the spectral signature of the received light, which was evaluated for quality assessment.

After the completion of these studies, the onions were cut through at their largest diameter at right angles to the shoot axis and photographed using a digital camera. The photos were used for the subjective visual evaluation of the internal structure, and a glassiness index was calculated for quantitative assessment. This calculation was based on the observation that the intensity of glassiness decreased from the outer layers to the centre. At the measuring point, the rings clearly discernibly affected by glassiness were counted (number of glassy rings). This

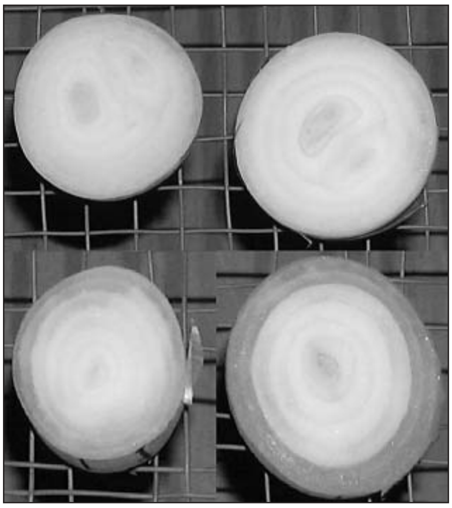

Fig. 1: Cross section of bulb onions, above: healthy, below: glassy

number was divided by the total number of rings outside the shoot area and finally multiplied by the estimated intensity of glassiness in the affected rings, which ranged between 0 and 1. The intensity of glassiness shows how strongly and with what lateral extension each ring is affected:

$$Index\_der\_Glasigkeit = \frac{Anzahl\_glasiger\_Ringe}{Gesamtzahl\_der\_Ringe} \times Intensität\_der\_Glasigkeit$$

According to this method, the index value for perfect condition is 0, i.e. all rings are free of glassiness and, consequently, intensity also equals 0. The index value 1 stands for complete glassiness, i.e. all rings are affected by glassiness and are completely glassy (intensity 1). The correlation of the index values with the data of the spectral-photometric measurement was evaluated stepwise using different mathematical methods.

Results and Discussion

The sample material collected with the suspicion of glassiness showed a large percentage of glassy and partially glassy onions (table 1). In order to be able to take this circumstance better into consideration, an index value of 0.2 was assumed as the threshold value for glassiness. Thus, the material was divided into three groups: sound (index = 0), partially glassy (0 < index ≤ 0.2), and glassy (index > 0.2). An onion with a glassiness index of 0.2 has two glassy rings with glassiness extending over two thirds of the area.

The boundaries between glassiness and perfect quality are fluid. Therefore, the clear determination of a tolerance limit is very difficult. In any case, subjective influences as a result of assessment by different evaluators must be taken into account.

This problem continues when the objective measurement data are evaluated so that one can only reliably differentiate between really sound onions on the one hand and heavily glassy onions on the other hand.

The spectral signature of partial light transmission was assessed in the wavelength range between 725 and 1,050 nm. In this range of near infrared light, absorption bands due to overtones and combinations of the vibrations in the water molecule can be found, which react sensitively to alterations caused by glassiness. Favourable wavelengths for the reliable distinction between clearly sound and glassy onions were determined (*fig. 3*). However, it was impossible to distinguish partially glassy onions with sufficient reliability. Multivariate statistical analysis (PLS analysis) of the spectral signature including the entire wavelength range did not allow suitable separation criteria with a low error rate to be established.

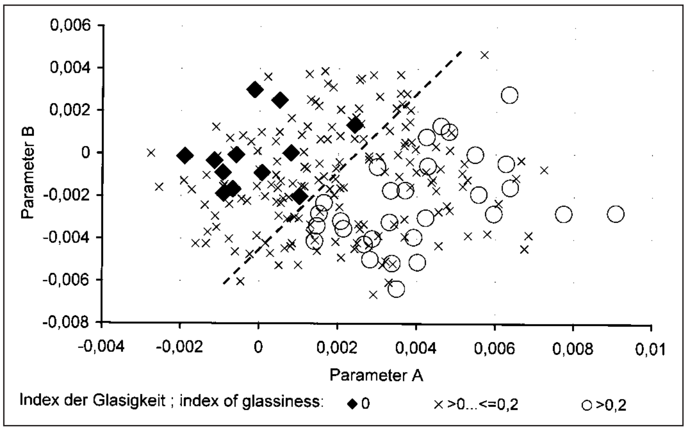

Fig. 3: Diagram of spectral optical parameters to distinguish between glassy and healthy onions (0 – sound; >0...<=0,2 partially glassy; >0,2 glassy), a symbolic dividing line is placed between glassy and onions without defect

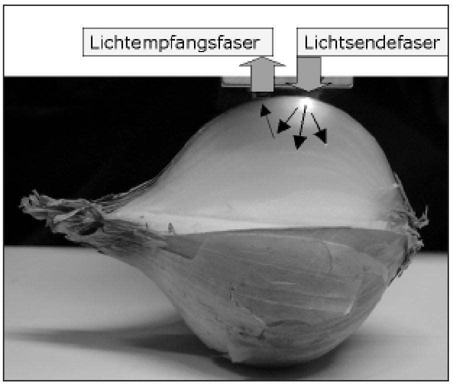

Fig. 2: Glass-fibre probe for partial light transmission on bulb onion

Outlook

The distinction of sound and glassy onions requires a quantifiable definition of glassiness, which can be handled by a subjective evaluator and is adapted to objective detection techniques as well. The index proposed in this study is an intital basis.

Spectral-optical measurements seem promising for the fast, destruction-free determination of the glassiness of bulb onions. A high correlation between the index visually determined after the onion has been cut open and parameters established without destruction through spectral-optical measurements has been shown. Available results could be improved through

- adaptation of the glass-fibre probe, especially stronger light transmission through the entire onion;
- expansion of the examined spectral range to include larger wavelengths.

In order to create a simple indication technique for the evaluator, the possibility of mechanical examination should be studied as well.

Table 1: Visual assessment of glassiness of the studied bulb onions (for every bulb the average from both measuring points was determined, then the bulb was graded into one of three groups)

description of glassiness	threshold of grading	sample 1 (glassiness suspect)	sample 2a (glassiness suspect)	sample 2b (seeming sound)
sound	= 0	5	2	5
partially glassy	<= 0,2	82	81	5
glassy	> 0,2	13	17	0
Total number of onions		100	100	10

Literature

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