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Quality monitoring in the fruit container

Modern fruit storage as well as transport over land and in cargo ships take place in sealed, often gas-tight containers within which there is up until now no way of directly checking quality of the fruit. Transportable „electronic noses" could be of help here with this new technique enabling rapid reaction to avoid losses from over-ripeness and rotting.

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Keywords

Storage, quality inspection, transport, non-destructive detection

Literatur

[1] *Friedrich, G. et al.*: Physiologie der Obstgehölze. Springer-Verlag Berlin Heidelberg New York Tokyo, 2. Auflage, 1986
[2] *Correa, E.C. et al.*: Use of a QCM electronic nose to evaluate the aromatic quality in apples. In: Zude et al., Fruit, Nut, and Vegetable Production Engineering, Proceedings of the 6th Int. Symposium, Institut für Agrartechnik Bornim, 2002

Storage and transport quality penalties with fruit and vegetables often lead to high losses. The storage of so-called climacteric fruits, which feature a further ripening development post-harvest with associated high metabolic activity, is especially critical [1]. Through their continued ripening (*fig. 1*) the sensitive products are susceptible to very rapid changes. Suitable methods for safeguarding the quality would not only minimise economic damage through over-ripeness or spoilage but also help relieve the environment in two ways: firstly by saving the waste of inputs in producing the fruit and secondly the efforts exerted in disposing of the damaged ware.

One solution could be through characterising the monitoring process by monitoring air within the fruit container. In the ripening process it is possible to identify changes in gas exchanges from fruit and vegetables (carbon dioxide, ethylene, aromatics....) in the surrounding atmosphere, although up until now the instrumentation involved has been very expensive.

In recent years, however, a series of different measurement methods have evolved for cost-efficient analysis of complicated gas mixes for industrial purposes and for measurement of biological material. These have gained increasing prominence under the description „electronic noses". For securing quality in fruit and vegetables an innovative sensor Multigas-SENSORiCCARD® (JENA-SENSORIK e. V, Jena) is being tested currently at the ATB for its suitability in characterising the metabolic process and the product quality. In the first place the atmosphere in a cuvette with fruit is being tested under laboratory conditions. Also in the cuvette is an „electronic nose" along with different highly sensitive gas sensors servicing as reference instruments. The visiting card sized multigas-sensor comprises a sensor measurement head with three semi-conducting SnO_2 layers of different capacity and two integrated platinum heaters (*fig. 2*) for heating the sensor layers from around 50 °C up to 400 °C. Also included: control and measurement electronics.

Gas molecules of different atom construction and resultant partial charges react to different extents on the surface of the sensor layers and influence their electrical conductivity. The resultant changes in sensor resistance are recorded. A measurement cycle lasts around one minute and includes a once-only heating of the three sensor layers.

Calibration

Depending on the gas mix in the space around the fruit, specific measurement signals or measurement signal series are recorded. Applied for evaluation are mathematical object identification methods whereby the measurement signals of all three sensor layers are used over the temperature range from around 200 to 400 °C. The signal characteristics allow a monitoring of alterations

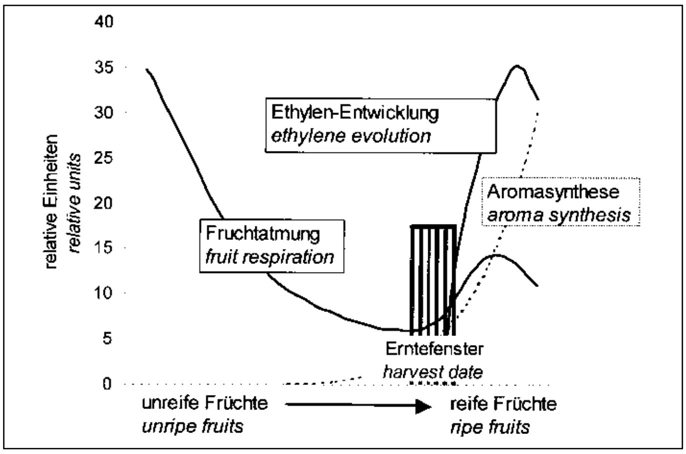

Fig. 1: Schematic view on the fruit development of apples with climacteric fruit ripening course

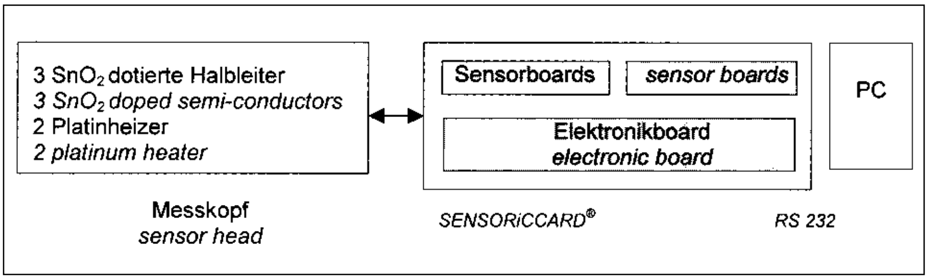

Fig. 2: Schematic view of the Multigas-SENSORiCCARD®.

in the cuvette atmosphere. Test results showed that calibration based on purest substances (fruit aromatics) introduced to a cuvette interior (*fig. 3*), as well as the identification of different ethylene concentrations, is possible with the help of the sensor.

The possibilities for application in enclosed storage or transport containers appear promising. Temperature, relative air moisture and the unexpected presence of volatile substances which may make more difficult the stable calibration of „electronic noses" in other application areas so far [2], appear only to a foreseeable limited extent in gas-tight containers and can be catered for in the calibration or minimised through corrective algorithms. Thus, e.g., a temperature influence is determined on the measurement signal of the multigas-sensor in a cuvette filled with synthetic air with a 4 K temperature increase. The processing of the measurement results took place over the measurement values of the sensor coatings from 200 to 400 °C. The temperature dependability of Multigas-SENSORiCCARD® was able to be eliminated with a suitable corrective function. Additionally, however, the product showed a temperature related reaction regarding the gas exchange rate of volatile fruit substances. A suitable corrective algorithm is currently being investigated with the help of parallel measurements by the „electronic nose" and the aromatic concentration in the areas around the fruit during varying temperatures. Aromatic-chromatograms, recorded at different temperatures show the non-linear dependability of the individual volatile substances recognisable in the illustration through the different changes in peak values (*fig. 4*). For robust application of transportable „electronic noses" in practice under varying environmental conditions, appropriate corrections to the measurements would be required. The first trial series on this are being carried out by the ATB in cooperation with the FG Fruit Production, Humboldt University, Berlin.

Outlook

The sensitivity of the „electronic nose" with regard to tested fruit aromatics and ethylene basically allows a monitoring of the continuing ripening process of fruit. Such an application would enable a first direct measurement of fruit ripeness development in a gas-tight sealed container or fruit store in practical conditions.

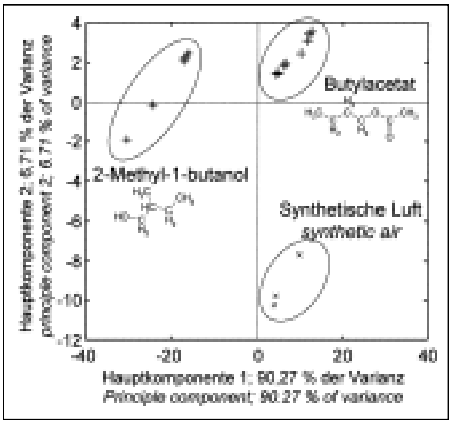

Fig. 3: Recognition of different fruit aromatics after 20 min measuring period, using component analyses

A stable calibration of sensors depends, however, on good repeatability being achieved in fruit ripeness determination. In this aspect a large number of trials are being conducted at the ATB currently on the influence of surrounding conditions as well as sensor stability (zero point drift, ageing of sensitive surfaces, housing construction).

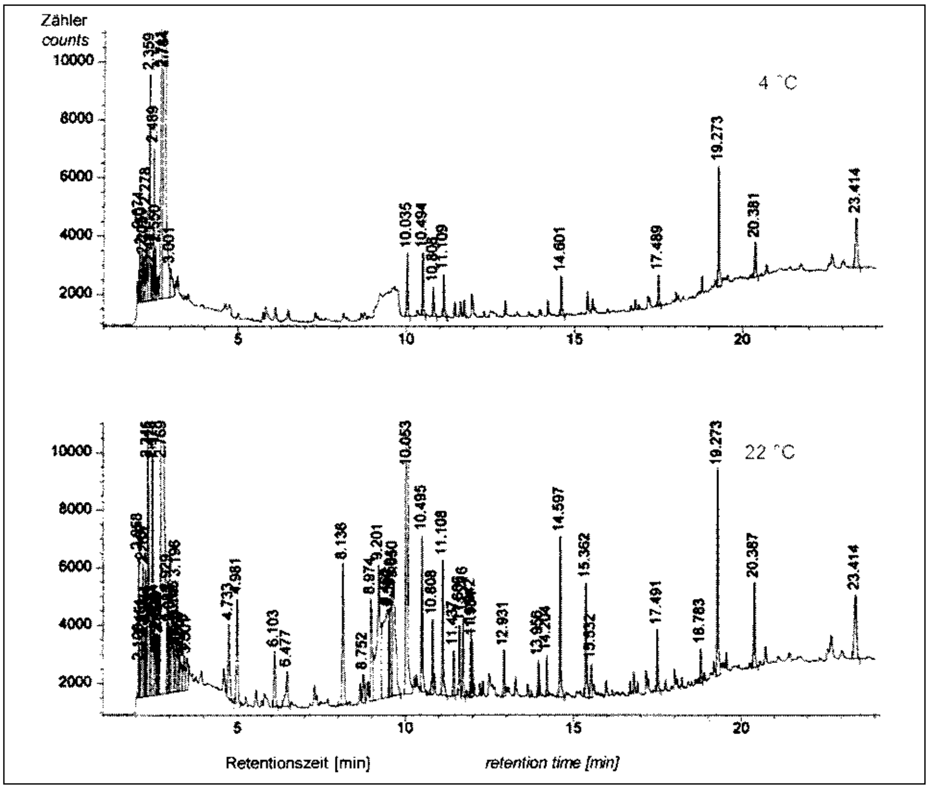

Fig. 4: Headspace analyses of stored apples at 4 °C (above) and 22 °C (below) recorded by gas-chromatography