Manfred Linke and Martin Geyer, Potsdam

Monitoring the Postharvest Behaviour of Fruit and Vegetables through Evaporation Devices

On their way from the producer to the consumer perishable horticultural produce frequently loses too much water, as a result of unfavourable environmental conditions. The principle causes are material transmission conditions from temperatures, air humidity and air flow close to the produce surface. Effective control of material transmission under practice conditions is almost impossible. In the study newly developed simple test devices are presented, which have transpiration properties similar to horticultural products. They make it possible to exert an active influence on unfavourable environmental conditions in the postharvest chain.

Manfred Linke is scientific employee in the Dept. of Horticultural Engineering (head Dr. Martin Geyer) of the Leibniz- Institute for Agricultural Engineering (acting scientific director: Prof. Dr. R. Brunsch), Max-Eyth-Allee 100, 14469 Potsdam-Bornim; e-mail: *mlinke@atb-potsdam.de*

Keywords

Horticulture, process control, postharvest chain, transpiration loss

Literature

Literature references can be called up under LT 07322 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

In principle postharvest changes in freshness of fruit and vegetables can be subdivided into respiration losses (internal compounds as vitamins, minerals, bio-active substances) and transpiration losses (water losses) [1]. The primarily temperature dependent losses of internal compounds are controlled increasingly with common, commercially available temperature data loggers. In contrast, no simple tools for the process control exist for transpiration losses, which predominantly are dependent on the partial pressure difference of water vapour between the produce surface and the environment.

The transpiration intensity is affected by both the state of the produce and the environmental conditions, whereas the actual state of the produce is characterised by preharvest parameters as well as postharvest climate components. The permeability of the tissue layers can show considerable differences through natural variability (plus preharvest climate conditions, fertilisation, irrigation). Next to these water losses directly associated with the state of the produce losses occur in consequence of the climate conditions in the postharvest chain. The flow conditions close to the produce surface, the air humidity in the surroundings and if applicable appropriate heat radiation affects the intensity of the mass transfer. The interaction between the produce and the environment normally becomes restricted by artificial transpiration resistances (packaging materials, films) and additionally through a certain self-protective function (superposition of boundary layers of several produce items) [2].

With changing external air movement, mainly as the result of the variety of forms and shapes of fruits and vegetables, complicated flow conditions at the produce surface are existent, which can have a strong influence on the water loss depending on the product state and the other climate parameters. The great number of influencing variables can be controlled with traditional test equipment for the temperature, air humidity and air velocity measurements only then effectively, if it is assumed, that forced airflow is almost completely restricted.

For the mentioned reasons at the Leibniz-Institute for Agricultural Engineering Bornim specific atmospheric evaporation devices with similar transpiration behaviour as real produce items were developed to get more detailed information about the mass transfer between the produce and the environment.

Material and methods

Essential feature of these test devices, realised through corresponding material selection and constructive design, is that water loss rates can be set in relation to the behaviour of real products. They control the influencing of the compound boundary layer between products and environment. The atmospheric evaporation devices always consist of a water holding material and one or more shells, which restrict the water loss. They are to be designed from their main dimensions so that they either are small in relation to the products to be controlled or have the form and shape of the product itself.

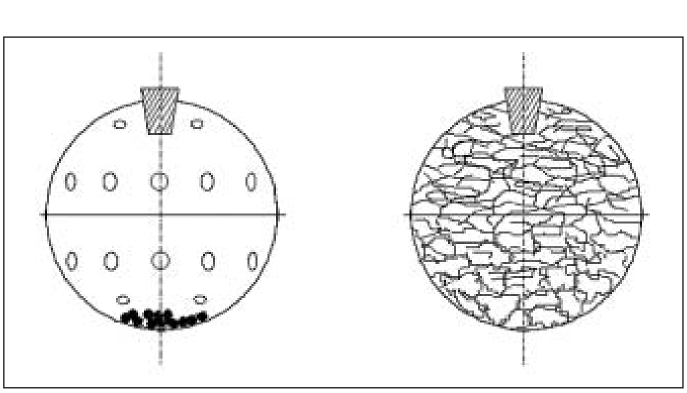

Fig. 1: Scheme of an evaporation sphere with waterholding material (right: dry; left: wetted)

The principle of operation of the atmospheric evaporation devices for the characterisation of the environmental conditions of perishable fruit and vegetables is based on the known diffusion laws [3]. The transpiration rate out of the product into the surrounding air is dependent on the concentration difference (absolute air humidity) and the resistances in the water vapour pathway (tissue, boundary layer, packaging material).

Such test equipment represents a cost-effective solution for the acquisition of postharvest treatments due to transpiration processes. A test device mainly consisting of water holding material is dimensioned showing similar transpiration properties as the horticultural produce to be controlled. For this reason there is an opportunity to change technical parameters (climate parameters, protection qualities of packaging units and other), and/or technological processes (air flow and control regime in storage rooms, transportation conditions, conditions during the product presentation and other) in such a way that losses of freshness can be minimised.

Taking an atmospheric evaporation sphere as an example, which is used for the supervision of the environmental conditions of fruit and vegetables in different packaging units, both some constructive details and methodical aspects of the development and the application are supposed to be represented.

The schematic construction is shown in *Figure 1*. A plastic hollow sphere from the size of a table tennis ball was equipped with a filler hole and many smaller openings and was filled with a water storing granulate material (polyacrylamide). The granulate material can be filled in dry or into soaked state in the hollow sphere.

At the beginning of comparative measurements the sphere shut with a stuffing should have taken up water amounts as similarly as possible. Attention must be paid to the fact that no free water - neither in form of droplets nor as film - is existent. In preparation for the measurement it is additionally important that the atmospheric evaporation sphere and the surrounding air are in thermal equilibrium (air temperature = sphere temperature).

The number and the diameter of the openings are calculated in such a way that the sphere shows a similar transpiration behaviour as the product to be examined in the case of defined environmental conditions (e.g. unrestricted free convection).

If radiation influences are to be expected, the surface of the test device should show a similar emissivity as the product to be examined.

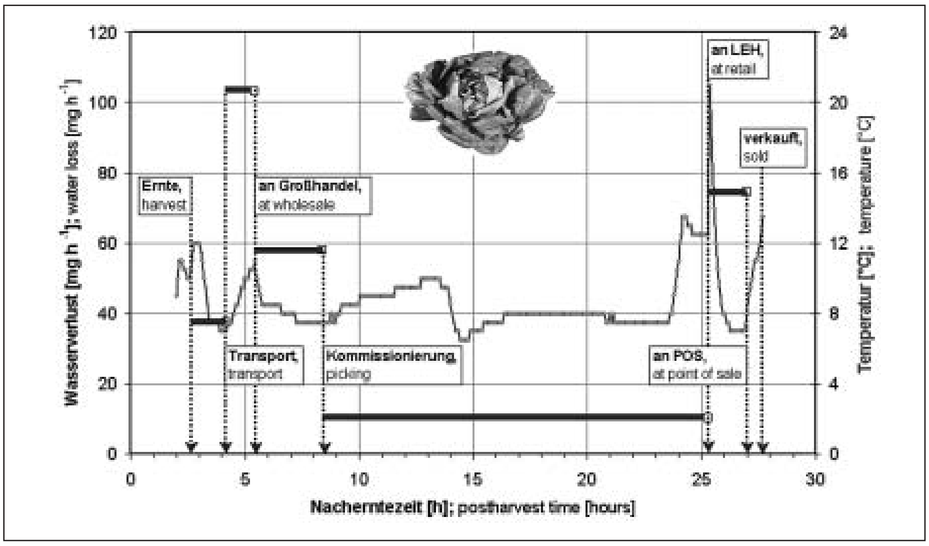

Fig. 2: Control of the climatic loads of lettuce in the postharvest chain by means of temperature devices and evaporation spheres

In the easiest case determined water loss of the test devices - as a result of differences in weighing in defined time intervals - can be used for the characterisation of the environmental conditions. These water losses (e.g,. per time and surface unit) includes the mass transfer coefficient (boundary layer resistance) and the effective potential difference (difference in water content between product and environment).

When the environmental conditions (air temperature, air humidity) in sufficient distance to the test devices are recorded, in addition more detailed specifications for the conditions at the point of measurement are possible from the water loss. Of special interest are the flow conditions close to the produce surface, which cannot be captured virtually with conventional measuring equipment.

Results and discussion

The above described atmospheric evaporation spheres, complemented with commercially available miniature data loggers, were applied within the scope of extensive investigations for the exposure of weak points in the postharvest chain of vegetables. *Figure 2* shows real climate treatments of head lettuce in a standard packaging unit on the way from the producer to the consumer that were determined with temperature data logger and atmospheric evaporation sphere. The objective of the investigations was to locate weak points in the postharvest chain [4]. For this purpose a sphere and a data logger were placed in the packaging (plastic container) in immediate proximity to the head lettuce (in the area of the boundary layer). While the temperature values were being recorded continuously over the entire measurement period, the evaporation spheres were to be exchanged at the before agreed checkpoints.

In the represented example both the sections transportation to wholesale and presentation in food retail show high water loss rates of the test devices. These indicate that in these sections the relative air humidity (too low) and/or the air flow close to the produce (too high) must have reached improper values. In addition the great difference in wholesale is noticeable in a total some lower level. Here the conditions are considerably more unfavourable in the region of incoming goods department than in the picking area. About the knowledge of the water loss of the spheres, active measures can be taken to improve the unfavourable environmental conditions. Possible countermeasures would be avoidance of cold draught appearances, changes of the air humidity and/or increasing the artificial transpiration resistances (foliation of the stacks or covering with transmissible films).

So and with similar measures quality maintenance can be attained with simple measuring equipment. Atmospheric evaporation devices are on one hand very much economical, on the other hand relatively sensitive weighing is necessary. For more precise analyses (e.g. on the basis of the mass transfer coefficient) the environmental conditions in sufficient distance to the produce surface (air temperature, relative air humidity) additionally have to be measured and the corresponding calculations have to be carried out using the known thermodynamic relationships of psychrometry [5].

The atmospheric evaporation device can be used also for the monitoring other fresh market products and in combination with temperature /air humidity measurements controlling flow conditions in rooms with great dimensions (among others warehouses, greenhouses, animal houses). Plant populations in outdoors can be controlled if a rain protection is installed.