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Active Transponder Technology in the Post-harvest Chain for Fruits and Vegetables

Capacity features and operation criteria of active transponders for the process control of fruits and vegetables are discussed here. Such systems measure the thermal stress on the harvested products and are simultaneously a medium for transmitting the information along the post-harvest chain. Correspondingly diverse possibilities for quality safeguarding of high-value fruit and vegetables arise. Basically detailed consumer information, as well as data on traceability can be provided.

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Keywords

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Fresh fruits and vegetables are limited in shelf life after harvest even under optimal storage conditions. Higher temperatures accelerate the loss of important ingredients. Lower air humidity and strong air current lead to undesired wilting. High air humidity in connection with high temperature support microbial growth and thus cause faster deterioration of the product. Main interest of the actors along the postharvest chain from the producer to the consumer is therefore to know, at which stage (producer, transport, wholesale, transport, retail) important losses arise, so that effective counter measures can be taken. The demand for comprehensive traceability along the value-added chain is growing, especially within the particular sensitive segment of food production.

Temperature-time information for quality control

To examine relevant process cycles small technological units have been available for a short time, which can be fixed on the packaging. Active transponders, which have approx. the dimensions of a credit card, measure temperatures in selectable intervals and store the obtained data. Similarly to price scanner systems additional information about the product (e.g. origin, harvest date etc..) can be saved on the transponder card by certain write/read units. Active transponders operate like complete, simply arranged data loggers with analogue input for temperature measurement. Additionally, radio wave technology (RFID, Radio frequency identification) allows non-contact transmission, i.e. writing and reading, and storage of user and produce specific data on a data memory. While the required energy for data transmission is generated from radio waves of the write/read unit via antennas, the energy for internal processes on the sensor card (including temperature measurement) is provided by a transponder integrated paper battery. The economic life-time of the battery is determined by the specific measuring requi-

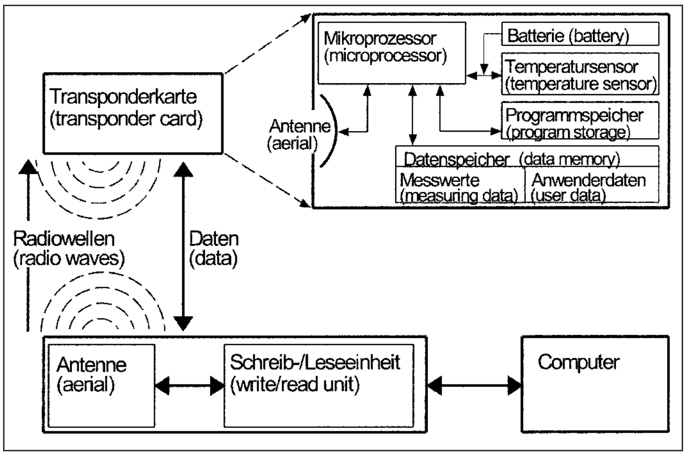

Fig. 1: System components of active transponders

Table 1: Efficiency parameters and fields of application

dimensions:	storage capacity: 64 temperature-time data sets, alternatively 48 temperature-time data sets and other relevant produce facts (encrypted)
frequency:	13.56 MHz
data access	write, read, write protection
maesuring interval:	adjustable between 5 s and 43200 s (12h)
measuring accuracy:	± 1 K (within a 20 K range of application)
measuring range:	-20°C to +50°C
measuring range:	2 limit values (without recording temperatures)
battery life time:	~ 10 month (depending on usage and environmental conditions)

Fig. 2: Transponder card, write/read unit and host computer in operation with temperature control of carrots

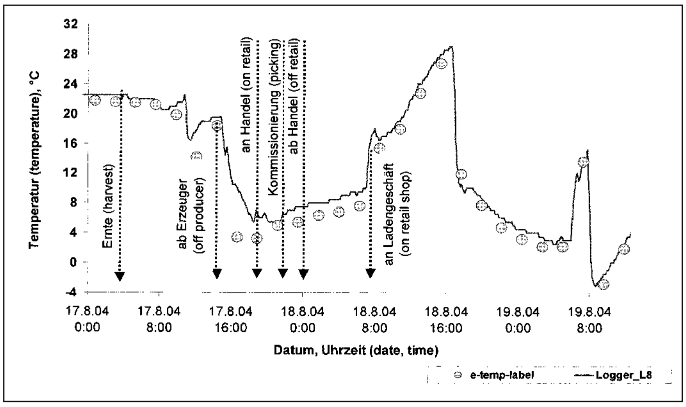

Fig. 3: Thermal postharvest treatment of broccoli on it's way from the producer to the consumer, recorded parallel with the datalogger (—) and with the active transponder (O)

rements and also by external parameters e.g. operating temperature and mechanical load.

Performance parameter and fields of application

The presently available systems are in an early phase of entering the market, so it can be expected that the performance parameter specified in the following *table 1* are gradually extended and improved. At present the available software focuses on special operational fields of application (e.g. monitoring of the temperature regime during the transportation of blood or drugs) and is therefore, in its existing form, applicable for quality control of perishable products with strong restrictions. For future applications appropriate software must be developed, especially considering the handling of additional information (kind, content, coding, write/reading authorisation).

Quality maintenance with active transponders

At the Institute of Agricultural Engineering Potsdam-Bornim (ATB) investigations on quality assurance of fruit and vegetable are carried out, which focus on the evaluation of relevant transponder systems under practical conditions. At first functional questions, like the reliability of the temperature measurements and the life-time of the battery under changing site conditions, were investigated. An innovative approach is based on the determination of the thermal load of a product indicated by the temperature sum, and the simultaneous availability of different product and process information along the postharvest chain. From the temperature sum, the degrees of internal quality degradation can be estimated and predicted. Additional information of cultivation conditions (soil, climate, harvest date, etc.) and data concerning the temporal and spatial allocation of the measured temperature levels along the postharvest chain allow to analyse weak points and thus to improve the quality maintenance. A typical application of the new transponder technology for fruit and vegetables in postharvest is the monitoring of the fresh products on their way from the producer to the consumer. For most products the relevant monitoring time will not exceed one week. Regarding the present technological parameters (e.g. life-time of the battery) about 40 cycles of the transponder unit can be achieved. Further economic considerations include the assumption of cost reduction in the near future. At present the re-usable transponder is offered for a prize of approx. 10 €. Such miniaturised data measurement systems offer various possibilities for the quality and safety issues when producing high-quality fruit and vegetables. At the same time both more detailed consumer information and required data to guarantee traceability can be provided. In *figure 3* the measured temperature values along the postharvest chain of organic grown broccoli are shown, using an active transponder (Schreiner LogiData). Additionally, a miniaturised datalogger (Meilhaus) was used to measure temperature changes within a 10 minutes interval. Setting the measuring interval to two hours the process can be monitored from the producer to the consumer (producer, transport, wholesale, retail) for a period of four days. Processing steps, whose duration is shorter than the measuring interval, cannot be exactly monitored when applying the configuration as mentioned before. Nevertheless it is clearly indicated that the active label sensor enables temperature measurement even with strong temperature fluctuations (e.g. in retail, presentation at high temperatures and subsequent cooling). For this investigation write/ read operations were performed only at the beginning and at the end of the processes of interest. With the arrangement of several write/read units more than 48 temperature time data pairs can be determined (by reading and removing the data from the memory). For such purposes reading/writing authorisations must be assigned and the data handling must be organised appropriate along the chain. This is also helpful, since many postharvest chains are more extensive than the chain represented in the example. Thus also shorter process sections (e.g. transport less than 1 hour) would be checkable.

Application possibilities in fruit and vegetable production

Based on simple shelf life prediction models, future applications should result in availability of information about degrees of quality deterioration at each step of the postharvest chain for further uses. Such models were developed at the ATB and are already available for selected products.

Beside the application for fresh marketed products, according to the authors opinion, probably of main interest are various other practical applications of the active label sensors in fruit and vegetable processing e.g. in processing of convenient products as iready to eat saladsî etc. However, to handle the obtained information, further adaptation (also for product similarity) will be necessary since their structure along the postharvest chain is not the same and relevant participants partly have opposite objectives.