# Sensors and Modelling in Postharvest Packaging and Storage of Fresh Produce

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Association

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Leibniz Institute for Agricultural Engineering & Bioeconomy (ATB) Potsdam, Germany



- Non-university research institution
- About 250 staff members, interdisciplinary working groups
- ATB acts in close collaboration with universities, agriculture / horticulture industry
- Partner in National / International Networks
- Average 120 publications per year in international journals
- Excellent scientific infrastructure (labs, pilot plants, experimental fields)



# WG: Packaging and Storage



#### Group Leader: Dr. Pramod V. Mahajan



### **Respiration Sensor**

- Portable and compact design (diameter: 88 mm)
- Fluorescence based optical O<sub>2</sub> sensor
- Two non-dispersive infrared absorption CO<sub>2</sub> sensors
- Temperature and humidity sensors
- 2 batteries 4V 900mAh
- Real time clock
- Data memory
- Software and data handling (interval 1 to 60 minutes)
- Wired data transmission via mini USB port
- Wireless data transmission



Ref: Keshri, Mahajan, et al. Computers and electronics in agriculture 157 (2019): 322-328.



Conceptualized and developed by ATB



#### **In-situ Respiration Measurement**

### Air-speed Sensor

- Sensor adapted to apple size
- Sensor element (Silicon diode) in the middle
- Non-directional air-speed measurement
- Range 0 to 1.5 m/s





#### Conceptualized and developed by ATB



Common bin wall

Modified bin wall



#### Air-speed within bin





Geyer et al., 2018. Measuring device for air speed inside apple storage bins. Sensors

### **Condensation Sensor**

- Two electrically conductive material (titanium film)
- Self-adhesive film on apple surface
- Measures moisture on fruit surface





Conceptualized and developed by ATB

- High humidity (> 90%), temperature fluctuations.
- Cooling and defrosting cycles.
- Condensation on fruit surface: occur due to temperature falling below dew point.
- Surface moisture: microbial growth and overall quality.

Linke et al., 2023. Water vapour condensation in CA storage.... Sensor.

### Heat-flux Sensor

- Peltier element: low-cost, small-sized.
- Peltier element: two thin plates usually of alumina ceramic and semi-conductor material.
- When there is a temperature difference between the two ceramic plates, an electrical voltage is induced, resulting in a current flow.



To investigate real-time monitoring of the heat exchange between horticultural product and the surrounding air during cold storage.



Hoffmann, Mahajan et al., 2023. Computer & Electronics in Agriculture

### MAP: Modified Atmosphere Packaging





#### Systematic study to compile database in ready-to-use format >> Optimal atmosphere (O<sub>2</sub>, CO<sub>2</sub>) Storage >> Storage temperature Database Adopted by several companies New release: humidity, condensation, shelf life >> Respiration rate **Product** Code freely available to download!!! >> Product density $>> O_2$ , CO<sub>2</sub> permeability Package >> Diffusion through micro-perforations >> Package geometry and size Jalali & Mahajan et al., 2021

- $\checkmark$  Mathematical algorithm to select the film, size & number of micro-perforations
- $\checkmark$  Mass balance equations to simulate package atmosphere

(Mahajan et al., 2007)

✓ Monte Carlo simulations to evaluate impact of product/package variability

### Modelling Approach: Perforation Optimisation



Source: Rux et al., (2016). Effect of perforation-mediated modified atmosphere packaging system on the quality of rucola. Acta Horticulturae. (1194)

### Modelling Approach: Shelf-life prediction



#### Plastic packaging has an important protective function

### Cucumber Story in Europe: No plastic wrapping = more food waste



One cucumber waste = 93 plastic cucumber wraps = same environmental impact **Plastics packaging prevents CO<sub>2</sub> emissions by preventing food waste** 

Shrivastava et al., 2022. To wrap or not t wrap cucumbers. Front. Sustain Food Syst.

#### **Food Loss and Waste**



Braunschweig: Johann Heinrich von Thünen Institute, Thünen Rep 71 (2019)

#### **German National Strategy for Food Waste Reduction**

The German Federal Ministry of Food and Agriculture (BMEL)

DO YOU ONLY GO FOR YOUNG

The BMEL launched *Too good for the bin!*, focused on the public's attention on the issue of food waste.



#### https://www.zugutfuerdietonne.de

#### German National Strategy for Food Waste Reduction



- The aim is to halve per-capita food waste in Germany by 2030.
- It is being considered whether legislative changes are required in order to <u>make the strategy more binding</u>.
- The BMEL is examining <u>tax breaks and benefits</u> under liability law in order to further <u>facilitate food donations</u>.

# www.sirplus.de

Start-up Company in Berlin

SIRPLUS is an online supermarket where you can order food that producers and wholesalers can no longer sell.



Send food to your home by post

Founder: Mr. Raphael Fellmer

Excess food is returned to the cycle, which in turn reduces food waste.

#### **Sensor + Modelling: Current Projects**

Fruity-Twin **Digital twin for condensation management during cold storage of fruits** 

Joint-Lab Fruit sensor & data analytics for in-situ monitoring of respiration of apples in DCA storage

DyNa<sup>†</sup>Cool **Transformation of cold management & refrigeration of fruit storage** rooms into the digital age and energy reduction

Mini-CA box Low-cost model-based electronic control device for storage and transport of fresh produce under modified O<sub>2</sub> and CO<sub>2</sub> atmosphere









## **Opportunities @ATB, Potsdam, Germany**

- Short visit
- Full PhD scholarship
- Post doc fellowship
- Collaborative project
- Joint publication

Thank you / Vielen Danke

