PTR-MS applications inside the SISTERS project – Preventing food loss and waste of fresh vegetables by monitoring quality decay through VOCs emissions

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Co-funded by the Horizon 2020 programme of the European Union

GA 101037796

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Background

Vegetables and fruits account for almost half of the total food loss and waste (FLW) globally [1] due to their perishable nature and quality decay after harvest which may compromise consumers' freshness perception. Inside the SISTERS project, a smart container - the BulkBox (BB) – has been developed to **reduce food losses and quality degradation** during transportation and storage by exploiting passive modified atmosphere and a sensor kit to monitor products' conditions in real time. In this work, BB performance was compared to regular transportation conditions by combining sensory and instrumental measurements on different fresh products (*i.e.* mushrooms, bell peppers and apples) including water loss, dry matter, texture parameters, color, appearance and volatile organic compounds (VOCs). VOCs emissions were monitored by combining proton transfer reaction mass spectrometry (PTR-MS) and gas chromatography mass spectrometry (GC-MS) during products' shelf life.

Material and methods

A pilot experiment with **apples** (cv Gala) was used for comparing different methods for sampling VOCs from the BB: syringe-vials coupled to the autosampler (measured immediately and after storage at -80°C), Tedlar bags and gas canisters (Figure 1). Performance was compared in terms of mass peaks detected, repeatability and concentrations.

Two other experiments were conducted with ***Agaricus bisporus* and bell peppers** (cv Lamuyo). After receiving 2 BBs and one standard pallet (STD) with fresh products from Spain, shelf-life experiments were conducted at refrigerated (T=2-7°C, RH=90-95%) and ambient conditions (T=20°C). Respiration rates (RR) and headspace (HS) analysis were performed. For RR, products were incubated in a 1 L glass jar hermetically closed for 30 minutes before measuring. After the incubation all samples were measured with a PTR-ToF-MS 8000 apparatus (Ionicon Analytik GmbH, Innsbruck, Austria) with H3O+ as primary ion. The Selective Reagent Ion mode was also used with O2+ as primary ion mode to collect data about ethylene emissions. Moreover, CO2 production rate was determined by measuring CO2 (Li-Cor, Nebraska USA) before and after incubation.

Results

1. Sampling strategies:

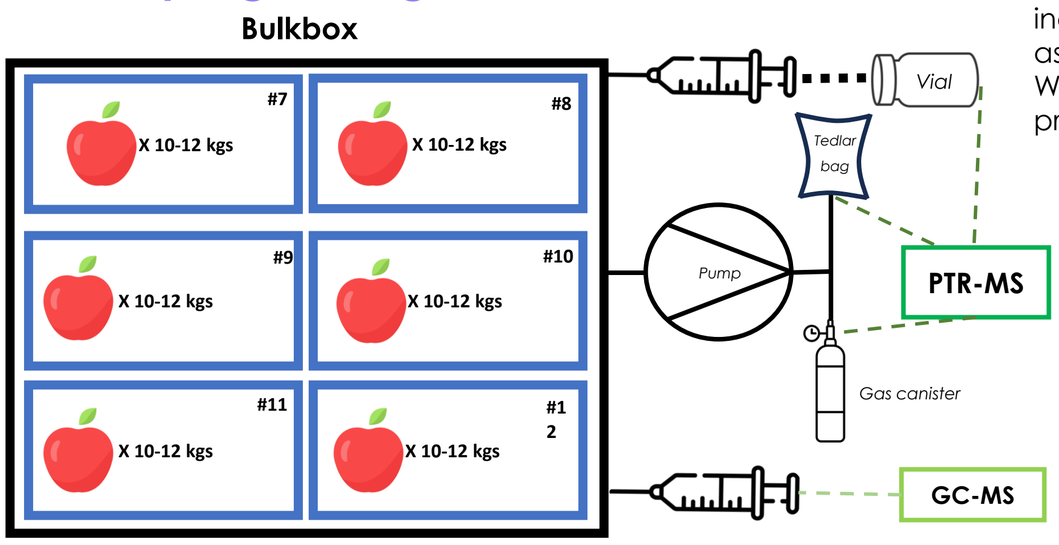

Figure 1 : *Sampling strategies. GC-MS sampling was performed by SPME fiber. For PTR-MS, a pump was used to fill Tedlar bags and gas canisters. Vials were filled by a syringe and measured immediately or after storage (-80°C)*

- Sampling with the gas canister performed poorly in comparison to the other two methods (Tedlar bags and syringe-vials methods) both in terms of VOCs concentrations and repeatability. Tedlar bags and vials showed a similar performance for different mass peaks including m/z 33.034 (methanol), 117.089 (mix of esters) (Figure 2) and other mass peaks associated with as the most important esters in the apple aroma of different varieties [2]. When frozen, the vials showed a slightly worse performance in terms of VOCs concentrations, probably due to evaporation and condensation.

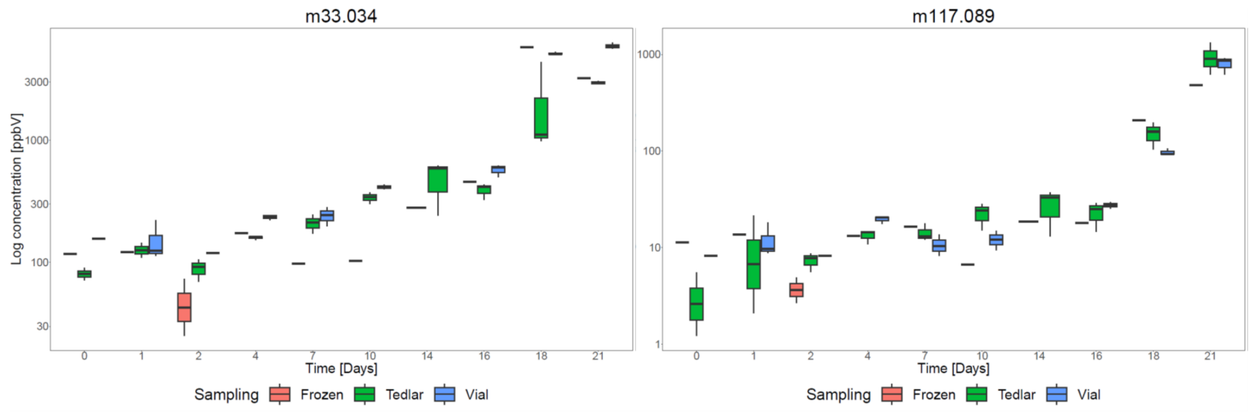

Figure 2: *Boxplots with the average concentration of m/z 33.034 (methanol) and 117.089 (mix of esters including ethyl butanoate, ethyl hexanoate, butyl acetate and isobutyl acetate) for the different sampling methods (Tedlar bags, syringe-vials and syringe-vials stored at -80°C during shelf life.*

2. Respiration rates:

- In terms of CO2 production (Figure 3), the BB had an effect in reducing peppers respiration rates during refrigerated shelf life after the first week of storage. This, in combination with reduced dehydration due to a better humidity retention, lead to a superior quality and freshness of BB peppers. Peppers quality and freshness was checked by both instrumental and sensory analysis.

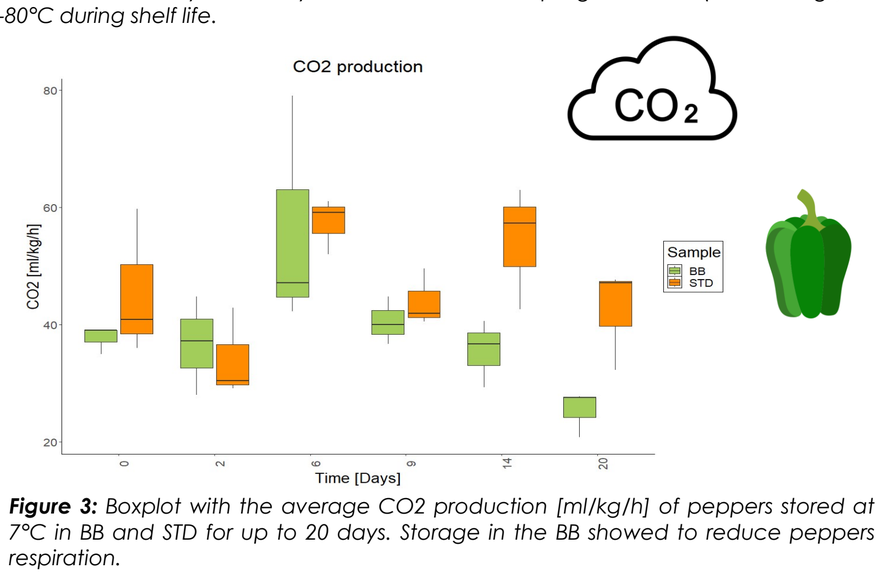

Figure 3: *Boxplot with the average CO2 production [ml/kg/h] of peppers stored at 7°C in BB and STD for up to 20 days. Storage in the BB showed to reduce peppers respiration.*

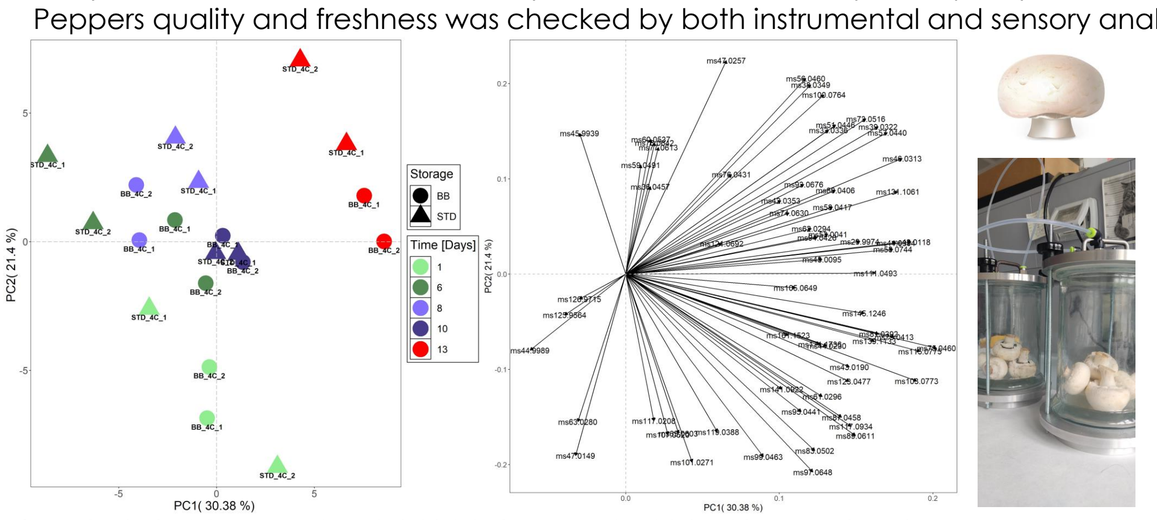

Figure 4: *Principal Component Analysis biplot of mass peaks obtained from Agaricus Bisporus stored at refrigerated temperature (4°C) and high RH (≈90%) for almost two weeks.*

- The PTR-MS analysis highlighted that during the refrigerated shelf life, differences in terms of VOCs emissions emerged between mushrooms stored in the BB and the STD (Figure 4).

Conclusions

The BB showed promising results as a possible solution to better preserve bell peppers quality along the food supply chain. PTR-MS was successfully applied to monitor VOCs emissions during the shelf life of bell peppers, mushrooms and apples. In combination with sensory analysis and more classic analytical techniques like GC-MS, the technique is a valid tool for evaluating fresh products quality and BBs performance which depends on the respiration rates and the physiological characteristics of each product.

References

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