Preserving freshness by smart logistics: PTR-MS applications to monitor bell peppers quality decay through VOCs emissions

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1. Background

Sweet peppers (Capsicum annuum L.) are an important food crop internationally, highly appreciated for its tasty flesh and peculiar long shape. When stored at their optimal conditions (7-10°C, 95-98% RH), bell peppers have a relatively long shelf life (approx. two to three weeks) [1]. Despite of this, the annual losses are estimated to be 40% [2] mainly due to quality degradation such as shriveling associated with water loss. Inside the project "SISTERS - Innovative systematic interventions for a sustainable reduction of food waste in Europe" (Horizon 2020, Grant Agreement No. 101037796), 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 the implementation of a sensor kit to monitor products' conditions in real time (*e.g.* CO2, O2, temperature and relative humidity).

In this work, different quality indicators, including volatile organic compounds (VOCs) emissions were monitored to validate the BB efficacy in better preserving the freshness of green sweet bell peppers (cv. Lamuyo) than conventional approaches during bulk transportation (Spain – Ita) and shelf life. BB performance during shelf life was compared to regular transportation conditions by combining sensory and instrumental measurements of bell peppers including water loss, dry matter, texture parameters, color, appearance and VOCs emissions by PTR-ToF-MS and GC-MS.

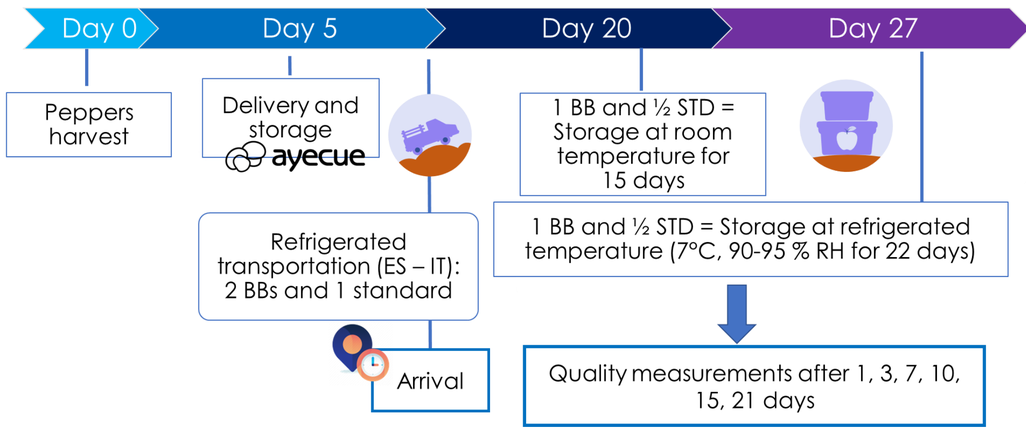
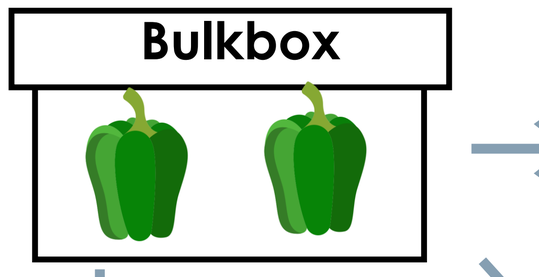


Figure 1: *Experimental design scheme of the 3 experiments including harvest of bell peppers in Spain, storage, refrigerated shipment to Italy and shelf-life storage at 7°C (refrigerated) and 20°C (ambient). During the shelf-life test quality changes were monitored by combining both sensory and instrumental measurements, including VOCs measurements with both PTR-MS and GC-MS*

2. Material and methods

Three different experiments were organized according to the scheme showed in Figure 1. Two different types of PTR-TOF-MS measurements were realized during the shelf life: respiration rates (RR) and headspace (HS) analysis. For RR, 3 peppers were sampled and after 3 hours at room temperature for equilibration, they were incubated 30 minutes in a 1 L glass jar. For HS analysis, samples were collected, grinded into frozen powder by using liquid nitrogen and conserved at -80°C. Samples were inserted into 20 mL glass vials together with an antioxidant solution before being measured through an adapted GC autosampler (MPS Multipurpose Sampler, GERSTEL). All samples were incubated at 40°C for 25 minutes for HS equilibration, then measured for 50 seconds with an acquisition rate of 1 spec/sec. All the measurements were performed with a PTR-ToF-MS 8000 apparatus equipped with an ion funnel (Ionicon Analytik GmbH, Innsbruck, Austria) with H3O+ as primary ion. The Selective Reagent Ion mode was used with O2+ as primary ion mode to measure ethylene emissions during the RR measurements. Data deadtime correction, internal calibration and extraction were performed with TOFOffice.

3. Results

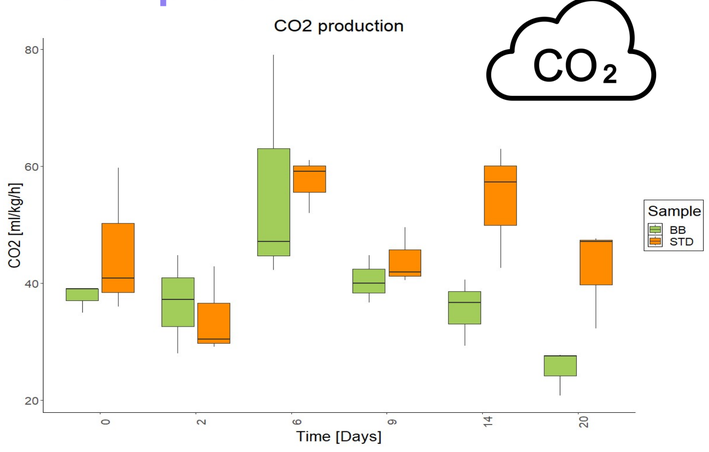


Sensory measurements:
1) Quality evaluation
2) Freshness evaluation (consumer test)

Instrumental measurements:
1) Color: Minolta & IRIS
2) Texture analyzer
3) Weight loss
4) Others: dry matter, TSS

Instrumental measurements:
1) RR: CO2 by Li-cor and PTR-MS
2) HS measurements: PTR-MS
3) Bulkbox and HS measurements GC-MS

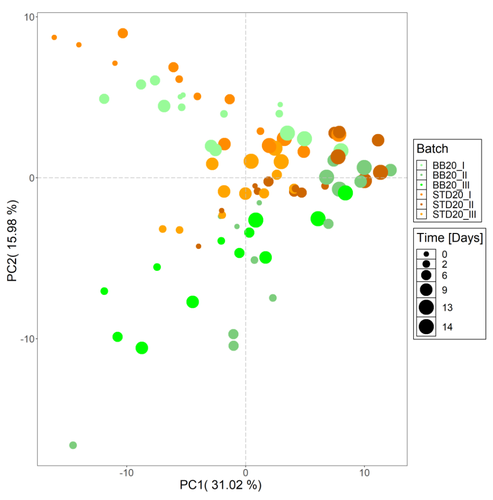
CO2 production:



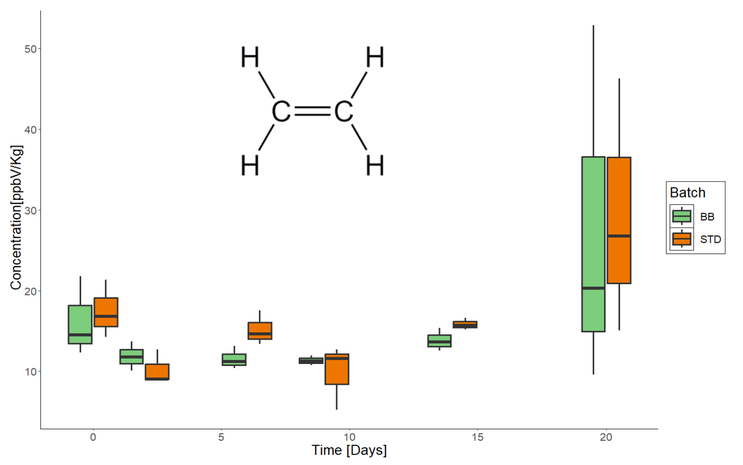
- In terms of CO2 production, the BB had an effect in reducing peppers respiration rates during refrigerated shelf-life after the first week of storage. This, in combination with reduced dehydration due to a better humidity retention, lead to a superior quality and freshness of BB peppers. Peppers quality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

PTR-MS headspace analysis:

- PTR-MS HS analysis was performed on peppers from all the three shipments. Data mining allows the efficient and non-invasive evaluation of the volatilome evolution during storage. PCA analysis on peppers stored at 20°C highlighted initial quality differences and a general decrease in VOCs emissions during the shelf-life.



PTR-MS respiration rates



- O2+ was used to follow ethylene production. Ethylene is a crucial biomarker in the postharvest management of peppers, playing a pivotal role in signaling and regulating various physiological processes that directly influence the quality, ripening, and freshness. As visible from the boxplot (ethylene production [ppbV/kg] of peppers stored at 7°C in BB and STD), storage in the STD showed to increase ethylene production.

4. Conclusions

The BB developed inside the SISTERS project showed promising results for better preserving bell peppers quality during the post-harvest phases of transportation and storage. PTR-ToF-MS was successfully applied to monitor respiration rates and VOCs emissions during the shelf life of bell peppers (cv Lamuyo). The technique allowed to follow changes of some important quality markers over time and it was successfully applied to measure ethylene emissions by using O2+ as primary ion. While the correlation between PTR VOCs profiling and other instrumental and sensory data requires further exploration, these initial findings underscore PTR-MS as a valuable tool for rapid and broad evaluation of the post-harvest quality of green Lamuyo peppers. The same experimental approach could be adapted to other food products and other storage modalities. PTR-MS analysis was also used to validate the BB performance which depends on the physiological characteristics of the fresh products.

5. References

[1] Kader AA. Postharvest technology of horticultural crops. Third edition. University of California Agriculture and Natural Resources Publication, p. 3311 (2002)

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