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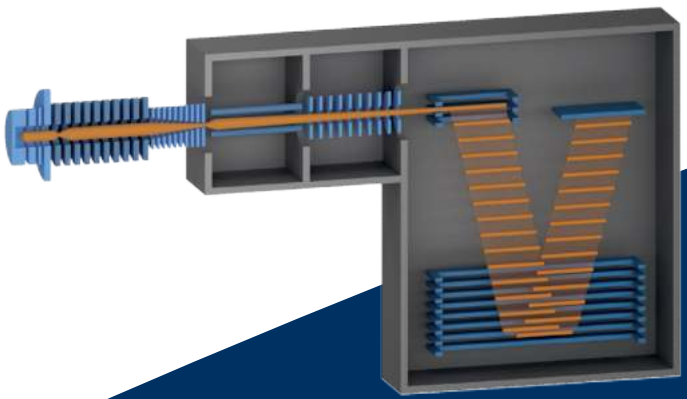

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Preserving freshness by smart logistics: PTR-MS applications to monitor bell peppers quality decay through VOCs emissions

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Abstract

Focused on green sweet bell peppers, the research evaluates the effectiveness of the BulkBox (BB) in preserving the quality of green sweet bell peppers during the post-harvest stages of transportation and storage. PTR-TOF-MS was applied together with other sensory and instrumental methods for monitoring volatile organic compounds (VOCs) and ethylene emissions during refrigerated and room temperature shelf life up to 21 days. The findings emphasize the positive performance of the BB as a valuable tool for enhancing the shelf life of bell pepper and the PTR-TOF-MS utility in providing valuable insights into the dynamic changes of quality markers making it an indispensable tool for assessing and enhancing the postharvest preservation of fresh produce.

Introduction

Sweet peppers (*Capsicum annuum L.)* are an important food crop internationally, highly appreciated for its tasty flesh and peculiar long shape. They can be consumed fresh or processed, as unripe (green or white) or ripe (red, yellow and orange) fruits. While worldwide the production of this crop has increased in recent years and despite its relatively long shelf life, the annual losses of this crop are estimated to be 40% [1]. When stored at their optimal conditions (7-10°C, 95-98% RH), bell peppers have a shelf life of approximately two to three weeks [2] but changes in storage temperature and relative humidity can lead 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.* CO_2, O_2, 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 for bulk transportation. Three different refrigerated transportations from Spain to Italy (1700 km) of realistic product quantities (200-300 Kgs) were performed, followed by shelf-life experiments. 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.

Experimental Methods

Bell peppers were harvested in Spain and stored for 5 days at refrigerated temperature (7°C) before being shipped through a refrigerated truck to Edmund Mach Foundation (Italy). After receiving the products, shelf-life experiments were conducted at two different conditions: refrigerated (T=7°C, RH=90-95%) and ambient conditions (T=20°C, RH not controlled) to simulate supply chain operations. Two different types of PTR-TOF-MS measurements were realized during the shelf life: respiration rates and headspace analysis.

For respiration rates, 3 different peppers were sampled from each batch in different days (0, 2, 6, 9, 14 and 20). Samples were left at room temperature for at least 3 hours to allow equilibration. They were then put in a 1L glass jar hermetically closed for 30 minutes before being measured. For headspace analysis, samples were collected during the same days, grinded into frozen powder by using liquid nitrogen and conserved at -80°C till the day of the analysis. When analyzed, samples were inserted into 20 mL glass vials equipped with PTFE/silicone septa and mixed 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 headspace equilibration, then measured for 50 seconds with an acquisition rate of one spectrum per second. A waiting time of 2 minutes was used for avoiding memory effects. The measurement order was randomized and empty vials were used as blanks. All the measurements were performed with a PTR-ToF-MS 8000 apparatus equipped with an ion funnel (Ionicon Analytik GmbH, Innsbruck, Austria) with H_3O^+ as primary ion. The Selective Reagent Ion mode was also used with O_2^+ as primary ion mode to collect data about ethylene emissions during the respiration rates measurements. Data deadtime correction, internal calibration and extracftion were performed through TOFOffice. Both multivariate statistical data analysis (*i.e.* PCA) and univariate data analysis (*i.e.* 1-way AOV followed by post-hoc tests) were used to investigate changes in the volatilome during storage and the treatment effect (BB *vs* standard). Mass peaks correlations with the other quality measurements was also checked.

Results

The headspace analysis on the vials, highlighted an evolution of the bell peppers volatilome during the shelf-life experiments. Despite the substantial inter-shipment variation observed in quality, notable trends in VOCs emissions emerged. First of all, a concentration decrease of most mass peaks was observed over time, including mass peaks associated with key bell peppers aroma compounds like *m/z* 101.096 and 137.134, tentatively identified as hexanal/(E)-2-hexen-1-ol and a mixture of monterpenes (ocimene, myrecene and limonene) [3-4]. This was correlated with other quality markers as weight loss and firmness (penetration test) which also decreased over time. Some differences between the BB and the standard way of storage were also observed for some mass peaks, especially as the shelf life progressed. For both *m/z* 33.034 and 47.049 (Figure 1) identified as methanol and ethanol the standard treatment showed higher concentrations both during storage at room (20°C) and refrigerated temperatures. These compounds are used as quality bio-markers since they can indicate microbial fermentation or spoilage resulting in the breakdown of sugars and other organic compounds.

By using O_2^+ as primary ion, ethylene emissions were measured during the respiration rates experiment where samples were incubated for 30 minutes at room temperature. In Figure 2, the trend of *m/z* 28.031 for peppers of the second shipment is shown. Ethylene emissions remined quite stable over time for peppers stored at 7°C with the exception of an increase observed after 20 days of storage. The average emission was significantly lower ($P. < 0.05$) for the peppers stored in the BB.

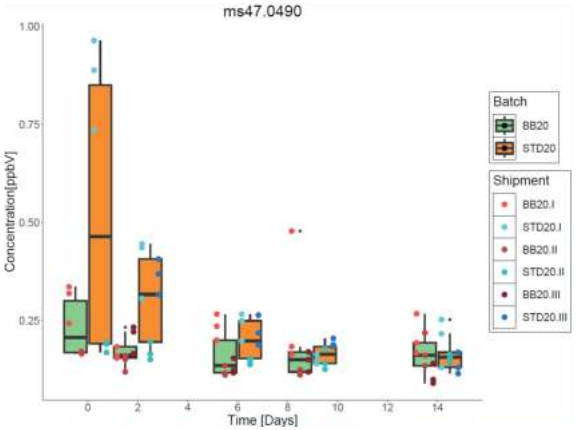

Figure 1: m/z 47.049 (Ethanol) trend during the shelf life of peppers at 20°C. The color of the points represents the different shipments for the two different treatments.

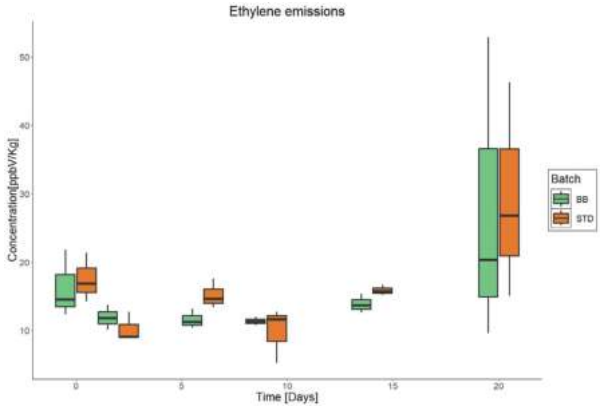

Figure 2: m/z 28.036 (Ethylene) trend during the shelf life of peppers of the second shipment stored at 7°C. The concentration is normalized by the samples weight.

Discussion & 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, not only allowed to follow changes of some important quality markers over time, but was also successfully applied to measure ethylene emissions by using O_2^+ as primary ion. 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. 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 technique was also used to validate the BB performance which depends on the physiological characteristics of the fresh products, including respiration rates.

References

[1] Scoma A., Rebecchi S., Bertin L., Fava F. High impact biowastes from South European agro-industries as feedstock for second-generation biorefineries. Crit. Rev. Biotechnol. 2016;36:175–189. https://doi.org/10.3109/07388551.2014.947238

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

[3] Eggink P.M., Maliepaard C., Tikunov Y., Haanstra J.P.W., Bovy A.G., Visser R.G.F. A taste of sweet pepper: Volatile and non-volatile chemical composition of fresh sweet pepper (Capsicum annuum) in relation to sensory evaluation of taste. Food Chemistry (2012). https://doi:10.1016/j.foodchem.2011.10.081

[4] Aziz Korkmaz, Ahmet Ferit Atasoy, Ali Adnan Hayaloglu, Changes in volatile compounds, sugars and organic acids of different spices of peppers (Capsicum annuum L.) during storage. Food Chemistry (2020) Vol. 311. https://doi.org/10.1016/j.foodchem.2019.125910