VII Postharvest Unlimited Congress
Abstract book

Day 1 (15-5-2023)				
08:30 - 10:00	1h30'	8:30 - 9:00 Opening 9:00- 9:30 Keynote Toine Timmermans 9:30 - 10:00 Keynote Ernst Woltering		
		chair Woltering		
10:00 - 10:30	**0h30'**	***break: Coffee & poster viewing***		
10:30 - 12:00	1h30'	Invited speakers: Innovations in postharvest technology and engineering Thijs Defraeye; Rick vd Zedde; Bart Nicolai		
		chair Verdonk		
12:00 - 13:30	**1h30'**	***lunch & poster session 1***		
time slot	**time allocated**	**Podium**	**Momentum 2+3**	**Momentum 1**
13:30 - 15:00	1h30'	PHU session 1a Invited: Pedreschi Physiology 1 *chair Brouwer*	PHU session 1b Postharvest Pathogens 1 *Chair Gabriëls*	PHO session 1 Invited: Celikel *Chair Schouten*
15:00 - 15:45	**0h45'**	***break: Coffee & poster viewing***		
15:45 - 17:15	1h30'	PHU session 2a Invited: Mishra Quality Measurements 1 *chair Nicolai*	PHU session 2b Storage and technology 1 chair De Fraeye	PHO session 2 Invited: Fanourakis *chair Celikel*
17:30 - 18:30		***business meeting Unlimited***		
Day 2 (16-5-2023)				
09:00 - 10:15	1h15'	PHU session 3a Invited: Bovy Pre-harvest conditions 1 chair Gabriëls	PHU session 3b Sensory & nutrition chair Langer	PHO session 3 Invited: Arens chair Fanourakis
10:15 - 11.00	**0h45'**	***break: Coffee & poster viewing***		
11:00 - 12:15	1h 15'	PHU session 4a Invited: Lukasse Logistics and modelling chair Bovy	PHU session 4b Pre-harvest treatments 1 chair Arens	PHO session 4 Chair Zepeda
12:15 - 14:00	**1h45'**	***lunch & poster session 2 & business meeting Ornamentals (momentum 1)***		
14:00 - 15:30	1h 30'	PHU session 5a Quality Measurements 2 *chair Mishra*	PHU session 5b Physiology 2 *Chair Farneti*	PHO session 5 Invited: Verdonk *chair Woltering*
15:30 - 17:00	1h 30'	Excursion NPEC/Phenomea/Unifarm	Excursion NPEC/Phenomea/Unifarm	Excursion NPEC/Phenomea/Unifarm
19:00 - 22:30		***Conference dinner WICC***		
Day 3 (17-5-2023)				
09:00 - 10:30	1h30'	PHU session 6a Invited: Farnetti Physiology 3 chair pedreschi	PHU session 6b Preharvest conditions 2 chair van de Zedde	PHU session 6c Postharvest Pathogens 2 chair Verschoor
10:30 - 11:00	**0h30'**	***break : Coffee & poster viewing***		
11:00 - 12:30	1h30'	PHU session 7a Quality Measurements 3 chair Lukasse	PHU session 7b Postharvest treatments 1 chair Singh	PHU session 7c Chilling and disorders 1 chair Affandi
12:30 - 14:00	**1h30'**	***lunch & poster session 3***		
14:00 - 15:00	1h30'	PHU session 8a Chilling and disorders 2 chair Ferrante	PHU session 8b Packaging and coating 1 chair Paillart	PHU session 8c Storage and technology 2 chair Pedrotti
15:00 - 15:30	**h30'**	***break: Coffee & poster viewing***		
15:30 - 16:30	1h30'	PHU session 9a Packaging and coating 2 *chair Beaudry*	PHU session 9b Postharvest treatments 2 *chair Campos vargas*	PHU session 9c Storage and technology 3 chair Wood
16:30 - 17:00	0h30'	***Closing of the Symposium***		
17:00 - 18:00		***Farewell drinks***		

VII Postharvest Unlimited
ISHS International Conference
14-18 May 2023 - Wageningen, NL

XII Postharvest Ornamentals
ISHS International Symposium
14-16 May 2023 - Wageningen, NL

Session: Plenary Session 1-1

Global progress and key solutions for reducing postharvest losses and food waste

Toine Timmermans

Abstract

No abstract available

Session: Plenary Session 1-2

Programmed Cell Death in postharvest senescence and disorders

Ernst Woltering[1 2] (Presenting author)

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Abstract

No abstract available

Session: Plenary Session 2-1

Augmenting our insights in cooling and quality preservation in the fresh-produce supply chain using physics-based modeling and data upcycling

Thijs Defraeye, Lerchenfeldstrasse 5, St Gallen, Switzerland; thijs.defraeye@empa.ch (presenting author)

Abstract

We seem to systematically underuse the available data in many fresh-food supply chains, but also the capabilities of physics-based or data-driven modeling. The resulting blind spots make us miss out on ways to further optimize these supply chains, improve food preservation, and save fresh produce and the associated carbon footprint. I present our research on unveiling some of these blind spots in refrigerated supply chains of plant-based foods from farm to fork. Our strategy is to combine the available sensor and postharvest metadata of shipments with our physics-based models to upcycle these data into actionable metrics for several stakeholders. I also explain opportunities to integrate preharvest information in these predictions. All these building blocks are vital in bringing digital food twins to life, which drift in-silico in the supply chain next to the real products. Furthermore, I show how we apply physics-based simulations to better understand cooling processes from an entire shipment down to a single fruit. Here, we simulate to obtain complementary data that is often challenging to sense in the supply chain down to the single fruit level. With this cyber-physical approach, we get closer to obtaining a complete picture of how all fruit in a shipment age. This enables us to identify some solutions to help save food by changing operational conditions. I also give our perspectives on the future of physics-based simulations in the advent of upcoming data-driven modeling.

Session: Plenary Session 2-2

Pre-harvest fully automated plant phenotyping, technology adoption and links to postharvest fresh produce quality traits

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Abstract

Adoption to new technology takes time and is a highly complex matter in all domains. Our food production system already suffers from the effects of climate change, therefor it's urgently needed to enable plant scientists in academia and industry to come up with solutions to deal with the effect of climate change. Enabling these experts with efficient new screening technology will boost the quest to find more robust and tolerant crop varieties to cope with climate change effect. Large-scale research infrastructure is a driver for innovation in research and for achieving scientific breakthroughs. At Wageningen University & Research recently the Netherlands Plant Eco-phenotyping Centre (NPEC) was developed to enable large numbers of users to use high-tech, data driven screening technologies for the next big step forward. Modern plant phenotyping technologies involve the objective, accurate, detailed and reproducible recording of a range of characteristics of a large number of plants over time, in response to their environment. NPEC provides its users with a multitude of state-of-the-art platforms at which to grow plants in controlled, semi-controlled or natural conditions, equipped with a range of modern sensors for far-reaching automation and digitization of plant phenotyping. Plant phenotyping is currently in the scientific spotlights because of its growing importance as a decisive factor in finding solutions to major global problems related to food security, the climate crisis and the loss of biodiversity. Several examples with links to post-harvest fresh produce quality traits will be discussed to show the impact of this upcoming technology.

Session: Plenary Session 2-3

Postharvest systems biology and kinetic pathway modelling

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Abstract

For more than two decades kinetic models have been used successfully to describe changes of quality attributes of fruit and vegetables after harvest. Such models typically consist of a few coupled ordinary differential equations that are based on chemical reaction kinetics theory and a simplified description of the actual biochemical processes underlying these changes. Yet, because of the many simplifications these models must be considered as semi-empirical, and, while useful to make predictions, do not provide much insight in the changes of the physiology of fruit and vegetables after harvest. In reality postharvest processes are complex, involve many metabolites and both linear and circular pathways that are tightly regulated by complex mechanisms at the level of the metabolome, proteome and transcriptome. The emergence of high throughput omics techniques in combination with powerful computer hardware and bioinformatics software has opened the door to study such changes from a holistic point of view. Kinetic pathway models are essential to integrate such information and better understand postharvest processes. In this presentation we will illustrate this approach with a systems biology model of ethylene biosynthesis and signal transduction of tomato at several ripeness stages. We will show how even more complex pathways such as those of the respiration metabolism can be modeled using fluxomics data.

Session: PHU1a-i

From targeted approaches to omics data integration to unravel postharvest disorders

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Abstract

Different physiological disorders are only evident after prolonged postharvest storage or transport and may account for significant food losses. Thus, understanding the mechanisms involved in the development of these disorders is of key relevance. In addition, relying on early biomarkers of these disorders will help industry to take early decisions on the fate of the different fruit batches. Combination of targeted and omics data integration approaches will allow not only to unravel the mechanisms involved in the development of these disorders but to search for potential early biomarkers. Thus, a study case on "color desynchronization with softening" of Hass avocado will be shown. A first targeted approach focused on main pigments, hormones and qPCR analysis of specific genes revealed the role of different hormones other than ethylene involved in the development of this disorder. Integration of omics datasets and network analysis revealed different transcription factors associated with differentially regulated genes related to avocado fruit color desynchronization control in ready-to-eat stage (RTE). Similar approaches can be taken to thoroughly study not only physiological disorders but quality traits of interest in different species.

Session: PHU1a-1

Understanding the Role of AOX in Fruit Ripening to Reduce Post-harvest Wastage

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Abstract

Climacteric fruits are characterized by a dramatic increase in autocatalytic ethylene production accompanied by a spike in respiration at the onset of ripening. The change in the mode of ethylene production from autoinhibitory to autostimulatory is known as the System 1 (S1) to System 2 (S2) transition. Existing physiological models explain the basic and overarching genetic, hormonal, and transcriptional regulatory mechanisms governing the S1 to S2 transition of climacteric fruit. However, the links between ethylene and respiration, the two main factors that characterize the respiratory climacteric, have not been examined at the molecular level. Some cultivars of Pyrus communis represent a variation in climacteric ripening, where the transition to S2 is enabled only by exposure to varying duration of cold. In addition, post-harvest application of 1-methylcylopropene (1-MCP), an ethylene receptor inhibitor, permanently suspends this transition resulting in inconsistent quality. We have recently demonstrated that during cold exposure, AOX reaches maximal expression preclimacterically, before transitioning to S2 stage and ethylene evolution. This observation inspired the approach of exogenously activating AOX resulting in consistent ripening while overcoming the stronghold of 1-MCP. Currently, we are investigating a few hypothesized mechanisms by which glyoxylic acid, an AOX activator, may be able to bypass the 1-MCP-mediated blockage of ripening in pears. Results of our and other recent studies indicate that the AOX respiratory pathway may play an essential role in mediating cross-talk between ethylene response, carbon metabolism, ATP production, and ROS signaling during climacteric ripening. New genomic, metabolic, and epigenetic information sheds light on the interconnectedness of ripening metabolic pathways, necessitating an expansion of the current ethylene-centric physiological models. Understanding points at which ripening responses can be manipulated may reveal key, species- and cultivar-specific targets for regulation of ripening, enabling superior strategies for reducing postharvest wastage.

Session: PHU1a-2

Tissue differentiation and the central carbon metabolism of tomato fruit

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Abstract

Tomato fruit consists of distinctly different tissue types (e.g. columella, septa, pericarp, locular gel, and seeds). A separate study from our group on tomato fruit microstructure found that these different tissue have different cell size and pore connectivity affecting their gas diffusion properties. This affects the accessibility of the tissue to oxygen driving the central carbon metabolism in the different tissues. However, currently only limited information is available on a possible tomato fruit tissue differentiation with regard to the central carbon metabolism beyond the direct effect of the oxygen gradient. Metabolomics has been used to evaluate the effect of environmental stresses on plant physiology, but only few applications of metabolomics to postharvest biology have been published. Metabolomic data can be used to construct mathematical models of metabolic networks facilitating a more detailed kinetic exploration of the physiology of fruit and vegetables post-harvest. To develop such dynamic models, experimental data on the uptake of isotope labelled substrates is generally required to fully reveal metabolite fluxes changing with time. In order to explore tissue differentiation with regard to the central carbon metabolism, we performed an extensive fluxomics study for the main tomato fruit tissues. After optimizing the experimental protocol, excised columella, septa and pericarp tissue was fed with U- 13 C 6 glucose. GC-MS was used to measure changing metabolite concentrations over a 24 h experiment including the isotope labelling information. The results showed, amongst others, that pericarp and septa tissue exhibited a similar carbon label enrichment and respiration activity, but both being lower than those of columella tissue. The results will be further discussed in the context of low oxygen stress and the differential responses of the different tissues types of tomato fruit.

Session: PHU1a-3

Molecular regulation of superficial scald in 'Granny Smith' apple fruit

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Abstract

Although low temperature storage can delay apple (Malus domestica Borkh.) fruit ripening and senescence, it may cause the superficial scald disorder under subsequent ripening at room temperature, which seriously affects fruit quality. The aim of this research was the in-depth characterization of the molecular mechanisms underlying scald development, using high-throughput sequencing technologies (transcriptomics, methylomics), coupled with mass spectrometry-derived proteomics and metabolomics. 'Granny Smith' fruits were harvested at two harvest (early and late) stages, and after 3 months of cold storage (0 o C), they were exposed to room temperature (20 o C) for scald development. Data indicated that scald symptoms were mostly observed in early harvested apples, which is highly linked to their enhanced transcriptional and translational activity during and just after cold storage. Analysis of post-translational protein modifications (PTMs)also revealed strong oxidation events following cold exposure. Global and target methylation analysis identified several genes, including α -farnesene synthase (AFS) and polyphenol oxidase (PPO), that subjected to cold-derived epigenetic alternations. RNAi-based silencing of α -AFS and PPO genes through pump-infiltration and injection in apple peel influenced scald phenotype. The combination of large scale -omics and functional characterization approaches may contribute to understand the molecular mechanism of superficial scald development in apple fruit.

Session: PHU1a-4

Themes of fruit aroma biochemistry: deregulation for propagation

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Abstract

When a fruit abscises, it is taking a literal leap of faith that it will be able to attract a consumer; an act that will ultimately lead to seed dispersal. However, evolution doesn't work by faith. For the wellbeing of its offspring, plants forgo and compromise otherwise canonical physiological patterns and biochemical inhibitions to make a fruit as appealing as possible. Among the many changes that occur in a ripening fruit, aroma is often the final development, signaling to the potential consumer that said fruit is as appetizing as possible while ultimately pursing the ulterior goal of dispersing mature seeds. Many aroma compounds made by fruits are derived from the same metabolic pathways as primary metabolites. Fruits have developed countless unique means in order to overcome guiderails that otherwise prevent the products of primary metabolism from accumulating and/or converting to the specialized metabolites that we love fruits for. Several examples of these modifications that have been identified in our laboratory will be highlighted, such as the neofunctionalized and unregulated enzyme citramalate synthase that feeds into isoleucine metabolism of ripening apple fruit, and the alternative splicing of two otherwise feedback inhibited enzymes of valine and leucine metabolism that allow for the production of the characteristic volatiles of banana aroma. Other concepts will also be touched upon, including the importance of precursor availability and its interplay with enzyme specificity, as well as how innovative experimental methods can be used in lieu of traditional backwards or forwards genetics approaches that are not feasible for tree crops.

Session: PHU1b-1

Detecting and localising black dot disease on potato tuber images using mask region-based convolutional neural network (mask R-CNN)

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Abstract

Potato black dot is a foliar and tuber blemish disease that has become an increasing economic problem in the past years. Black dot is caused by the fungus Colletotrichum coccodes and is characterized by microsclerotia (black dots) which further develop as silvery lesions on the tuber skin during postharvest cold storage leading to lower aesthetic quality of potatoes destined for the pre-pack market. Traditionally, disease incidence and severity are measured by manually scoring percentage coverage on individual tubers, but this method is time consuming and subjective. Therefore, standard computer vision has been proposed for the assessment of external quality attributes. However, the existing automated machine vision systems can only detect black dot lesion, whilst microsclerotia still requires human examination with hand lenses or microscopes. Deep-learning based techniques using convolutional neural networks (CNNs) are the most popular methods in machine learning for the classification of plant diseases. CNN can work on large datasets with standard photography and low-cost cameras. This study investigated how disease severity and location of the black dots can be measured on natural colour photographs of potato tubers using deep learning models. Mask region-based convolutional neural network (mask R-CNN) architecture was trained and validated using a dataset of 5,100 labelled images of potato tubers. The work made use of existing datasets involving labelling, image pre-processing, augmentation, model selection, training, and evaluation, and made recommendations for an operational system for automatic detection of black dot (microsclerotia) and black dot lesion. The outcome is part of the holistic approach to create a predictive model that can be used as a decision support tool, able to determine the optimum storage time for different potato consignments based on the initial incidence and severity of black dot at storage loading, therefore, contributing to reduce food loss and waste.

Session: PHU1b-2

Avocado stem-end rot detection using hyperspectral imaging

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Abstract

One of the most common post-harvest diseases impacting avocado is stem-end rot, a fungal disease whose damage is usually not externally visible. Only after extensive damage do symptoms become visible to the eye. Currently infections are primarily detected using the destructive approach (cutting the fruit). There is significant interest in identifying non-destructive approaches testing entire avocado batches for stem-end rot. We explore Visible-Near Infrared, VNIR (wavelengths 470nm-1000nm), hyperspectral imaging and machine learning to non-destructively detect stem-end rot in Haas avocados. The training/validation set (85% / 15% split) consisted of 240 untreated and 240 inoculated (with fungus) avocados destructively tested for ground truth. An independent test set of 80 avocados was also collected. Hyperspectral images were normalized using SNV (standard normal variance). Spectra from avocado stem pixels (and neighbouring regions) are automatically averaged to obtain image features. Training spectra are modelled with Random Forest and XGBoost, obtaining 82% and 83% accuracy respectively on the validation set. However, testing on the independent set yielded 60% and 65% accuracy respectively, as well as elevated levels of false positives while false negatives remained low. These results suggest application of models derived using VNIR data may not be directly applicable for predicting stem-end rot when new samples arrive. In general, NIR models have been reported to perform poorly when used on batches that are different from the ones used for model construction. These models however can be recalibrated to new data, which is the future direction of the current research.

Session: PHU1b-3

dsRNA as a promising eco-friendly treatment to control postharvest diseases

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Abstract

Pathogenic fungi are a main cause of postharvest loss. The most effective treatment against postharvest diseases is fungicides. However, due to growing concern for their harmful influences, there is a need to develop new strategies. One of the new environmentally friendly approaches is the use of dsRNA. By designing dsRNA construct which targets essential genes in pathogenic fungi, we were able to reduce decay development. However, the dsRNA treatment suffers from two major disadvantages: not all fungal species have the propensity to uptake dsRNA, and low stability of dsRNA in the natural environment. By examining the uptake of cy5-labeled dsRNA by various pathogenic fungi we demonstrated that the uptake of dsRNA by Botrytis cinerea occurs in the emergence zone of the germination tube, whereas Colletotrichum gloeosporioides presented no uptake. We studied the fungi's mechanical properties using atomic force microscopy. The elastic moduli measured for both conidia and germination tubes of C. gloeosporioides were remarkably higher than for B. cinerea indicating that dsRNA penetration to the fungi is dependent on the fungi's stiffness. Upon this observation we developed new techniques which allowed the penetration of the dsRNA to C. gloeosporioides. Next, to overcome the instability of the dsRNA it was loaded onto layered double-hydroxide (LDH), which protected the dsRNA from degradation and served as a slow-release device. The dsRNA display an ability to serve as a selective treatment which decreased only the targeted fungi without affecting other species during storage. The LDH-dsRNA complex had a prolonged effect and maintained its efficiency in decreasing decay development up to six weeks post-treatment. Moreover, storage conditions affected the release pattern of the dsRNA from the LDH. Overall, this study advances the use of dsRNA one step closer to an applicative eco-friendly alternative to conventional postharvest fungicides.

Session: PHU1b-4

Detection of false codling moth (Thaumatotibia leucotreta Meyrick) infestation in Midknight Valencia fruit (Citrus sinensis L. Osbeck) using SIFT-MS

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Abstract

False codling moth (FCM), Thaumatotibia leucotreta (Meyrick), is a phytosanitary pest capable of attacking various agricultural products including citrus fruit. As a quarantine insect pest, its presence limits the trade and market of host crops internationally. Producers have control measures in place in the field, but the absence of infestation is not always guaranteed. Moreover, detection of FCM infested citrus fruit in packhouses remain challenging especially during the early stages of infestation. An alternative screening method for FCM infestation is now under investigation. This study evaluates the applicability of selected ion flow tube mass spectrometry (SIFT-MS) for the rapid and non-destructive detection of FCM infestation in citrus through volatilome profiling. In addition, headspace sorptive extraction- gas chromatography mass spectrometry (HSSE-GC-MS) was used to identify specific volatile compounds relevant to the infestation. Midknight Valencia orange (Citrus sinensis L. Osbeck) were inoculated with FCM eggs, and infestation was allowed to proceed for 20 days. Volatile profiling was performed at regular intervals from the early to later stages of larval development. Using multivariate statistics, the results indicate that discrimination between healthy and infested fruits is possible using SIFT-MS in full scan mode with the discrimination improving at the later stages of infestation. Furthermore, compounds unique to FCM infested fruit and larva were identified with HSSE-GC-MS. It was observed that the volatiles unique to the infested fruit generally increase during the progression of infestation. In conclusion, SIFT-MS could potentially be used for the rapid and non-destructive postharvest screening of FCM infested citrus fruits.

Session: PHU2a-i

Recent progress in NIR spectroscopy for fresh produce analysis

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Abstract

NIR spectroscopy is widely used for material charaterisation in different domains of analytical sciences. In the area of post-harvest technology for fresh produce, NIR has been used to predict wide range of physicochemical parameters such as dry matter, soluble solids content, firmness etc. In the current state of the art, NIR spectroscopy is widely explored in both field applications to facilitate harvest decisions as well as in post-harvest such as for fruit sorting applications. Although successful development of NIR spectrometer hardware has reached saturation, one of the main components of NIR spectroscopy, i.e., data modelling, is still a challenge. The challenge is particularly related to achieving generalized models which works well on new harvests, and new cultivars, without requiring any readjustment of the existing models. In that regard, the presentation will provide recent progress in achieving generalized models to make NIR spectroscopy a preferred tool for post-harvest applications.

Session: PHU2a-1

Predicting freshness and shelf-life of tomatoes by non-destructive technologies

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Abstract

Monitoring product quality is essential to reduce food waste in the fruit & vegetable chain. Retailers demand high quality products and consumers expect products with a good flavor and a long shelf-life. Growers want to produce high quality products without sacrificing production yield. To assess product quality, quick and objective tools are necessary. One of the available tools is the tomato flavor model that can predict the flavor liking of tomato based on various destructive measurements, such as sugar content, titratable acidity, firmness and juiciness. The current study aims to take the next step by modelling tomato quality based on non-destructive measurements of shelf-life and freshness. Advanced imaging techniques and sensor systems are used to monitor products in the supply chain, including NIRscan, microwave sensors and imaging techniques. The non-destructive parameters will give insight in both the external and internal quality properties of the fruits, for example fruit color, fruit shininess, visual defects and sugar content. Parallel to the non-destructive measurements, the tomatoes are assessed by an expert and consumer panel on their freshness and shelf-life parameters, and finally the products are measured destructively. Real-time data access, data integration and modelling will allow for prediction of product characteristics at each moment of its lifetime. With these elements, a predictive model for the freshness and shelf-life of tomato in the food supply chain will be created and continuously updated. The predictive model will allow for simulation of future behaviour in various scenarios, and thereby enables chain actors to make optimal decisions at each moment in time.

Session: PHU2a-2

Investigating spectral imaging for predicting tomato sepal sensitivity of recently harvested tomatoes to fungal infections

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Abstract

We address the problem of identifying tomato sepals, in recently harvested tomatoes, which are susceptible to fungal infections. Near-Infrared (NIR) spectral imaging (1000-1700nm) is explored for identification of the susceptible tomato sepals before any visual signs of infections appear. Spectral images are acquired for the tomato cultivar Capricia, a day after the tomatoes were harvested. The tomatoes were then placed under controlled conditions, of 100% relative humidity, to facilitate fungal growth. After 3 days, individual sepals were rated by 3 experts in terms of fungal presence and severity. A Bayesian network was designed to combine the ratings from the experts in order to gain a single, more confident, rating. The images from the first day were manually annotated to generate masks of individual sepals. Manual labelling is tedious and prone to errors, especially at the sepal edges and the tip, and the manual masks still contain extra spectral pixels from the tomato skin. To clean these masks an SVM was trained to segment the tomato crowns. The cleaned masks are used for extracting the mean spectra of individual sepals which become their representative features. Standard Normal Variate transformation is applied to the mean spectra in order to suppress scattering effects. A Random Forest classifier was trained using repeated stratified 5-fold cross validation. The independent test set is 30% of the overall dataset. Sepals showing only marginal, possibly ambiguous, signs of infection were eliminated from all datasets to improve overall correct assignment of ground truth labels. The model trained on the training set reported 71% balanced accuracy on the validation set. Testing on the independent set yielded a balanced accuracy of 78%. These results suggest NIR imaging may be suitable for automatically predicting the susceptibility of sepals of recently harvested tomatoes to future fungal infections.

Session: PHU2a-3

Using Vis/NIR hyperspectral imaging and wavelength selection for accurate postharvest discrimination of similar loquat cultivars

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Abstract

Similar fruit cultivars can be mixed in postharvest and sold as the same, whereas their quality might differ considerably. These differences in quality between cultivars can lead to rejection by consumers if the fruit does not meet their expectations. Thus, confusion must be avoided. Destructive methods to analyse composition are expensive and cannot be performed on all fruits. Alternatively, hyperspectral imaging is a non-destructive technology that has already been used to assess the internal quality of fruit. 'Algerie' is a traditional cultivar known for its sweet taste, while 'Xirlero' is a lower-quality new variety. Both varieties are harvested in the same period and have a similar external appearance, making them difficult to distinguish. This work aims to find a non-destructive way to distinguish between these two varieties, as the external appearance is similar, but the internal quality differs. 300 samples of 'Xirlero' loquat and 259 'Algerie' were used in the experiments. Samples were harvested weekly in a commercial orchard for five weeks to obtain several maturity levels. Hyperspectral images of the fruits were acquired using a Vis/NIR hyperspectral imaging system (400-1000 nm). The mean spectra of the samples were extracted, pre-treated with Standard Normal Variate, and randomly divided into a training set (70%) and an independent test set (30%). Principal component analysis (PCA) was used to find the most important wavelengths. Three PC were chosen, which explained 99.5% of the total variance. The highest and lowest loadings of each component were selected, which corresponded to the 995, 550, 678, 508 and 412 nm wavelengths. Partial Least Squares Discriminant Analysis, Support Vector Machine and Extra Trees Classifier models were trained using the whole spectrum and the selected wavelengths. Accuracies higher than 85% were obtained with all wavelengths, and higher than 84% were obtained using the selected wavelengths in the test set.

Session: PHU2a-4

A proposal of the optimal sampling interval for shock pulse measurement

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Abstract

Shock and vibration are the important hazards in handling and transport that cause physical damage to products or to their packages. For the analysis of transport vibration, Nyquist frequency is widely used as an indicator for selecting measurement frequency or sampling rate. However, little is known about the analysis method of the shock pulse in the physical distribution. Our previous research showed that the simple shock data loggers could not adequately record shock peaks in the physical distribution. This failure might be due to the low sampling rate (Hz) or long sampling interval (ms) of the shock loggers. Here we propose a method which effectively obtains the optimal sampling interval in terms of peak acceleration (PA) and velocity change (VC), or the area under the acceleration time history of the shock pulse. For this purpose, we generated three types of shock pulse to test the efficiency of the analysis method: half-sine, triangular, combination of half-sine and triangular. For each shock pulse, we calculated the expected relative value (ERV) of PA and VC for each sampling interval. In the case of ERV calculation for VC, trapezoidal rule was applied. In both PA and VC, the longer the sampling interval, the lower the ERV were found. The sampling intervals to obtain equals or more than 90 % of the original values were less than 20 % or 30 % of the pulse duration for PA or VC, respectively. Although the use of a shorter sampling interval improves measuring performance (accuracy), it increases the amount of data recording. Therefore, it was concluded that the optimal sampling interval was 20 % of the duration of shock pulse. The results help to reconsider/design the sampling interval of a simple shock logger and to optimize shock measurement in the physical distribution of postharvest products.

Session: PHU2b-1

Can dynamic controlled atmosphere help reduce postharvest diseases of pome fruit?

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Abstract

Washington State (WA) provides nearly 100% of organic apples grown in the USA and makes up to 20% of the state apple production. While the semi-arid climate of central WA allows growing organic fruit with minimum impact of biotic stresses, storing organic fruit is a challenge with postharvest diseases being the number one limitation. After 5 months of storage, an organic packer can lose up to 50% of organic fruit to diseases. Currently, there are no effective postharvest bio-fungicides available for postharvest application and decays are managed by preharvest applications of some organic materials and postharvest sanitation. Dynamic controlled atmosphere (DCA) is a new approach used by organic packers specially, to extend the shelf life of organic fruit and reduce physiological disorders and DCA is increasingly used in the U.S. Pacific Northwest (PNW). The ability of the microorganisms, especially, fungi that infect fruit and cause postharvest diseases, to growth and thrive under ultra-low oxygen concentration may vary but unknown for several postharvest pathogens. In this study, we compared the ability of DCA with static CA and regular atmosphere (RA) to reduce the incidence and severity of five apple postharvest pathogens, i.e., Penicillium expansum , Botrytis cinerea , Neofabraea perennans , Mucor piriformis , and Phacidiopycnis washingtonensis . Unwounded and wounded apples were inoculated with spore suspensions of each pathogen and disease incidence and severity was assessed every two months up to 8 months. Our results indicate variability between the five different pathogens to grown and cause postharvest diseases and that a gain of 15 to 50% in reduction is possible compared to CA or RA.

Session: PHU2b-2

Electrohydrodynamic air amplifier- a low-energy postharvest airflow generation technology for ventilation

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Abstract

Airflow generation is omnipresent in cooling operations in postharvest applications. In the current state of the art, the need to move air is predominantly satisfied by rotating impellers, propellers, or other mechanical machinery with blades. On the other hand, electrohydrodynamic (EHD) air propulsion is an alternative way to produce airflow without moving parts, vibration, and noise. EHD airflow, or ionic wind, arises when a high voltage gradient is applied to a pair of electrodes. An area of ionized air molecules in between electrodes forms (corona discharge), which accelerate within the electric field and exchange momentum with the surrounding neutral air, leading to a macroscopic airflow [1]. This device also does not produce additional heat, in contrast to fans. Some ozone is produced, which disinfects and destroys ethylene. Ionizing air itself is energy-efficient [2]. However, reaching competitive airflow rates for ventilation purposes remains a problem from the high voltage engineering point of view. In this study, we tackle the problem from the aerodynamic side by combining the EHD principle with air amplification technology to ramp up flow rates. We propose a novel bladeless air propulsion device called EHD air amplifier that multiplies flow rates with the same amount of electrical power. In the simulation proof-of-concept, we could increase the airflow rate performance by 59 % compared to regular EHD airflow generation and 48 % compared to a similar-sized axial fan. We confirmed the concept also with a laboratory test rig leading to a novel prototype for a bladeless ventilation device that allows us to further decrease energy consumption in post-harvest processes. Fig. 1 . Velocity field results of the in-silico proof-of-concept study for the open space configuration of the electrohydrodynamic (EHD) air amplifier. The device consists of two axisymmetric elements that partly overlap, creating room for electrical components. As part of a scalability study, the inner diameter varies from 10 mm (a) to 100 mm (d). The electrical field is scale-invariant, thus, allowing for efficient scaling of the device where the power consumption increases linearly. This means we can produce air amplifiers in a range of sizes to cover various postharvest application areas.

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Session: PHU2b-3

Evaluation of the performance and farmer benefits of a solar-refrigerated, evaporatively-cooled structure designed for off-grid storage of perishables

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Abstract

Stand-alone cooling systems for the storage of perishables are needed in regions of the world lacking reliable electricity and the financial wherewithal to make sufficient investments in on-grid cold stores. To meet this need, we have designed an off-grid, batteryless solar refrigerated and evaporative cooled (SREC) structure that can be self-built by smallholder farmers. Several innovative features have been incorporated including a "water battery" (a thermal reservoir) to provide nighttime cooling, a dual-use refrigeration coil to cool the thermal reservoir and interior air simultaneously, and a solar adaptive controller to regulate power demand by refrigeration compressor based on available solar energy. Two SREC designs were built with frames of concrete (c-SREC) and iron (i-SREC) and evaluated for their ability to regulate temperature and humidity. The interior temperature reduction relative to ambient ranged between 5 and 35 °C, varying throughout the day and across the seasons. During the hot, dry season of the year, the temperatures inside the i-SREC structures were lower than those in c-SREC structures, however, when solar insolation declined during the monsoon season, the two structure types performed similarly. One i-SREC cool storage yielded 2 times the initial investment within a single growing season. The findings suggest the i-SREC structure is feasible for perishables storage by smallholder farmers and farmer organizations, however, it should be noted that the cloudier months caused a sharp decline in cooling capability as solar radiation levels restricted compressor function, so storability limitations for target crops will need to be considered as a function of season.

Session: PHU2b-4

A battery-powered air sampler to monitor the evolution of ethylene during reefer container transport of fruit

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Abstract

Over the last decade we have frequently encountered the question how the ethylene concentration evolves over time during reefer container transports of fruit. Unfortunately we were, till recently, not able to answer those questions. Ethylene is hard to measure, and hardly any data is (publicly) available on ethylene concentrations occurring during reefer transport. We failed to find a suitable device to monitor ethylene in reefer containers. Therefore we decided to develop our own battery-powered air sampler. Since spring 2022 it has been deployed fulltime to collect air samples during reefer container transports of perishables. The battery-powered programmable device contains 24 air sample bags of 0.75 L, which are filled sequentially at a flexibly programmable sample interval. After completion of a shipment the device is taken to the lab, where the gas content of the air samples is analyzed with a gas chromatograph tuned to measure ethylene. Over the course of four consecutive commercial avocado shipments in reefer containers the air sampler operated flawlessly and proved fit for the purpose of monitoring the evolution of ethylene concentrations during commercial intercontinental (CA) reefer container transport of fruit. In the absence of good replicates it is not possible to draw conclusions from the collected data so far, but the data do yield some interesting indications, which might serve as good hypotheses for further research on ethylene in CA container transport of avocado. One of those interesting indications is the possible effect of delays between stuffing and the start of cooling on the accumulation of ethylene, and how that ethylene accumulation affects avocado quality at unstuffing.

Session: PHU2b-5

RipeLocker: An innovative postharvest technology that utilizes hypobaric chambers to extend the storage life of several horticultural commodities

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Abstract

Despite success in postharvest research, low pressure system (LPS) technology has failed to be commercialized due to size, cost, engineering and supply chain constraints. Under LPS conditions, horticultural commodities experience rapid gas diffusion between the environment and their intercellular air spaces due to open stomates and leveled gas gradients. This enables tolerance to ultra-low oxygen (ULO) and higher carbon dioxide (CO 2) levels, when compared to traditional postharvest technologies, without risk of fermentation and/or injury to the perishable. These environmental conditions enable advantages such as: reduced respiration, delayed senescence, fully saturated air (to mitigate weight loss) and pathogen growth suppression. In recent years, RipeLocker, a disruptive and innovative postharvest technology company, has developed a pallet-size, dynamically controlled, low pressure (i.e., hypobaric) chamber that has been commercially deployed and shipped successfully. RipeLocker (RL) chambers are monitored continuously, providing information such as the respiration rate (e.g., O 2 consumption, CO 2 production), respiratory quotient (RQ) and atmospheric composition to enable real-time decision making and dynamic intervention. RL has showcased efficacy in reducing weight loss, extending storage life and retaining quality in hops, roses, blueberries, cherries, pomegranates and more for 4, 6, 8, 10 and 12+ weeks, respectively. RL has also shown potential as a quarantine replacement for pests and pathogens, given the ability to hold environmental conditions at zero O 2 and/or high CO 2 at intervals that negate pests, but do not negatively impact the horticultural commodity. RL continues to conduct efficacy trials on various flower, fruit and vegetable species to further extend the postharvest life of valuable perishables and to further improve the technology.

Session: PHU2b-6

‘Rocha’ pear ripening under the 1-MCP evergreen effect: the impact of the auxin 1-naphthaleneacetic acid treatment

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Abstract

'Rocha' pear (Pyrus communis L. cv. Rocha), is a DOP cultivar from the West region of Portugal that is appreciated worldwide. Combined with controlled atmosphere storage, 1-methylcyclopropene (1-MCP) application, an antagonist of ethylene action, has been one of the most applied techniques to extend the storage of 'Rocha' pear. However, fruit industry is facing a problem resulting from 1-MCP application: it prevents the normal ripening of the fruit and affects the final quality at the consumer level. In this study, we exposed 1-MCP treated fruits to an auxin 1-naphthaleneacetic acid (1-NAA) solution (2 mM) and analyzed the efficacy in restoring the ripening of 'Rocha' pear. First, during the first 24 h, we determined the primary impact of 1-NAA on the expression of genes encoding ethylene receptors (PcETRs) and ethylene biosynthesis enzymes (PcACS and PcACO), combined with lipid peroxidation and reactive oxygen species. We also studied the effect of 1-NAA on ethylene production, respiration, and other ripening markers (firmness and sugars) across shelf life . Herein, the expression of PcACS1 and PcACS4 increased in 1-MCP fruit treated with 1-NAA compared to pear treated only with 1-MCP. Additionally, the expression of PcETR2 and PcETR5 was enhanced, revealing the potential of the 1-NAA treatment in inducing the production of new ethylene receptors. Time course physicochemical analysis revealed that fruit ripening was accelerated by 1-NAA treatment, as judged by ethylene evolution and respiration associated with softening. The 1-NAA treatment increased firmness loss (ca. 60%) and internal ethylene production (ca. 50%). Also, exogenous 1-NAA treatment increased 1-aminocyclopropane carboxylic acid (ca. 28%) and ACC oxidase activity (ca. 15%) corroborating the increased in gene expression. Our findings reveal that 1-NAA treatment may circumvent 1-MCP effect providing valuable information for ripening studies in pear.

Session: PHU3a-i

Breeding for postharvest quality in fruits and vegetables

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Abstract

No abstract available

Session: PHU3a-1

Orchard-specific factors contribute to the apparition of CA-related disorders in ‘CH 201’ pears

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Abstract

The pear cultivar 'CH 201', marketed under the FRED® brand name, has been recently launched in Switzerland and is in expansion in several European countries. It is characterized by a red blush and a crunchy texture and has a good storage potential, mainly due to its excellent firmness maintenance in both cold and shelf-life conditions. However, under CA conditions 'CH 201' is susceptible to the development of CA-related disorders, mainly cavities. Postharvest factors such as low CO2 level <1 %, O2 levels between 3 and 5 %, and a CA-delay of 4 weeks help limiting the apparition of cavities, while 1-MCP treatment increases the incidence of this disorder. As cavities' incidence greatly varied between orchards, this problem cannot be addressed only by postharvest strategies but must take into consideration orchard-related factors. This study investigated such factors and their impact on cavities development during storage. For this purpose, experiments were conducted with pears issued from orchards located in various regions of Switzerland, harvested at commercial maturity and stored in the same room under CA conditions. In specific orchards, the influence of rootstock and crop load was evaluated and correlated with cavities development. The results showed that trees under 4 years old, low crop load and high tree vigor were factors associated with CA-related disorders in 'CH 201' pears.

Session: PHU3a-2

Effect of system, grafting, and harvest maturity stage on the quality of tomatoes grown in greenhouses

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Abstract

It is important for greenhouse growers to incuse fruit quality to meet consumers' preference for nutritious food. Established technologies that are utilized within greenhouse systems include grafting and hydroponics. Aquaponics is an emerging technology that combines crop and fish cultivation to minimize chemical fertilizer inputs. We evaluated a decoupled (DAQ) aquaponic system, where nutrients were supplemented to optimize crop productivity. The goal of this work was to explore the integration of the DAQ system with grafting on tomato fruit quality. Furthermore, we harvested fruit at different maturity stages (light red, pink, red) and evaluated quality to determine how DAQ and grafting affect the development of quality attributes during ripening on and off-the-vine. The experiments were performed University of Thessaly. A split-plot RCBD was utilized with three replications whereby the nutrient system (hydroponic vs. DAQ) were the main plots and grafting (nongrafted vs. grafted) were the sub-plots. Grafting and nutrient system did not affect the titratable acidity, sugar-acid ratio, or dry matter of the fruit. Fruit from grafted plants had 6% greater SSC than fruit from nongrafted plants. Fruit from the hydroponic production system had 5% greater SSC than those grown with DAQ. Tomatoes harvested at light red and red stages had higher TA when ripened off the plant. The hydronic system produced tomatoes with 24% higher lycopene compared to DAQ. Interestingly, the grafted tomatoes had significantly lower lycopene content than nongrafted tomatoes at the red stage when they were ripened off the plant. However, lycopene accumulation was similar in grafted and nongrafted plants when fruit ripened on the plant. More research is needed to determine how the integration of these technologies will impact the quality of tomato and other fruiting vegetables commonly-grown in greenhouses. Funded provided by: Horizon 2020 Research and Innovation Program; Green Deal grant agreement No. 101037128 m PestNu

Session: PHU3a-3

Control of bitter pit in apple achieved with reduced calcium inputs

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Abstract

Bitter pit is a disorder of apple (Malus domestica) due to calcium deficiency in the fruit during development and maturation. The disorder results in fruit loss and reduced fruit quality. Calcium is phloem mobile so the majority of it is transported to the leaves rather than the fruit, where it is needed for maturation. Absorption of calcium by the fruit is linked to auxin levels, which are only high during development rather than maturation of the fruit. This work evaluated the use of the novel LoCal technology in the Albina (Levity Crop Science, UK) fertilizer that enables maturing apples to access greater amounts of calcium. The trial was conducted in the Hawkes Bay region, New Zealand during the 2020-21 growing season on Braeburn apples. The treated plots were managed commercially by the grower. The calcium applications were two industry standard products containing 1750 and 1600 grams active ingredient/ha/application for 14 applications compared to two different application timings of the new product containing 120 grams active ingredient/ha/application at 14 and four applications and no calcium application. Throughout the growing season the crop was assessed for phytotoxicity. At harvest the apple cores and flesh had mineral analysis conducted. The fruit finish was assessed at harvest. Bitter pit and flesh firmness were assessed 21 and 42 days post-harvest. There were no signs of phytotoxicity from any treatment. There were no significant differences between the levels of calcium in the apple cores or the fruit finish at harvest. All the treatments gave significantly less bitter pit than the untreated. These results show that the new products are the equal of the two industry standard products, but they achieve this with much lower levels of inputs and costs, especially for the new product with only four applications over the season.

Session: PHU3b-1

A chemometric approach to investigate post-harvest behavior of Cucumis melo phytonutrients

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Abstract

Melons (Cucumis melo) have abundant health-promoting phytonutrients; understanding how these change during post-harvest storage provides important information for preserving these phytochemicals. Three cantaloupe cultivars (Western shipper, Infinite Gold, and Da Vinci) and three honeydew varieties (Orange Casaba, HD-150, and HD-252) grown in Uvalde, Texas were tested. Fruits were stored at 10 °Cfor 20 days, and processed and analyzed at 5-day intervals for carotenoids, amino acids, and ascorbic acid using high-performance liquid chromatography. Da Vinci melons had high levels of β-carotene (24.27+-0.88 mg kg^{-1}) on day 0 of storage. Total ascorbic acid was highest in Western Shipper and Da Vinci melons on day 0 (112.82+-13.96 and 90.39+-14.43 mg kg^{-1} , respectively), which decreased at day 20 (17.67+-1.88 mg kg^{-1} , 31.33+-3.88 mg kg^{-1}), respectively. Honeydew variety HD252 showed the highest total ascorbic acid at day 5 and lowest levels at day 20. Levels of γ-amino butyric acid (GABA) were highest in Da Vinci cantaloupe at day 0 (2985.04+-79.17 mg kg^{-1}) and lowest (2426.89+-102.57 mg kg^{-1}) at day 20. Da Vinci and Infinite Gold varieties showed high total amino acid contents on day 0, which increased on day 20. Interestingly, the biogenic amines putrescine and spermidine were observed during storage. Total phenolics varied in each variety: Da Vinci showed high phenolics on day 0, Western Shipper on day 5, HD150 on day 15, and HD252 on day 20. The aroma profile of each variety was analyzed using headspace solid phase microextraction-gas chromatography-mass spectrometryand the identified compounds were classified as alcohols, aldehydes, esters, monoterpenoids (limonene, alpha-terpineol, 1,8 cineole, citronellal), and norisoprenoid (beta-ionone). The results indicate that the changes in bioactive compounds during post-harvest are influenced by melon variety and storage duration.
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Session: PHU3b-2

Evaluating nutritional quality and consumer acceptability of lettuce (Lactuca sativa L.) grown with a movable high tunnel

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Abstract

Light quality is known to affect the growth and phytochemical content of numerous crops, including lettuce (Lactuca sativa L.). High tunnel production of lettuce provides many benefits to growers including increased yield due to higher soil temperatures and protection from abiotic stressors, such as strong wind and heavy rains. However, the use of UV-blocking polyethylene films can also result in lower antioxidant capacity and phenolic content, leading to a decrease in nutritional quality compared to lettuce grown in the open-field. Movable tunnels provide the ability to expose the crop to full-spectrum light once the crop has grown to full size. Our objective was to identify management strategies to optimize yield, phytochemical production, color, safety, and consumer acceptability of red-leaf cultivar ('New Red Fire'). Lettuce was planted in a movable high tunnel April 2022 and exposed to 0, 2, 7, or 14 days of full sun prior to harvest. Total marketable yield, leaf color (L*a*b* color space), total phenolic content (TPC) and anthocyanin content were measured at harvest. Lettuce consumers (N=100) were asked to rate overall liking and various sensory attributes using continuous intensity scales, CATA, and open-ended comments. Total marketable yield and TPC were not affected. Leaf redness (a*) and anthocyanin content were significantly higher after 14, 7, and 2 days of full-sun exposure compared to 0 days. Significant differences were found in consumer liking for overall liking, color intensity, and ruffleness. The crop that was exposed to 14 days of full-spectrum light had a higher liking and more red color intensity. Using a movable tunnel system provides lettuce growers the ability to affect the color, phytochemical content, and consumer liking of their crop to varying degrees. This level of flexibility provides local, small-scale growers a crucial advantage in marketing their produce.

Session: PHU3b-3

Sensory and postharvest attributes of four blackberry varieties

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Abstract

Blackberry production and consumption has increased in the United States in the last ten years. Similarly, blackberry production acreage in Georgia has increased from 300 acres in 2009 to 818 acres in 2017. Blackberries are harvested in Georgia from June to mid-July, and the main production area is South Georgia. The most common varieties cultivated in South Georgia were developed by the University of Arkansas blackberry breeding program. However, sensory and postharvest fruit quality attributes of Arkansas cultivars grown under Georgia conditions were not previously reported. The small fruit program at the University of Georgia evaluated physical and compositional attributes as well as sensory characteristics of the cultivars 'Caddo,' 'Osage,' 'Ponca,' and 'Ouachita.' The four cultivars were harvested from a commercial farm in South Georgia. A non-trained panel (n=16) evaluated the four cultivars on appearance, texture, sweetness, overall liking, and flavor. The panelist rated each characteristic using a 9-point hedonic scale, in which 1= dislike extremely, 2= dislike very much, 3=dislike moderately, 4= dislike slightly, 5 = neither like nor dislike, 6= like slightly, 7=like moderately, 8= like very much, and 9 =like extremely. Compositional attributes like volatile organic compounds (VOC), total soluble solids (TSS) and titratable acidity (TA) were measured using a GC/MS, refractometer, and automated titrator respectively. Berry firmness and berry size were measured using a Fruitfirm 1000. The cultivar with the biggest berry size was 'Caddo,' while the cultivars 'Osage' and 'Ouachita' had a smaller berry. There were no significant differences in firmness among cultivars. Panelists rated 'Ouachita' as less sweet. 'Ouachita' flavor was liked slightly by the panelist and 'Caddo,' 'Osage,' and 'Ponca' were liked moderately. 'Caddo,' 'Osage,' and 'Ponca' were rated higher by the panelist on sweetness and flavor. In conclusion, participants liked the sweetness of 'Ponca', 'Caddo', and 'Osage' more than 'Ouachita'. Low scores from the taste panel regarding sweetness and overall liking of 'Ouachita' correlates with this cultivar's low amount of TSS and high TA value. Additionally, a higher number of panelists found less floral aroma and higher citric aroma in 'Ouachita.' 'Caddo' had bigger berries compared to the other cultivars.

Session: PHU3b-4

Influence of maturity stage on consumer perceived quality of Lane Late oranges. Relation between sensory properties and physicochemical parameters

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Abstract

It is well known that maturity stage of fruit at harvest conditions their quality. However, few studies have quantified to what extent consumers perceive the sensory changes linked to ripening and how these changes may affect their purchase intention. This study evaluates consumer response to Lane Late oranges harvested at three different maturity stages (MS). Oranges were harvested when they have reached the following maturity indexes: MS 1 =9.4, MS 2 =13.8 and MS 3 =14.9. Firmness, total soluble solids, titratable acidity, juicy yield and maturity index were evaluated the day after harvest. Besides, a sensory study was performed with 94 consumers. They described the main sensory properties perceived in each of the three samples by means of the Check-All-That-Apply test (CATA-questions). Moreover, consumers were asked to indicate their intention to purchase the oranges. Oranges at MS 1 were described as firm, very acid, juiceless, not very sweet, not very aromatic, tasteless. Thirty percent of participants indicated their willing to purchase, while 20% stated that they maybe do it. Oranges at MS 2 and MS 3 were described with attributes like intense orange flavour, sweet, refreshing taste or juicy. The term 'not very acid' was mainly used for the MS 3 -samples. Fifty percent of consumers would buy this fruit, while 20% maybe do it. Study of the relation between physicochemical parameters and sensory properties perceived by consumers was carried out by performing a multifactor analysis (MFA). It revealed a clear link between an increment in the titratable acidity and the use of the following descriptors: very acid, not very sweet, not very aromatic. In the other side of the MFA map, parameters associated with maturity such as high total soluble solids and maturity index, high juice yield and low firmness were correlated to the sensory attributes 'intense orange flavour', 'juicy' and 'sweet'.

Session: PHU3b-5

Prediction of tomato overall liking from instrumental analysis

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Abstract

Flavour is considered one of the most important drivers of consumer liking of tomatoes. The characteristic tomato flavour is the result of the interaction of a diverse set of compounds, including sugars, acids, and aromatic volatiles. Evaluating this complex flavour attribute is prone to limitations due to the cost and several technical constraints. Prediction of the outcome of a hedonic panel from the instrumental response might potentially reduce the need for sensory panels which are inherently limited by their low throughput. To tackle this issue, we developed a multivariate statistical model that can predict consumer liking by linking volatilomics data together with some classical quality measurements (Total soluble solids, acidity, colour, and firmness) to the corresponding consumer scores. In total 60 different tomato varieties were included. The relationships between the instrumental data and the overall liking values were modelled by means of partial least squares regression (PLSR). The PLS regression model predicted the overall liking score fairly well with an R 2 of 63 %. From the developed flavour model we can determine the main factors associated with consumer liking of tomato fruit. From the Physico-chemical parameters, soluble solids content was the main influential variable. The tentatively identified volatiles Acetaldehyde, 6-methyl-5-hepten-2-ol, 1-pentanol, 2-pentanal, β-Ionone, and 2-hexenal/3-hexenal were the major volatile compounds influencing tomato liking. The compounds previously mentioned have been associated with a fruity and fresh green aroma. The generated model will be implemented as part of the yearly Flemish tomato segmentation, screening new cultivars for commercial production and marketing. This should contribute to an improved selection of good flavour cultivars being introduced to the Belgium market.

Session: PHU4a-i

Trends in reefer container technology

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Abstract

I write this overview without the pretension to be complete. Yet I have been involved in the industry for more than two decades and do observe some trends, on which I will elaborate a little in this manuscript. Subjects I intend to touch upon: global fleet size, costs of a reefer container, equipment reliability, greenhouse gas emissions (direct and indirect), energy consumption, achieved energy savings, potential for further energy savings, reefers as thermal batteries in a smart grid, hot stuffed cargo, temperature uniformity, controlled atmosphere, ethylene, internet of things, in-transit ripening, vulnerability of global supply chains, end of life for reefer containers, life cycle assessment. As future trends I foresee: respiration monitoring, low GWP refrigerants, continued costs optimization (= reduction of GHG emissions if the right incentives are in place), digital twins to predict fruit quality, variable speed evaporator fans.

Session: PHU4a-1

Predictions of postharvest quality of orange fruit towards the implementation of an intelligent logistic management system

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Abstract

Fruit and vegetables are usually stored according to the First In First Out (FIFO) method, thus the marketing decisions are based on storage duration alone. The objective of the current study was to examine the effects of various pre-harvest and postharvest factors on the quality of late-season oranges and develop quality prediction models in order to promote the implementation of the First Expired First Out (FEFO) method, that provides a more efficient logistic management system. The experiments were conducted on late-season 'Rustenburg' Navel and 'Valencia' oranges purchased from a commercial citrus packinghouse. The pre-harvest factors included different harvesting periods, tree ages, yields, and rootstocks. The postharvest factors included different storage temperatures and humidity's. Fruit quality evaluations were conducted at harvest and at one- or two-week intervals during a 20 week prolong storage period, and included measurements of fruit weight loss, firmness, color, development of decay and peel damage, TSS, acidity, vitamin C, flavor acceptance, ethanol accumulation, and overall acceptance score. The achieved results served as a large database for the development of fruit quality prediction models at different time points under the different pre-harvest and postharvest storage conditions. The developed model will allow the implementation of a novel decision support system for intelligent logistic management for storage and marketing of late-season oranges.

Session: PHU4a-2

Digital twin for monitoring citrus fruit quality during overseas container shipments

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Abstract

In this research, we focus on citrus fruit export from South Africa to Europe, which is characterized by a long postharvest chain. During overseas transport, the conditions, like air temperature and relative humidity, should be well controlled to prevent fruit losses and maximally maintain fruit quality. However, no shipment evolves the same, both in transportation time and applied conditions. Consequently, the fruit quality upon arrival of the shipments will differ. Currently, we do not know where, when and how much quality is lost during each shipment. Measuring fruit quality experimentally for a sufficiently large amount of fruit samples after each transport is not possible on commercial shipments as this is a time-consuming, expensive, and destructive task. Digital twins, which are virtual representations of the fruit that are linked to the 'real world' by sensor data, can close the knowledge gap by numerically converting the measured sensor data into fruit quality. In this study, a digital twin was developed for refrigerated containers filled with 'Valencia' oranges for export from South Africa to Europe. Sensor data of overseas shipments were used as input to the model. As a result, the quality of each fruit inside the container including multiple quality attributes, such as overall quality, remaining shelf life, TSS, TA, firmness, moisture loss, chilling injury, and pest mortality, was mapped for different shipments. As such, we quantified the expected quality heterogeneity both within and between different shipments. This insight makes it possible to pinpoint where quality issues are likely to occur and to better manage product handling upon arrival. The digital twin developed in this research acts as a first step towards real-time monitoring of fresh produce shipments and will be further extended to cover the entire export chain.

Session: PHU4a-3

Quality decay model with multinomial logistic regression and image-based deep learning to predict the firmness of conference pears

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Abstract

Traditional quality-decay models (e.g., multinomial logistic regression) for fruit quality classification deals with tabular data which focus mainly on the storage parameters such as storage duration and conditions (D&C). Those parameters have the effects on quality decay at an aggregate scale across different experimental levels; they are not good at capturing the variations within each experimental level. This may restrict the predictive power of the traditional model. On the contrary, image-based deep learning models are dealing with individual products and can extract the deep features of each fruit to provide individual-based quality information, but lack information regarding the post-harvest conditions (time of harvest, storage conditions etc.). In this research, we investigate the combined performance of the multinomial logistic regression with the image-based convolutional neural network (CNN) for conference pears' quality prediction (measured by firmness) where the extracted deep features are used as the explanatory variables for the logistic regression model. The results show that combining deep features with D&C parameters are likely to improve the predictive power of the logistic regression model to predict the firmness of the conference pears. The managerial implications as well as future research directions are also discussed.

Session: PHU4b-1

Salicylic acid preharvest treatment improves green pepper fruit quality and antioxidant capacity during postharvest storage

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Abstract

Salicylic acid (SA) is considered as a phytohormone with a wide range of physiological effects on plant tissues, from germination to flowering, although the most studied ones are the induction of systemic acquired resistance (SAR) and resistance against abiotic stresses. The main aim of the present study was to evaluate the effect of SA preharvest treatment on quality and functional parameters of the whole green pepper fruit at harvest and after 21 days of storage at 7 °C. In 2020 season, SA as preharvest treatment was applied at 0.5, 1 and 5 mM concentration by foliar spray on green pepper plants (Capsicum annuum L.), 'Herminio' cultivar. Based on the results obtained in this season, the most effective concentration of SA on increasing the parameters studied was repeated throughout the developmental and maturity cycle in 2021 season. Physico-chemical and functional parameters were analysed in 3 replicates of 6 green pepper fruits (18 fruits in total per treatment). Results showed that SA significantly reduced the respiration rate and weight losses of green pepper fruits compared to control at harvest and during postharvest storage. On the other hand, fruit colour and firmness were significantly improved by SA at 0.5 mM after 21 days of storage at 7 °C. In addition, those SA treated green pepper fruits showed the highest total acidity, especially for 0.5 mM concentration. However, no significant differences were observed among treatments on total soluble solids content. Regarding the functional quality, phenolics, hydrophilic and lipophilic-total antioxidant activity were significantly increased during 21 storage days at 7 °C in SA treated fruits, being the highest increment observed in 0.5 mM dose. These results were corroborated in 2021 season for 0.5 mM SA treatment. In conclusion, the foliar application of 0.5 mM SA to green pepper plants has a significant effect on increasing green pepper fruit quality parameters and its antioxidant capacity at harvest and after 21 days of storage at 7 °C.

Session: PHU4b-2

Putrescine foliar application improves ‘Sunburst’ sweet cherry quality during cold storage

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Abstract

Sweet cherries (Prunus avium L.) are one of the most appreciated fruits worldwide for their organoleptic properties and nutritional value. Moreover, sweet cherries are a good source of bioactive compounds with high antioxidant, anti-inflammatory and anticarcinogenic activities, mainly due to polyphenols, which can have beneficial effects on human health. Putrescine is a type of polyamines, which are classified as plant growth regulators (phytohormones). Therefore, putrescine has the ability to intervene in a wide range of physiological and biochemical processes such as cell division, embryogenesis, fruit development and fruit ripening, among others. Furthermore, putrescine is involved in the defense reaction of plants against biotic and abiotic stress conditions. The present study was carried out in a commercial plot of sweet cherry in the mountains of Alicante and the main objective was to evaluate the effect of preharvest treatment with putrescine (Put) at concentrations of 0.01, 0.1 and 1 mM on sweet cherry quality, 'Sunburst' cultivar, during its postharvest storage. Treatments were applied by foliar spray at three key moments along fruit growth and ripening cycle, namely, stone hardening, colour changes and four days before harvest date. Sweet cherries were harvested in accordance with the company's commercial criteria and were stored for 28 days at 2 °C. Throughout postharvest storage, the following parameters were evaluated: weight loss (%), firmness (N mm 1), colour (hue angle), total soluble solids (TSS) content, total acidity (TA), total anthocyanin and phenolic contents. Regarding the results, weight loss was significantly delayed with the Put 0.01 µM treatment compared to the control. However, fruit firmness showed no significant differences among the treatments evaluated. On the other hand, treatment with Put 0.01 µM significantly increased external color of the fruits, TSS content and TA. Finally, the content of total anthocyanins and total phenolics increased significantly in cherries treated with Put 0.01 µM after 28 days of cold storage, compared to the control fruit. In conclusion, Put 0.01mM treatment could be an environmentally sustainable tool capable of increasing the shelf life of 'Sunburst' cherries, while improving the organoleptic quality parameters of the fruit and increasing the content of bioactive compounds during post-harvest storage. It is worth highlighting the great importance of this study due to the scarcity of scientific studies on the evaluation of the application of exogenous putrescine in pre-harvest during cold storage.

Session: PHU4b-3

Effect of Pre-harvest Foliar Applications with Methyl Jasmonate on Sweet Cherry Cracking in Different Growing Seasons

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Abstract

The onset of rainfall during sweet cherry development can cause serious pre-harvest losses due to fruit cracking on tree. Therefore, rainfall at specific phenological stages can affect fruit quality and total yield. Some cultivars are particularly susceptible due to the incidence of persistent rain during the most advanced phenological stages. This study focuses on the pre-harvest application of methyl jasmonate (MeJa) at different key points to reduce the incidence of sweet cherry cracking during ripening on tree and the influence of the phenological stage in which rainfall is coincident. In addition, these fruits have a short shelf life during post-harvest storage. Therefore, in this study, we propose pre-harvest foliar applications with 0.5 mM MeJa on different sweet cherry cultivars ('Prime Giant', 'Early Lory', 'Sweet Heart' and 'Staccato') to evaluate the influence of this natural elicitor on cracking tolerance during sweet cherry development on tree and at harvest time during several growing seasons. After studying the results, we found that pre-harvest treatments were successful to reduce fruit cracking and improving post-harvest quality. In addition, it delayed fruit ripening on tree in general for the cultivars studied and this effect was maintained also during post-harvest storage. This delay in ripening could be an interesting factor in terms of plot management, and therefore helpful in the adaptation to climate change providing on the other hand, sweet cherries with higher quality during post-harvest storage.

Session: PHU4b-4

Pre-harvest application of sodium benzoate for fungal decay control in lemon fruit

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Abstract

The limitations of the use of pre- and post-harvest products in the lemon industry, as well as the companies needs to access to the international market, makes it necessary to research about new tools that allow the reduction of fungal decay and the improvement of the fruit quality. The main postharvest diseases of lemon fruit are due to the presence of phytopathogenic fungi, responsible of important economic losses. Currently, this problem is controlled with the application of synthetic fungicides, however, their use is increasingly restricted due to their impact on consumer health and the environment. Among the main low-toxicity chemical alternatives, the food additives have been studied. Thus, the aim of this work was to evaluate the effect of pre-harvest treatment with sodium benzoate (SB) to reduce rot incidence and improve 'Fino' lemon cultivar quality. Experiments were carried out during two consecutive seasons (2021-2022). During the first season, treatments were applied by foliar spray at three different concentrations (0.5, 1 and 3 % w/v). The quality and functional parameters were analysed at harvest and during 35 days of cold storage at 10 ºC. Moreover, the decay incidence was studied during this period. The results showed a reduction in rots in SB-treated fruits, and an improvement in some quality parameter. However, SB-treated lemons presented higher weight loss, respiration rate and lower firmness than control fruit related to the stress caused in the fruit. Based on those results, during the second season, an optimization of BS pre-harvest treatment concentration was carried out, selecting 0.1 % and 0.5 %. Therefore, pre-harvest application of sodium benzoate could be considered as an alternative tool to the use of synthetic fungicides for the control of fungal decay in lemons and the improvement of their shelf life.

Session: PHU4b-5

Preharvest putrescine treatment improve blood orange commercial quality during storage at 8°C

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Abstract

Blood orange (Citrus sinensis L.Osbeck) is a non-climateric fruit that has a rich source of bioactive compounds such as anthocyanins, flavonoids and ascorbic acid. Skin anthocyanin content is considered an important quality index of blood orange as external red color is the main characteristic that influences blood orange fresh consumption. Previous researches have demonstrated that pre- and post-harvest treatment with putrescine (Put) increased anthocyanins content in different fruits. Therefore, the main aim of this research work was to assess the effect of preharvest foliar spray putrescine treatments, at three concentrations (0.01, 0.1 and 1 mM), on blood orange quality, at harvest and during 40 days of storage at 8ºC. Different quality parameters (weight loss, firmness, external and internal color, respiration rate, total soluble solids (TSS), total acidity (TA) and anthocyanins in juice) were measured at harvest and during 40 days of postharvest storage at 8ºC. Results showed that all Put treatments significantly delayed weight loss and the fruit softening during storage. Moreover, all the concentrations tested significantly reduced the hue angle, both on the external fruit surface and fruit flesh, as well as significantly increased anthocyanins juice content, especially for the 0.01 mM concentration. On the other hand, all the treated fruits also showed a higher amount of TSS and TA respect to the control, being the 0.01 mM the best concentration. In conclusion, results showed that a preharvest foliar spray treatment with Put improved commercial quality on blood oranges and preharvest treatment with Put at the concentrations of 0.01 and 0.1 mM could be effective on maintaining quality parameters during postharvest storage at 8 °C on blood oranges. This strategy could be of interest in other blood orange cultivars and/or fruit species, although further research is needed.

Session: PHU5a-1

Determination of taste in strawberries through the use of non-destructive sensors

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Abstract

Continuous assurance of product quality is important to achieve sustainable added value within a specific market segment. Not only how the product looks like, but also how consumers appreciate the taste. In case of disappointing taste, the repeat purchase will not occur, while a consistently good taste will stimulate the choice for a healthy product. Compared to processed food, there is a lot of unwanted variation in taste in fresh fruits and vegetables. In these type of supply chains, there is an increasing need for a method to measure the pleasantness of taste objectively, non-invasively and quickly. Previous research determined liking of the taste of strawberry fruit by combining the input of analytical methods of various quality traits (measured destructively) such as brix and acidity, with sensory information obtained from consumer and sensory panels. In order to deal with the inherent variation existing in consumer data, the present study incorporated the use of two artificial strawberry flavoured sirop-based juices -referred here to as reference juices-. These reference juices, each one with a different sugar level content, were given to the participants with the purpose of calibrating panelists during the taste sessions. Preliminary results show that the liking of the reference juices was correlated with the liking of the strawberry samples. Additionally, this research takes a step forward by adding the use of non-destructive technologies, namely N ear I nfra r ed (NIR) spectroscopy with the aim of predicting strawberry taste in a non-invasive manner. The development of a non-invasive flavour model would provide a quick, reliable and real time prediction of how pleasant the taste of an actual strawberry is -on a fruit-level basis-, supporting better decision-making processes for all the different stakeholders in the supply chain.

Session: PHU5a-2

Non-destructive detection of microstructure in pome fruit with X-ray dark field radiography

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Abstract

Pome fruit are prone to postharvest disorders that are caused by microstructural changes such as cell damage and cavity formation. Detection of microstructure may thus be helpful for sorting and storage management of fruit. Today microstructure measurement is cumbersome and involves destructive sampling and advanced imaging methods such as high resolution microscopy or X-ray micro-CT. However, grating-based phase contrast X-ray imaging (GB-PCI) has appeared as a means to generate X-ray scattering caused by the tissue microstructure and render so-called dark field images that capture the scattering on radiographs directly. In this contribution, this novel imaging method is explored and the dark field images are correlated to microstructure properties measured by high resolution micro-CT. Apple (cv. Braeburn) and pear (cv. Celina) fruit were harvested late and a batch was immediately used for GB-PCI of fruit slices. Subsequently small tissue samples were extracted for X-ray micro-CT imaging to investigate the fruit microstructure. The rest of the fruit was stored in optimal and disorder inducing controlled atmosphere gas conditions. After six months, the fruit was investigated using the same procedure of GB-PCI and micro-CT imaging as described before. Statistical analysis was conducted to correlate microstructural features with dark field signal. Intact fruits were additionally scanned using GB-PCI. The dark field images of both sliced and intact fruits indicated higher contrast between healthy and defect regions compared with corresponding transmission images. The micro-CT results showed clear differences in tissue morphology between healthy and damaged fruit tissue. Damage of the fruit tissue appeared as either flooding of tissues or cavity formation and affected changes in the dark field signal, which appeared different in apple and pear. Detailed statistical analysis of the results revealed how microstructure of stored pome fruit and X-ray scattering could be related.

Session: PHU5a-3

Tomato (Solanum Lycopersicum) shape classification with deep learning AI-algorithms

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Abstract

On the Belgian fresh market different varieties of tomatoes (Solanum Lycopersicum) are commercialized within different market segments according to size and shape. An important tomato shape descriptor is called 'groovedness', a specific descriptor used to describe the amount and depth of the grooves or notches mainly found on the crown side of the tomato. A 4-level scale was created for classification of this shape attribute: (1) tomatoes are perfectly round, (2) tomatoes appear 'lightly grooved', which indicates that some grooves are present, (3) tomatoes appear 'grooved' and have more and deeper grooves that run through the equatorial plane and (4) tomatoes are 'ribbed' in which they have distinct notches in the fruit surface and a tomato has lost its round shape. A dataset of images of tomatoes that were scored for groovedness by an expert panel was collected to train a deep learning AI-algorithm. A preprocessing step was applied to size and correct RGB-color information before training the model. Image augmentation consisted of rotating the images, which created additional input for the model. Models using images taken from the crown side performed better then models using images from the equatorial plane. A model accuracy of 75,3% was found using the crown side images, although 95% of the misclassified images only differed one class. In general the 'lightly grooved' tomatoes were more difficult to distinguish from the 'grooved' tomatoes, while the extreme classes were more easily distinguished by the algorithm. This also became clear when comparing the classifications performed by an expert panel as they too find it harder to distinguish between the middle classes. Comparing the AI-algorithm with the expert panel showed that the algorithm was equally good at classifying images into the different classes, with the added benefit that the AI-algorithm is user independent.

Session: PHU5a-4

Use of optical coherence tomography (OCT) to detect and quantify changes during shrivel development in kiwifruit

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Abstract

Shrivel is a common postharvest storage quality problem in kiwifruit. It is characterized by wrinkled skin and deformation of the fruit surface. Shrivel is associated with water loss; generally, fruit is at risk of shrivel when approximately 4 n 5% of the at-harvest fresh weight has been lost during storage (Burdon & Lallu, 2011). However, some fruit with high levels of water loss (>5% weight loss) may not show shrivel symptoms, suggesting that shrivel may be related to other fruit parameters including tissue structure. Typically, shrivel symptoms are evaluated by imprecise, subjective visual assessment (Burdon et al., 2014); comparatively, optical coherence tomography (OCT) could provide an objective method of evaluation. Optical coherence tomography is a fast, non-invasive, real-time, in-vivo technique that allows the acquisition of consistent and high-resolution two-dimensional (2D) and three-dimensional (3D) images of near-surface internal structures. This technology has been used to evaluate the near-surface cellular structure of various fruit (Li et al., 2019), including kiwifruit (Li et al., 2015). This research utilised OCT to identify parameters related to shrivel development. Kiwifruit from several cultivars were stored for up to 8 weeks at 1°C and 10°C (55 n 85% RH) to induce a range of shrivel symptoms. An OCT system with 820 nm central wavelength and 5.5 µm resolution was used to monitor changes in the near-surface structure of kiwifruit over the course of storage during shrivel progression. The acquired OCT images were processed before analysis by averaging, smoothing, filtering, thresholding, and binarization. The changes in the internal structure were analysed by obtaining parameters such as the attenuation of the intensity with depth, surface roughness, and cellular morphology parameters. The feasibility of OCT to detect and quantify shrivel in kiwifruit will be discussed.

Session: PHU5a-5

Non-destructive estimation of sugar content and acidity in apple fruits based on Vis/NIR spectroscopy and hyperspectral imaging

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Abstract

Sugar content and acidity are one of the most important quality factors in apple fruits and are commonly used as references in the sorting systems of apple fruits. In this research, non-destructive methods for the estimation of sugar content and acidity of Fuji apple fruits were suggested based on Vis/NIR semi-transmittance spectroscopy and hyperspectral imaging techniques. Spectra over 400-1000 nm were measured using a semi-transmittance acquisition system, and 400-1700 nm were measured from a reflectance hyperspectral imaging system. With the spectral data, multivariate regression modeling was performed for the prediction of sugar content and acidity values of the apple fruits based on partial least squares regression. Different kinds of preprocessing methods including standard normal variate (SNV), and multiplicative scatter correction (MSC) were applied, as well as different variable selection methods including variable importance in projection (VIP) and competitive adaptive reweighted sampling (CARS) algorithm. From the prediction models, correlation of each wavelength to the sugar content and acidity was evaluated and characteristic wavelengths were selected.

Session: PHU5a-6

A comparison between Visible-NIR spectroscopy and laser Doppler vibrometry for the assessment of mango fruit ripening

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Abstract

The UK alone imported 55,000 tonnes of mango (Mangifera indica L.) in 2020, with industry estimating that 10-15% of these fruits are lost before packaging; primarily due to uneven ripening and chilling injury. Currently, assessment of ripening stage is done through destructive testing, which can be both subjective and time-consuming. This creates further losses, and does not account for variability within a shipment. The use of non-destructive technologies can allow assessment of internal quality traits without creating these losses. They also allow a larger number of fruits to be assessed, meaning that variability can be better accounted for. Visible and near infrared spectroscopy (vis-NIRS) uses the absorbances of biochemical markers, such as sugar, water, and phenol content, to predict consumer-valued quality traits including ripeness. However, the biochemical composition can vary within a single fruit, meaning point measurements can give more limited information. Laser Doppler vibrometry (LDV) measures the resonant frequency of a fruit, which is influenced by the texture, and hence has been used to estimate ripeness. However, this technique gives a single measure for the fruit, which contains different textures (both spatial variation in the pulp, and between pulp, skin, and stone). This study compares the efficacy of vis-NIRS and LDV as non-destructive technologies for assessing mango fruit ripening after cold storage. Here, we investigate i) the physiological and biochemical changes (i.e., firmness, internal colour, and individual sugar content) spatially and temporally, during cold storage and subsequent ripening; and ii) how analysis of both vis-NIRS and LDV data collected on fruit imported through the industry supply chain can be used to classify mango fruit according to their ripening stage. Better understanding of the strengths and limitations of each method will allow for the selection of the most suitable non-destructive technology, to deliver consistent quality and potentially reducing waste.

Session: PHU5b-1

The molecular and genetic basis of 'salad' rocket (*Eruca vesicaria* subsp. sativa) taste and flavour

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Abstract

Salad rocket (Eruca vesicaria subsp. sativa) is a rich source of sulfur-containing metabolites called glucosinolates (GSLs). GSLs and their breakdown hydrolysis products are known to impart the characteristic taste and flavour of the crop. Understanding how plant phytochemical and human taste perception genotypes interact is key to developing cultivars with improved sensory quality. First and second cut Eruca leaves, and postharvest time points (day 0 and day 5) were subjected to sensory analysis by two trained sensory panels of varying TAS2R38 bitter taste receptor and CA6 fungiform papillae density (FPD) genotypes across two cultivation regions (Italy and United Kingdom). We hypothesised that taste sensitive ('supertaster') individuals are less able to perceive aromas and flavours due to heightened perception of bitterness. Data showed flavours important to the quality of Eruca are associated with growth environment, gene expression, sulfur availability, and phytochemical composition; specifically, GSLs and hydrolysis products. TAS2R38 'non-taster' individuals scored traits such as 'burnt' and 'soapy' flavour significantly higher than taste sensitive individuals. Similar observations were made for FPD genotype, with G/G (low FPD) individuals scoring aroma and flavour traits significantly higher than A allele individuals. The data support our hypothesis that individuals with functional TAS2R38 and CA6 genes cannot perceive aroma and flavour traits as strongly as 'non-tasters'. These observations are possible evidence of an evolutionary trade-off in the ability to perceive aroma and flavour in individuals with increased bitter taste sensitivity.

Session: PHU5b-2

Anaerobic metabolism affected by storage conditions in different apple varieties

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Abstract

The anaerobic metabolism of apples leads to acetaldehyde, ethyl acetate, and ethanol accumulation in the fruit. These volatile compounds change during the period of fruit maturation and storage conditions. Under hypoxic storage conditions, some apple varieties can also produce acetaldehyde, which is reduced to ethanol. Finally, the alcohol acyltransferase (AAT) enzyme transfers an acyl group from acyl-CoA to the OH group of an alcohol to form an ester. Storage techniques such as CA (controlled atmosphere) like ultra-low oxygen (ULO) and DCA (Dynamic controlled atmosphere) allow apple storage under low O 2 partial pressures. These conditions can produce acetaldehyde, ethyl acetate, and ethanol through anaerobic metabolism. Therefore, this study aims to determine the effects of regular air (RA), ULO, and DCA-CD (carbon dioxide) on acetaldehyde, ethyl acetate, and ethanol accumulation in apple flesh pulp after 8 months of storage plus 7 days of shelf-life in 5 different apple varieties: 'Santana', 'Braeburn', 'Jonagold', 'Pinova', and 'Red Prince'. Volatile compounds were collected using solid-phase microextraction (HS-SPME) and analyzed using GCMS. Ethyl acetate was found in the highest quantity in all 5 varieties, followed by acetaldehyde and ethanol. DCA-stored fruit showed higher acetaldehyde, ethyl acetate, and ethanol than fruit stored in ULO and RA. The results show that the low O 2 storage induces the production of these anaerobic respiration compounds for selective apple varieties. Acetaldehyde, ethanol and ethyl acetate may be noxious for the fruit tissue and may negatively influence fruit quality maintenance. A noteworthy fact is that ethanol in low concentration can reduce the ripening process However, Acetaldehyde, ethanol and ethyl acetate are also known to be precursors for several volatile compounds. Therefore, it can be concluded that the impact of acetaldehyde, ethanol and ethyl acetate may differ based on the storage condition and the fruit varieties. The storage conditions with a low level of O 2 may increase the content of acetaldehyde, ethanol, and ethyl acetate. If the content of acetaldehyde, ethanol and ethyl acetate is to higher, this may induce the off flavour in the fruit. Although ethanol production can reduce the ripening process in low concentrations, it may also increase the aroma content in the fruit under these low-O 2 level conditions.

Session: PHU5b-3

The use of herbicides to study fruit aroma biochemistry

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Abstract

For over 50 years a relationship has been known to exist between branched-chain amino acids and the characteristic branched-chain volatiles of fruits. Throughout this period the relationship was largely thought to be catabolic in nature, suggesting that amino acids, scavenged from senescence-driven protein degradation, are catabolized into volatiles. This dated dogma can now be unequivocally dismissed. Through the application of commercially available herbicides that inhibit the enzymes that are responsible for de novo flux into the branched-chain amino acid pathways we have demonstrated that the precursors that become branched-chain esters in fruits are not the result of catabolism, but are actually produced through actively engaged biosynthesis. On average, 2-methylpropyl and 3-methylbutyl acetate esters were reduced 48 and 10-fold, respectively, in herbicide-treated banana fruit. This was complemented with a 7 and 1.5-fold decrease of valine and leucine, respectively. Similar trends were observed in apple fruit with regards to 2-methylbutyl esters and isoleucine. Furthermore, the use of this newly purposed tool has revealed a novel pathway for the production of butyl esters in banana fruit and has led to insights into the aroma biochemistry of plantain and quince fruits.

Session: PHU5b-4

Study of volatile organic compounds, organic acids, firmness, sugars in stored ‘Royal Gala’ apples

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Abstract

The British apple industry is continuously asked by domestic retailers to extend availability; this being achieved by implementing ever more sophisticated storage technologies, but the industry is challenged by imports. In order that primary production of UK apples can be fully utilised and be made more competitive, a paradigm shift is needed to improve how apples are stored such that the focus is moved towards 'flavour-life' rather than being just driven by firmness and sugar content. This work studies storage interventions, in order to control ripening whilst maintaining 'flavour-life'. This offers a route to incremental storage extension to help reduce the reliance on imports and extend the window in which high quality fruit can be offered. In this study, 'Royal Gala' apples were evaluated under different storage conditions for 20 weeks and sampled every three weeks. They were taken from dynamically controlled atmosphere (DCA) or air, respectively, combined with or without the addition of 1-MCP, an ethylene inhibitor. Ripeness indicators and volatile organic compounds (VOC) were measured after one week of shelf life. The results have shown that DCA in combination with 1-MCP has positive effects in retaining firmness and organic acid content during shelf life after removal from storage. DCA storage maintained a higher sugar concentration in apples. In general, the VOC concentrations in apples was found to be close to 0 after one month DCA storage. Apples under this treatment showed increased VOC after a month in only a few compounds, which are not typically associated with a ripe 'Gala' smell. Apples stored in air showed a trend to have higher VOC concentrations, this included compounds with unpleasant aroma as well as a typical 'Gala' smell; however, not all differences were significant, so that further studies are required to improve flavour of stored apples.

Session: PHU5b-5

The progression of programmed cell death hallmarks in low oxygen-treated ‘Conference’ pear tissue

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Abstract

Pear fruit (Pyrus communis cv "Conference") is one of the most valuable commercial crops in Belgium. Since fruits continue important metabolic processes like respiration, postharvest storage conditions aim to extend shelf-life through low temperatures, hypoxic conditions, and slightly elevated carbon dioxide. Unfortunately, disorders including internal browning and cavity formation are commonly induced, indicating a type of local cell death. However, limited understanding of the molecular regulation behind postharvest disorder development in pear fruit remains a major challenge. Our hypothesis would be that this process is controlled through the process of programmed cell death (PCD). To verify the potential role of PCD in the pore and cavity formation in pear fruit during postharvest storage, 'Conference' pear tissue slices were subjected to different hypoxic conditions (21 % O 2 as control, 3 % O 2 , 0.5 % O 2 , and 100 % N 2) and sampled over a 72 h period. A set of PCD hallmarks or cellular features indicating that PCD has been initiated or completed, were tracked throughout the experiment. To detect membrane permeabilization, Evans blue staining showed 21 % O 2 and 0.5 % O 2 -treated tissue to have the greatest dye uptake, followed by N 2 -treated tissue. Nuclear changes and DNA fragmentation, detected by DAPI (4′,6-diamidino-2-phenylindole) and Terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) assays, respectively, indicated a significant difference in the cell death rate of all treatments versus 3 % O 2 -treated tissue. Needless to state that these early signs of PCD in response to low oxygen stress were observed prior any visual pore formation. Transcriptomic analyses of PCD-related genes is ongoing to resolve the molecular events underpinning the different treatments. In future work, pear fruits during long-term storage will also be characterized in relation to oxygen gradients present in bulky fruit.

Session: PHU5b-6

Evaluation of a ripening gradient across the blood orange fruit at ten maturity stages

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Abstract

Fruit color is the first characteristic perceived by consumers and, therefore, is one of the key factors influencing market value. In the case of blood oranges, the changes in color that take place during ripening are related to the synthesis and degradation of three major pigments, namely chlorophylls, carotenoids and anthocyanins. Chlorophylls are the predominant pigments in the green skin of an unripe citrus fruit, while the yellow-orange colors , of a mature fruit are due to carotenoids and the purplenred colors of flesh and rind in some citrus cultivars are due to anthocyanins. In the present experiment, a ripening gradient across the blood orange fruit, cv. 'Sanguinelli', at different maturity stages (S1 to S10), was evaluated. These ten maturity stages of blood orange fruit were chosen according to the external fruit colorand each fruit was cut into 4 sections from the flower bud to the distal zone, in which total soluble solids (TSS), total acidity (TA), internal color and the content of total anthocyanins in juice and rind were measured. Results showed that the external hue angle significantly decreased from S1 to S10, leading to a color change from green to orange and, then, to red. On the other hand, differences on internal color among sections were only significant after the S5, where the sections 2 and 3 showed a different color than sections 1 and 4. On the other hand, both sections 2 and 3 also showed the higher amount of TSS, being this difference greater from S7. Similar results were observed on the TA content, since the higher differences were obtained at S7 and the sections 2 and 3 were those with the higher TA values. Finally, the content of total anthocyanins of juice and skin was significantly higher at sections 2, 3 and 4 from the S1, and the higher differences were observed at the intermediate stages in our scale (S5-S8) since these differences were minimized at the most advanced stages of maturity. In conclusion, results show that maturation along the longitudinal section of blood orange fruits evolves in a different way, starting at sections 2 and 3, that is to say in the central sections of fruit and going on distal and basal sections.

Session: PHU6a-i

Interdisciplinary omics studies to improve fruit quality and storability

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Abstract

Fruit quality can be defined by the achievement of four key factors: appearance, flavour, texture, and nutritional properties. Although the importance of these factors can hardly be underestimated, breeding efforts have historically been oriented to improve mostly fruit appearance and productivity. However, often, selection for yield, fruit size, colour, and shelf life properties has unintended negative consequences on other fruit quality traits, such as taste and aroma. Defining and quantifying these quality components, in relation with distinct segments of the production chain, needs comprehensive investigations and a tight synergy of analytical approaches, with a particular focus on rapid and multi-omics methods. Understanding the stability of each quality trait during different storage and growing conditions may allow a better definition of future breeding strategies aimed, for example, at the selection of accessions suitable to improve distinct market sectors. During this presentation we will address several analytical methodologies, developed in recent years at the Edmund Mach Foundation labs, for the objective analysis of the most relevant qualitative aspects of fruit and vegetables. In particular, we will show how methods for the analysis of texture, and primary and secondary metabolites of fruit have been developed and applied. Specific attention will be paid to the application of direct injection mass spectrometry techniques (i.e. PTR-ToF-MS) for the analysis of volatile compounds, in order both to define the aromatic component of a product and to determine possible biomarkers applicable in physiological, genetic, and postharvest studies. In our institute, this synergism of novel analytical omics approaches is fully applied into the breeding activities of several fruit species (i.e. blueberry, apple, grape, raspberry and strawberry) in order to develop new cultivars characterized by both prolonged storability and high perceived quality. Moreover, this research approach is valuable to deeply investigate and step forward in the comprehension of the genetic and physiological aspects controlling fruit quality, especially during the postharvest phase. In our opinion, this knowledge would enable, in a close future, for a more precise selection of the most favourable new accessions distinguished by superior fruit quality, and for the development of more cultivar-tailored postharvest strategies.

Session: PHU6a-1

A global understanding of calcium postharvest action during kiwifruit ripening

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Abstract

Kiwifruit postharvest ripening has been reported to be related to calcium (Ca), however the underlying mechanisms by which Ca regulates this process remain largely unknown. In the present study, 'Hayward' kiwifruit harvested at the commercial stage and immediately dipped in 2% CaCl 2 . Afterwards, fruit cold stored (0 °C) for 3 months and the subsequent ripening traits were evaluated at 20 °C for 7 days. Calcium treated kiwifruits exhibited higher Ca concentration and intracellular calcium (Ca 2+) fluoresce signals in outer pericarp and placenta that accompanied by a reduction in softening and ethylene production. Fluorescent microscopy with cell wall primary antibodies showed that de-esterified homogalacturonans (HG) (antibody LM19) was increased while arabinogalactan proteins (AGPs) (antibodies LM19 and LM30) were depressed in Ca-treated fruit. Metabolomic analysis revealed that 27 primary metabolites (i.e. glucolic acid, oxoproline and galactinol) were altered by Ca in pericarp tissue. RNAseq analysis performed either at early (12 hours) or late (3 months of cold storage) period following Ca dipping identify 89 and 370 differentially expressed genes that mainly involved in ethylene, calcium and cell wall metabolism. Also, Ca-exposed fruit was characterized by elevated abundance of numerous (> 890) proteins, notably at the late period. Weighted correlation and network analysis based on the integration of transcriptome, metabolome and proteome datasets identified candidate modules involved in the Ca postharvest action in kiwifruit. These results provide basic information regarding the Ca function in fruit ripening, which may be helpful for kiwifruit postharvest control.

Session: PHU6a-2

Transitional changes of the spatially distributed ROS metabolism in apple fruit during storage and shelf life

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Abstract

Low oxygen stress can, depending its severity, induce various levels of ROS production. Even under normoxic conditions, the diffusion resistance of the fruit skin and underlying tissues induces a gas concentration gradient towards the center of the fruit. As a result, hypoxic stress will increase when moving from the outer into inner tissues. The aim was to study the impact of such spatial gradients especially during the transitional phase of fruit moving from one gas condition to the next. The spatial distribution of ROS metabolism was evaluated analyzing four radial samples of 'Greenstar' apple with flesh samples taken along an equatorial radius. Two experiments were performed. One during the initiation of CA storage and one during the initiation of shelf life after extended CA storage. The main players involved in the ROS metabolism were measured (O 2 ●- , H 2 O 2 , TPC, AsA, SOD, CAT, APX, MDA, and PPO). Depending on the component different spatial gradients were observed either or not changing over the 14 days of the experiment. The differences in tissues characteristics and gas gradient between inner and outer samples can explain the typical radial pattern of ROS metabolism in apples under low oxygen stress. Samples from the different locations were differently prone to oxidative burst indicating different levels of oxidative stress. The adaptive response of the apples was largest during the initiation of CA. This study is a step towards a better understanding on spatial gradients affecting the localized metabolic process in general and it provides detailed insights in the ROS metabolism during the initiation of low oxygen storage.

Session: PHU6a-3

The Role of Crisper-Cas9 In Post Harvest, Biotic and Bbiotic Stress

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Abstract

Food security has been currently threatened by the rapidly increasing population and the limitations of agricultural production due to global climactic change. Postharvest losses are also an essential contributor to food insecurity. The short shelf-life of fresh agricultural production leads to take place an enormous amount of postharvest waste. Obviously, approximately 35% of the fresh product has been lost before consumption. Improving crop characteristics including disease resistance, drought tolerance, and resilience to heat and salinity stress as well as extending shelf life could be a serious alternative to face climatic change. In the latest decades, the rapid progress in molecular biology accelerates using genome editing techniques extensively. Clustered regularly interspaced short palindromic repeats "CRISPR" game-changer associated protein (Cas9) is the most common genome editing technology which provides various opportunities to engineer desirable crop traits. The CRISPER-Cas9 system enables the editing of genes in a targeted genome region with high accuracy and efficiency. With precise genome engineering and transgene-free applications, it is predicted that CRISPR can face the main difficulties of crop improvement. This review will focus on the role of CRISPER in reducing plant stress to biotic and abiotic stress. Additionally, the effect of CRISPER on extending the shelf life of some agricultural products will be highlighted in the review.

Session: PHU6a-4

Influence of firmness measurements by dehydration and ripening depends on both measurement device and fruit type

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Abstract

Increasing energy prices are leading to reduced storage of produce. Consequently, increased amounts of produce are stored at suboptimal temperatures for extended amounts of time, resulting in accelerated loss of fruit firmness. Simplified, the main processes leading to loss of fruit firmness are fruit ripening-related loss in tissue structure and dehydration-related loss of turgor, both of which are accelerated under suboptimal storage conditions. Classically, ripening-related loss of firmness is assessed using Magness-Taylor type firmness determination using a penetrometer. However, since this measurement is destructive and thus cannot be applied on every fruit, non-destructive alternatives have been developed, using acoustic, impact, deformation, compression and NIR-based technologies, among others. While available devices using these technologies have been validated for ripening-related losses in firmness, little is known about the sensitivity of the underlying technologies to fruit dehydration. This work assesses the influence of ripening and dehydration on multiple 'non'-destructive firmness measurement devices in both blueberry and pear. Firmness was measured using durometers, impact-deceleration devices, impact-acoustic, limited compression and Magness-Taylor based technologies. Different technologies differed in their dependency on dehydration and ripening. Furthermore, their dependency on dehydration and ripening also differed between blueberry and pear. Strategies to separate dehydration and ripening-related firmness are discussed for different fruit.

Session: PHU6b-1

Research on prediction of nonchilling physiological rind disorders in citrus fruit based on weather data using extreme gradient boosting (XGBoost) model

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Abstract

Appearance is the primary parameter used to evaluate the quality of citrus fruit for the fresh food market; so the condition of citrus rind is an important quality attribute. Preventing the development of rind disorders is one of the key challenges in postharvest handling of citrus fruit. Citrus fruit rind disorders are highly influenced by wide range of preharvest (e.g. climatic conditions, exposure to sunlight) and postharvest factors (storage temperature, relative humidity (RH%), dehydration). Although many researchers aimed at elucidating the causal mechanism of rind disorders has been conducted, it still occurs frequently and unpredictably, reducing the quality of the citrus fruit. Accurate prediction of disorders comes with multiple benefits, such as advanced logistic planning capabilities, higher fresh-produce quality with less variability and reduced food losses and the associated environmental impact. Artificial intelligence techniques, such as machine learning (ML) models can be used as a valuable tool for aiding decision makers due to its ability to learn and find interesting patterns in data. The overall goal of this study is to design a ML pipeline using XGBoost algorithm for predicting citrus fruit non-chilling physiological rind disorders before the harvest period, based on 2-years of weather data related to climate, temperature (T o C), RH%, exposed sun hours and amount of rainfall. We managed to build a total dataset composed of 140 rows labelled with the percentage of non-chilling physiological rind disorders. The Kinnow (MKN) citrus variety was the most important feature affecting citrus rind quality, followed by the exposed sun hours, average RH%, variety of Valencia (VAL) citrus and the average T o C. The experimental results proved that the XGB model offers good rind disorder predictions for citrus fruit, with a correlation coefficient (R) of 0.818 and a root mean squared error (RMSE) of 0.426 for the prediction set.

Session: PHU6b-2

Is the climate change affecting fruit quality? A raspberry study from SouthAmerica

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Abstract

Climate change sustained heat and CO 2 increase have been studied in cultivated plants, with most focused on yield and production of row crops such as rice, wheat, maize, among others. Much less attention has been paid to fruit. The temperature studies imposing heat treatments by using portable polyethylene have been an appropriate technique for field studies. Despite the tremendous economic relevance of fruits worldwide, fruit physiology and quality have not been deeply explored under increased temperatures, including important crops for Chile such as raspberries. Raspberries are cultivated from northern Chile to Patagonia and 70-80% of raspberries are produced in peasant family farms. Raspberry production in Chile is expected to increase because of the high prices in the last years and the rise of international demand. We studied the impact on fruit quality and nutritional value of increased temperatures on raspberry fruits cv. Heritage during 2022/2023 summer (Southern Hemisphere). Raspberries fruits were collected from three different orchards that span the Chilean raspberry production area (north, central, and southern Chile). Fruit was picked at the full red stage (commercial fresh market harvest). Three portable heating chambers was used to impose the increased temperature treatment in each orchard and each chamber will enclose four raspberry plants in a row. Temperature increase was electrical heaters connected to two temperature sensors, one located inside the chamber (raspberry cane) and the other in the closest unheated control row. The difference was programmed to be 4 °C higher in the inside with respect to the outside, based on the projected temperature proposed for South America by 2100 year. Preliminary data showed that heated fruit presented smaller fruit size, and the sugar/acid (TSS/TA) ratio increased; suggesting that the raspberry fruit might be losing this organoleptic trait. Nutritional value data will be discussed. Funding by Fondecyt Regular N°1221725.

Session: PHU6b-3

More sustainable reduced application of water and N-P-K fertilizers does not adversely affect postharvest quality of cold-stored 'Mollar de Elche' pomegranate fruit

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Abstract

Several combined strategies of irrigation and N-P-K fertilization were applied to 'Mollar de Elche' pomegranate orchards in the Elx area (Alacant, Spain). Irrigation treatments included a control irrigated at 100% of crop evapotranspiration (ETc) and more sustainable regulated deficit irrigation (RDI) with severe water restrictions (25% of control irrigation) during flowering to fruit set (RDI flow) or during the last part of fruit growth and the ripening period (RDI ripe). These irrigation conditions were combined with two fertilization rates of 100 and 50% of the common dose used in the area: 170 N, 100 P 2 O 5 and 205 K 2 O kg.ha -1 year -1 . The influence of these strategies on the quality of 'Mollar de Elche' pomegranate fruit was determined at harvest and after 8 and 16 weeks of cold storage at 5ºC plus a shelf-life period of 7 days at 20ºC. Overall, results showed few significant differences among treatments in fruit quality, both at harvest and during cold storage. After 16 weeks plus shelf life, the lowest weight loss was observed in pomegranates treated with RDI ripe and 50% N-P-K. Higher solid soluble content was obtained in pomegranates from control and RDI ripe treatments. In addition, pomegranates from RDI and reduced fertilization treatments had higher juice yield than control samples. A slight increase was observed in total antioxidant activity, anthocyanins, and phenolic content after 8 weeks plus shelf life and no differences were observed among treatments at the end of the storage period. Overall, reducing water and nutritional resources in pomegranate orchards did not negatively affect fruit quality of 'Mollar de Elche' pomegranates compared to traditional strategies.

Session: PHU6b-4

Calcium content at harvest positively correlates with internal browning incidence in 'Braeburn' apple during long term storage

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Abstract

Internal browning (IB) incidence in apples stored under a controlled atmosphere (CA) can vary considerably amongst seasons. Apples are typically harvested with similar firmness, soluble solid contents and starch values; thus, the observed variation in IB incidence in apples may be related to other quality parameters. Quality traits that also vary year-to-year include skin colour (ascorbic acid and anthocyanins) and mineral composition, and these parameters can be greatly influenced by climate. Therefore, the relation of these quality traits to IB incidence in 'Braeburn' apple was investigated. Over five seasons (2017-2021), ascorbic acid and mineral composition were measured at harvest in 'Braeburn' apple grown in southwest Germany. These results were then compared to the average incidence of 'Braeburn' Browning Disorder (BBD) of fruit stored under optimal CA conditions (1 °C, 1 kPa O 2 and <1 kPa CO 2). According to our results, fruit calcium content was positively correlated with BBD incidence (r = 0.90, p > 0.05). Principal component analysis revealed that fruit calcium content and BBD incidence were negatively correlated with relative humidity (RH) 42 days after bloom (DAB). These results indicate that lower calcium content, due to higher RH during the first 42-DAB, is important to reduce 'Braeburn' apples' susceptibility to browning during controlled atmosphere storage. These results may have drastic implications for southwest Germany as the average RH during the spring (Mar-May) has decreased by 10% over the last 20 years.

Session: PHU6b-5

Systematic dose response of lettuce to blue and far-red: the effects on yield and post-harvest quality

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Abstract

To realize profitable growth of vegetables in vertical farms, optimizing growth, light use efficiency and crop quality, like post-harvest shelf life are key value drivers. In this research we show how light composition and dynamic spectra can be used to optimize shelf life and yield. Addition of far-red light can accelerate growth, due to stretching of leaves and might be beneficial in terms of yield (kg/m 2 /year). However, this typical shade avoidance response, often results in thinner leaves and reduced shelf life. Conversely, Blue light is known to keep plants more compact and enhances antioxidant levels and photosynthetic pigment concentrations in leaves, which potentially results in improved shelf life. A series of systematic dose response experiments were set-up to investigate effects of blue and far red on growth and quality of lettuce (Lactuca sativa). Increasing blue (range between 0-36%) in a Red/Blue spectrum, resulted in decreased yield, while leaf dry matter percentage and shelf-life improved. At constant Daily Radiation Integral (DRI), increasing far-red (range between 0-15%), decreased yield and leaf thickness, while leaf dry matter percentage and shelf-life increased in baby leaf lettuce. However, when far-red was added on top of a constant PAR (range between 0% - 30%), yield increased, while dry matter percentage in head lettuce showed a decreasing trend, suggesting a worse shelf-life. In a fourth experiment, additional far-red and blue light was applied dynamically. Compared to a standard red/blue spectrum, adding far-red in the first phase, and replacing it by blue light in the last days before harvest, showed increased yield, but it also showed a higher dry matter percentage. These results suggest that using dynamic lighting recipes can be used to increase yield and post-harvest quality.

Session: PHU6b-6

Degreening of kiwifruit (Actinidia chinensis) cv. 'Dori' at different stages of maturity and temperatures

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Abstract

The world trade of Kiwifruit, based in Actinidia chinensis var. deliciosa 'Hayward,' has been expanding with the introduction of yellow-flesh cultivars. The full conversion of flesh color from green to yellow is relevant for the commercial acceptance of these cultivars; however, this is often achieved on the vine at a high rate of softening that limit its conservation. This work aimed to determine the impact of fruit harvest maturity on the degreening "off the vine" of kiwifruit cv., 'Dori' at different temperatures. The fruit was harvested weekly at three stages of maturity (M1, M2 and M3) based on the color of the flesh with hue values of 107° (breaking flesh color), 103° and 100° (commercial harvest), respectively. The maturity was also characterized by the concentration of starch, dry matter, titratable acidity, soluble solids and fruit firmness. At each maturity, the fruit was degreened using three storage temperatures: 0, 5 and 15°C for 4, 7, 14, 21, 30 and 41 days, then 3, 6 and 9 days at 20°C. The highest effectiveness of degreening occurred at 15°C, and it varied according to the initial flesh color. After 14 days at 15°C, M1, M2 achieved a hue value of 99-100°, at a degreening rate of 0.5° and 0.08° per day respectively, and in M3 the changes were minimal. Kiwifruits from M1 at 15 °C softened at the same rate as fruit at 0 °C during the first 21 days with a similar concentration of soluble solids as fruit of M3 at ripening. Fruit stored at 0°C showed a 40-50% incidence of chilling injury, but it was half at 5 °C and absent at 15 °C. The degreening at 15 °C of Kiwifruit cv. Dori counteracts the lack of ripening of immature stages, but more studies are required to ensure its conservation at low temperatures.

Session: PHU6c-1

Investigation of antifungal mechanism of hinokitiol against Botrytis cinerea using gene expression analysis

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Abstract

Fungal infestation is one of the major causes of pre and postharvest deterioration of fruits and vegetables which results in great economic losses. Botrytis cinerea , a commercially significant phytopathogen, causes gray mold on over two hundred plant species around the world. In a previous study, it was discovered that hinokitiol strongly inhibited the mycelial growth of B. cinerea in a dose-dependent manner. However, the inhibitory mechanism remains unknown. Most of the fungicides act on disrupting the biosynthesis pathway of ergosterol. Ergosterol maintains the integrity and fluidity of the plasma membrane in fungi. The present study aims to investigate the effect of hinokitiol on ergosterol content and the control mechanism of ergosterol biosynthesis. Particularly study the mechanism of antifungal activity of hinokitiol against B. cinerea on gene expression involving the ergosterol biosynthesis pathway. B. cinerea spores were treated with different hinokitiol concentrations (0, 10, 30, and 60 mg L -1) and incubated for 0, 12, 24, and 48 h. The ergosterol level in B. cine rea (30 and 60 mg L -1) remained stable at different time intervals, while it increased in the control treatment (0 mg L -1). These findings led to further research into the expression levels of 13 genes (ERG1, ERG2, ERG3, ERG4, ERG5, ERG6, ERG7, ERG9, ERG11 ERG24, ERG25, ERG26, and ERG27) which were examined using qRT-PCR. The present research may provide insights into the mechanism of hinokitiol against B. cinerea through ergosterol biosynthesis

Session: PHU6c-2

Aspergillus species contamination of postharvest Cannabis sativa L. inflorescence

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Abstract

As legal consumption of Cannabis sativa L. increases globally, the need to assess microbial safety thereby ensuring the quality of commercial strains, has now become tantamount. Aspergillus comprises a group of environmentally ubiquitous fungal species found worldwide. Several members of this morphologically and physiologically distinct genus are known to significantly impact human health and the agricultural industry for example in the case of the presence of mycotoxins in food. The extent to which fungal contamination of Cannabis plants exists after production, postharvest storage and in the final products available in the tropics, is not widely known. This is particularly important where the plant is used in its raw form and for the production of pharmaceuticals and cosmetics. We describe the isolation of Aspergillus sp, from commercially available Cannabis flowers produced in Jamaica. Medical microbiology laboratory techniques were used for primary in vitro screening of samples, for fungi. Multiple 0.1-gram samples of each Cannabis flower were cultured onto Sabouraud Dextrose Agar and the selective isolation medium Potato Dextrose Agar and incubated at 28&#xFFFD;C for a duration of up to 21 days. Plates were macroscopically inspected every 1-2 days and each colony observed to be growing on the plant material, was subcultured to fresh agar and incubated as described. Following growth of isolated colonies, isolates were subjected to microbiological staining, microscopy, biochemical testing and where applicable, MALDI-ToF Mass Spectrometry, in order to definitively confirm the fungal genus. Among the 60 samples that were screened, 25 Aspergillus identifications were made, which included samples from which as many as three different species were isolated. Preliminary data obtained suggests that the establishment of Aspergillus species limits in Cannabis products is fundamental to determine safety, in relation to human consumption, plant pathogenicity, toxicity and spoilage.

Session: PHU6c-3

Effect of postharvest treatments on fruit rots of sweet pepper (Capsicum annuum)

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Abstract

Sweet pepper (Capsicum annuum) is an important vegetable crop in Israel for local consumption and as an export crop to European markets. Fruit rots developing during transport and storage are a major concern for growers and cause significant annual economic loss. Black spot caused by Alternaria spp. and gray mold (Botrytis cinerea) are important diseases developing during postharvest storage. Fungal diseases including Cladosporium rot (Cladosporium cladosporioides) and minor diseases caused by Rhizopus stolonifer , Penicillium expansum , and Geotrichum candidum can result in localized outbreaks and are frequently observed. There are limited management strategies that are used to control these postharvest rots due to concerns over fungicide residues. Heat treatments have been shown to control pathogens in fruit and vegetable production systems and are effective and economical. In this research, six pathogens frequently isolated from pepper were tested for sensitivity to hot water treatments and fludioxinil, a reduced risk fungicide. The ET 50 for A. alternata , B. cinerea , and C. cladosporioides was < 1 min at 54°C. P. expansum was significantly more tolerant of high heat. At 50°C the ET 50 was < 5 for all fungi tested except for P. expansum (9.1 min). Inoculated peppers dipped for 3 minutes at 50°C and stored at 7°C for 10 d showed reduced levels of disease compared to undipped fruit. Lesion size for all pathogens increased by wounding the fruit prior to inoculation. The interaction of fungicide and heat treatment was tested and will be discussed. Additional research is needed on the effect of heat treatments on phytoalexin production and induced resistance of pepper fruit.

Session: PHU6c-5

Unravelling the potential microbial food safety risks in the citrus supply chain

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Abstract

Due to the inedible peel, citrus fruits present a relatively lower microbial food safety risk to consumers. However, the detection of microbial contaminants (e.g., Listeria monocytogenes) on the fruit surface could trigger export market access issues and pose a potential trade risk. Given the volatility in export markets due to various geopolitical reasons, this risk is significant. In this investigation, we aimed to identify potential hotspots for microbial contamination and cross-contamination along the supply chain. We also studied the pathogen survival and persistence on fruit surfaces by simulating export supply chain scenarios. With the voluntary participation of citrus growers and packers, fruit and environmental samples (~2,040) were collected from various stages in the supply chain with a focus on postharvest processing facilities (50 citrus packers) located across five states in Australia. The samples were analysed using real-time polymerase chain reaction (RT-PCR) assays to detect the target foodborne bacterial pathogens such as Listeria monocytogenes (Lmono) , Salmonella species and Escherichia coli O157:H7 . The positive detections were cultured, isolated and subjected to whole-genome sequencing (WGS) to better understand the prevalence and transmission of target pathogens. Results showed that harvest bins, fruit receival area and cool rooms were the potential hotspots for harbourage and transmission of Lmono onto the fruit surface and processing equipment. The WGS data supported the hypothesis that harvested fruit was the principal vehicle for transmission of Lmono from the field to postharvest packing facilities. The postharvest export chain simulation trials showed that citrus fruit (oranges and mandarins) surfaces did not support the multiplication of environmental pathogens (Lmono and Salmonella), but these could survive on the surface with a slight reduction in their populations during 3-4 weeks of cold treatment (2.8-3.0°C), which is the major phytosanitary treatment for citrus export from Australia. This project's outcomes will enhance the industry's food safety capacity and influence the preharvest and postharvest practices to mitigate microbial food safety risks associated with the citrus supply chain.

Session: PHU7a-1

The assessment of the risk of the internal browning of 'Alexander Lucas' pear

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Abstract

The aim of the study was to evaluate the influence of various factors including mineral content (N, P, K, Mg, Ca, B, Cu, Fe, Mn, and Zn), dry weight, ascorbic acid content, total phenolic content, polyphenol oxidase activity, storage conditions (regular and controlled atmosphere with 2% O 2 + 0.7% CO 2 and 2% O 2 + 2% CO 2), and postharvest treatment with 1-MCP, on the incidence of internal disorders (internal browning, CO 2 injury) of the fruit. Additionally, the incidence of internal browning during long-distance transport in MAP conditions was evaluated. Beside storage disorders, the fruit quality (skin colour, flesh firmness, total soluble solid content, and titratable acidity) and ripeness (the rate of ethylene and CO 2 production) were assessed. The experiment was carried out in two consecutive storage seasons, 2021/2022 and 2022/2023. Fruits from ten orchards were used for the experiments. The results showed that 1-MCP postharvest treatment inhibited fruit ripening (maintained the green colour of the skin and flesh firmness, and kept low ethylene production) during storage, but enhanced internal browning (especially in controlled atmosphere conditions). High variability was observed in the susceptibility of fruits to internal browning (among the orchards tested). The low calcium and boron content, and the high iron and manganese content in fruits seem to be influential factors in increasing the susceptibility of the fruits of 'Alexander Lucas' to damage. This work was performed in the frame of grants (the special purpose subsidy for 2021 and 2022), Task 5.1, financed by the Polish Ministry of Agriculture and Rural Development

Session: PHU7a-2

Image processing to assess repeated impact damage in banana fruit

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Abstract

Banana is one of the highly perishable produce that require an advanced inspection during the postharvest supply chain. Applying new non-destructive methods like image processing in identifying bruise intensity in bananas and other fresh produce is necessary. To emphasize the relationship between mechanical damage and quality attributes of bananas, a computer vision system was used. This study presents an approach for determining bruise damage of fresh bananas resulting from repeated impact using the simulated handling experiment (the drop impact test). One impact energy of 0.57 J was used with three repeated series (1, 3, and 6) and two storage temperatures (13 and 22°C) on banana fruit. Image process technique was used to determine bruise area (BA), bruise volume (BV), bruise susceptibility (BS), color (lightness (L*), yellowness (b*), and yellowness index (YI)), and surface area (A S). Bruise magnitude and the studied quality attributes were perfectly presented in this study due to the application of a computer vision system. The results demonstrated that the repeated impact series could significantly influence the BV and BS of banana fruit. Increasing the repetition of impact showed a higher deterioration of the fruit. Statistical analysis showed that the effect of the interaction between impact level and storage temperature was statistically significant on A S (P<0.05). More repeated impact and storage at 22°C were more likely to reduce the A S of the fruit after the storage period. Besides, the data obtained by converting the RGB values to L*a*b* color space showed an alternation of L* and b* after 72 hours of storage. Using image processing can facilitate the measurements of bruising and other quality attributes in the actual locations of damage occurrence like farms and markets. Also, knowledge regarding mechanical bruise damage from fresh banana fruit under repeated series of impacts is essential for developing strategies for decreasing or even avoiding this problem.

Session: PHU7a-3

Direct injection volatilomics to improve the quality of tree nuts

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Abstract

Nuts are particularly valued for their sensory, nutritional, and health attributes. Considering their wide use both for fresh consumption and confectionery, the flavour of both raw and roasted kernels greatly influences their economic value. Since aroma involves the perception of a plethora of volatile organic compounds (VOCs), their assessment is crucial to guarantee the selection and marketability of high-quality tree nuts. Thus, high priority should be given to replace poor flavour cultivars or with off-flavours with favourable ones, exploiting the variability already available in nature by considering also kernel performances during postharvest and transformation. However, the aroma analysis of many samples which are necessary to overcome the significant biological and genetic variability among samples, may be laborious and time consuming. VOC phenotyping is currently a limiting step in breeding programs, due to high costs and complex analytical techniques. The interaction between fruit genetics, environmental effects, postharvest strategies, and product transformation is another limiting factor difficult to control. According to recent publications, direct injection mass spectrometry (DI-MS) techniques, like Proton Transfer Reaction -Time of Flight- Mass Spectrometry (PTR-ToF-MS), are powerful high-throughput phenotyping tool for both genetic and quality-related studies [1]. The rapidity and moderate cost of DI-MS analysis may allow to perform a detailed aroma characterization with a peculiar attention to fold changes in VOC profiles caused by ad hoc postharvest and transformation experiments. In this presentation we would like to report three case studies about the application of PTR-ToF-MS to monitor the quality of several type of tree nuts at different stages of the production chain: breeding, postharvest and transformation such as i) volatilome profiling of raw and roasted almond kernels for genetic characterization of an almond germoplasm [2]; ii) volatilome profiling of raw walnut kernels for valorisation of traditional Italian walnut [3] and iii) quality control of raw hazelnuts [4]. In the first case study a broad germplasm collection composed by 106 Italian and international elite almond cultivars was characterized. The roasting process of some cultivars was monitored online for observation of VOCs formation in real time. Almond VOC profile seemed to be mostly influenced by roasting, but still with significant interaction with genetic variability. According to the multivariate data analysis raw and roasted almond kernels were clustered into two separated clusters due to the roasting process and formation of products of Maillard reactions. A preliminary Genome Wide Association Studies (GWAS) enabled the identification of 63 mass peaks (related to fresh and/or roasted treatment) showing a significant phenotypengenotype association. The second case study dealt with VOC differences between walnut cultivars ("Blegette", "Bleggiana", and "Lara") related with exsiccation process, postharvest, and year of production. VOC analysis showed the presence of a reach aroma blend and the absence of typical markers of walnut oxidation. The third case study was focused on the possibility to predict sensory quality of raw hazelnuts by using volatilome analysis. For this reason, good and bad quality grain hazelnuts and their mixtures in known proportions were analysed by PTR-ToF-MS with different precursor ions (H 3 O + , NO + and O 2 +). The method was able to discriminate samples containing 20% of hazelnuts with unacceptable quality from good quality samples. Finally, unsupervised data clustering of VOCs fingerprints obtained with different precursor ions provided a correct classification rate higher than 90% for all ions. These case studies show that PTR-ToF-MS is suitable DI-MS technique for investigation of aroma profile of different type of tree nuts from various perspectives.

Session: PHU7a-4

Recent developments in time domain NIRS for non-destructive fruit quality assessment: non-contact measurements and device miniaturization

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Abstract

At present, most near infrared spectroscopy (NIRS) devices for non-destructive assessment of fruit quality exploit continuous wave (CW) light sources (e.g., lamps, LEDs) and detectors (e.g., photodiodes). Unfortunately, CW NIRS is not able to distinguish light scattering (related to microscopic changes of refractive index) from light absorption (related to fruit chromophores) phenomena. Furthermore, when working in reflectance mode, CW NIRS suffers from limited sensitivity to fruit pulp, since source-detector distance and tissue optical properties markedly affect the portion of tissue that is sampled. Potentially, such limitations can be overcome by using multiple source-detector distances, however the complexity of the setup results increased. As different approach, Time Domain Near Infrared Spectroscopy (TD NIRS) sensors can acquire the Distribution of Time-of-Flight of the detected photons, by employing picosecond pulsed laser sources, single-photon sensitive detectors, and fast timing electronics. Thus, analysis of TD NIRS data enables to disentangle reduced scattering coefficient from absorption coefficient. Furthermore, fruit pulp is more reliably sampled by photons travelling deeper into the fruit, that is those characterized by later arrival times, on average. TD NIRS devices have not been broadly adopted yet due to the cost of the components, the complexity of the instrumentation, and the requirement for the optical probe to be in contact with the sample. In this work we present the latest advancements in TD NIRS technology concerning feasibility of non-contact measurements and device miniaturization. We present three TD NIRS systems for the non-destructive assessment of fruit internal quality: a multiwavelength device hosted on a 19" rack, a non-contact prototype for fast measurements suitable for future implementation in industrial sorting lines, and a portable device for in-field measurements. As an example of application, we present the results of measurements performed by the three TD NIRS systems on a set of Mantuan PGI pears.

Session: PHU7a-5+6

Photondelta Roadmap (provisional title)

Lex Oosterveld

Abstract

No abstract available

Session: PHU7b-1

Post-harvest treatments with γ-aminobutyric acid increase strawberry (Fragaria x ananassa Duch.) quality during storage

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Abstract

Strawberries (Fragaria x ananassa Duch.) are fruits with a short shelf life and very susceptible to mechanical damage. They are also considered non-climacteric fruits since they do not increase the ethylene production during fruit ripening. Strawberry is a very perishable fruit and its commercial quality is affected during post-harvest storage. For this reason, refrigerated storage is traditionally used to preserve strawberry quality, however, even at low refrigerated temperatures strawberry shelf life is greatly reduced. In this study we evaluated the effect of γ-aminobutyric acid (GABA) as an antisenescent strategy in strawberry. GABA is a natural elicitor that is also able to protect against biotic and abiotic stress. The results have shown that treatments applied by immersion at different concentrations with this elicitor were effective in delaying senescence, thus increasing the shelf life of strawberries. This fact can be observed especially in the delay of weight loss and in the maintenance of firmness levels. In addition, it was effective in maintaining overall fruit quality by delaying different quality parameters, showing effects on fruit antioxidant activity. Therefore, we can confirm that treatments with γ-aminobutyric acid could be an important post-harvest tool, capable of increasing strawberry shelf life.

Session: PHU7b-2

Effects of pre-flowering cytokinin applications on cell wall dynamics in table grapes

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Abstract

Consumers around the world prefer firmer table grape berries. To achieve higher quality traits at ripening, grapevine producers apply different plant growth regulators. The synthetic cytokinin forchlorfenuron Nn(2nchloron4npyridinyl)nN'nphenylurea (CPPU) is widely used, but its effect on grape quality is poorly understood. During ripening, changes in berry firmness have been associated with modifications in cell wall structure and composition. We hypothesized that the use of CPPU in pre-flowering can lead to changes in cell wall metabolism that affects grape firmness at harvest. Therefore, we investigated the role of CPPU applications on the quality of grapes by studying morpho-anatomical changes and cell wall and proteomic analyses. CPPU-treated grapevines showed a significant increase in berry size and firmness. Our results showed that CPPU-treated berries presented a higher cell density at harvest. In addition, the cell density of CPPU-treated berries was observed to be significantly higher in the inner mesocarp than in the outer mesocarp. Cell wall analysis indicated that CPPU-treated berries contained more monosaccharides within the berry skin. Moreover, a higher amount of galacturonic acid, galactose, and arabinose was detected in the skin of CPPU-treated grapes. Immunohistochemical analysis displayed changes in the methylation pattern in CPPU-treated berries, concomitant with a higher signal for egg-box calcium-binding motifs. Interestingly, proteomic analyses indicated that at harvest, CPPU-treated berries accumulated enzymes associated with cellulose biosynthesis and pectin modifications, including pectate lyases, polygalacturonases, and pectin methylesterases. These findings suggest that CPPU applications modulate cell wall metabolism, improving grape berry quality (FONDECYT 1200260).

Session: PHU7b-3

Comparison of Calcium gluconate and calcium chloride immersions on physicochemical quality of green Thai peppers during cold storage

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Abstract

The efficiency of calcium gluconate (Ca-G) immersion on postharvest quality improvement of green Thai peppers compared with CaCl 2 and water immersions during cold storage was investigated. The green Thai pepper were dipped in 1 % Ca-G, 1% CaCl 2 and water (control) for 15 min and then stored in the condition of 13 ºC and 85 % RH. Ca-G immersion could maintain the visual appearance rather than CaCl 2 and water immersions, consequently. The increased weight loss was delayed by both calcium immersions. Ca-G immersion maintained the fruit greenness and chlorophylls content being better than CaCl 2 and water immersions, consequently. Both calcium immersion enhanced antioxidant activity and bioactive compounds (total phenols and ascorbic acid) content more than control treatment. Interestingly, antioxidant activity and bioactive compounds content of Ca-G treated fruits were higher than those of CaCl 2 treated fruits. In conclusion, 1 % Ca-G immersion is a potential alternative calcium treatment maintaining postharvest quality and enhancing nutritional values of the green Thai pepper when compared to CaCl 2 immersion.

Session: PHU7b-4

Effects of osmotic dehydration on nutritional quality of amaranth (Amaranthus cruentus) leaves

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Abstract

Osmotic dehydration (OD) is recommended as a processing method to improve food quality by enabling modification of structural, nutritional, sensory, and other functional properties of raw products. The present study aimed to investigate the effects of OD application on quality attributes of amaranth, a widely consumed African indigenous vegetable. Fresh leaves were treated under two osmotic solution concentrations (2.5%, 10% NaCl), temperatures (20°C, 60°C), and durations (60 min, 180 min), while fresh amaranth leaves without OD treatment were used as a control. The leaves were then subjected to two different commonly applied drying methods, i.e., freeze drying and oven drying (60°C and 30°C for 24 h), and thereafter, characteristic nutritional quality attributes of the dried leaves were analyzed. Results showed that total soluble solids (TSS) content, vitamin C, protein and carotenoids content were influenced in different ways by OD and drying method applied. Specifically, TSS was significantly increased in leaves osmodehydrated at higher osmotic solution concentrations. The change in vitamin C content for osmodehydrated oven dried leaves was not statistically significant, whereas that of freeze-dried leaves was significantly higher compared to the control. Although it showed a tendency to increase in both oven dried (31.5% increase) and freeze dried (7.5% increase) leaves pre-treated at 2.5% NaCl for 60 min compared to the control. Similarly, protein retention was significantly higher in oven and freeze-dried leaves pretreated under these conditions, while carotenoids content was only significantly higher in oven dried leaves. In general, low temperature OD treatments at low osmotic solution concentrations resulted in better preservation of vitamin C, carotenoids and protein contents of leaf amaranth. In conclusion, the results indicate that OD can be used as a measure to preserve nutritional quality of dried amaranth leaves in postharvest when applied as a pretreatment.

Session: PHU7b-5

Influence of postharvest GA3 and 1-MCP treatments on quality of banana Musa acuminata cv. Pisang Mas (AA) harvested at different age of fruit

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Abstract

Banana cv. Pisan Mas growth in Costa Rica was harvested at 6 weeks (w) from emerged the floral shoot. GA3 applied by aspersion at the doses of 4000, 4500, and 5000 mg·L - 1, and 1-MCP applied by immersion at the doses of 10, 25, 50, and 100 µg·L - 1 were tested in addition to a control. Treatments followed the commercial-normal process and packaging, and then were stored for 7, 14, 21 and 28 days (d) in a cool room at 14 C. At the end of each storage period, 'green life' was evaluated as external colour (GC), skin (GSF) and pulp firmness (GPF). Then, fruit were exposed to ethylene at 18 C until reached the grade 5 of maturity, where quality was evaluated as skin firmness (MSF), titratable acidity (TA), total soluble solids (TS) and days to reach grade 5. From this experiment, results suggested that GA3: 4500 mg·L - 1, and 1-MCP: 10 µg·L - 1 were performed as the best. A second experiment was carried out following the same methodology but combining the best dose of GA3 and 1-MCP with different ages of fruit: 5w, 6w, and 7w. Results indicated that GSF, GPF and MSF were not affected by treatments at each period of storage excepted for fruit of 7w in which 1-MCP was higher followed by GA3 and the control. TA and TS were not affected by treatments at 7d and 14d of storage, however at 21d only fruit treated with 1-MCP remained on good quality based on their firmness. Independent of the age, fruit treated with 1-MCP delayed the days to reach maturity, while GA3 treatment got a similar number of days to the control. Based on quality and yield parameters fruit harvested at 6w and treated with 1-MCP were concluded to be the best treatment to extend the postharvest life without compromising quality.

Session: PHU7b-6

Pre- and post-harvest treatments to extend the shelf life of Cucurbita moschata Duchesne pumpkin 'Tripolitani'

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Abstract

Pumpkin is considered one of the leading crops worldwide in terms of production of nutritious food per unit of area and per unit of manpower, due to its high nutritional value, large yields, and the low requirements of labor for cultivation and harvest. The tropical pumpkin, Cucurbita moschata Duchesne 'Tripolitani', has been the leading cultivar of pumpkin grown in Israel for decades. The plants of 'Tripolitani' are rampant and late to bear, approximately 130 days after planting. The fruits are round, from flattened globe to oval, and very large, usually weighing 15m25 kgs. but sometimes much more, deeply furrowed, dull orange, light yellow, or dark green externally with thick, intensely orange, high-quality flesh. The fruits have a long shelf life, as much as 6m10 months, and usually are sold as freshly cut slices at produce stands, groceries, and supermarkets. In recent years, farmers have reported significant losses, as much as 50%, due to fruit decay in storage. In order to determine the cause of postharvest pumpkin rots, a four-year survey was performed at five different sites in Israel. The results indicated that most cases of fruit decay in storage begin with rotting at the stem end of the fruit. Fusarium solani was identified as the primary pathogen causing the typical initial symptoms of a gray hollowing around the stem that subsequently spreads into much of the fruit. Pathogenic F. solani was also isolated from the seeds of healthy-appearing fruits and plant parts (stems and leaves), suggesting that seeds may serve as a source of inoculum. Seed disinfection with Celest Top (flowable concentrate of thiamethoxam, fludioxonil, and difenoconazole; Gadot Agro, Netanya, Israel and Syngenta, Revadim, Israel) before planting reduced postharvest fruit rot by 30%. In addition, fungicide treatments amended to the soil during the growing season (Signum - pyraclostrobin and boscalid; Adama Agan, Ashdod, Israel), every two weeks starting from flowering until two weeks before harvest, similarly reduced postharvest fruit rot. Combined treatment of seed disinfection (Celest Top) with 5 treatments of Signum amended to the soil during the fruit set and fruit development period, further decreased postharvest fruit rots by 27%. Moreover, growing the pumpkins in a greenhouse covered with 50 mesh shading net, which prevented insects' penetration, completely prevented fruit rot for up to 6 months of storage. Postharvest storage of pumpkin fruits (grown in open field) at 20-25°C with RH 70% reduced fruit rot incidence by 50%, and is already being applied in small organic farms. Combining these pre and post-approaches may provide adequate control of Fusarium stem-end rot, to reduce produce losses of 'Tripolitani' pumpkins in storage. The effect of insects' activity during cultivation along with heat waves during storage on fruit resistance to Fusarium fruit rot will be discussed.

Session: PHU7c-1

Chitosan-24-epibrassinolide composite coating maintained aril quality attributes of pomegranate fruit subjected to chilling temperature by enhancing the antioxidant systems

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Abstract

This study investigated the effect of chitosan-24-epibrassinolide composite coating on postharvest quality attributes of pomegranate arils during whole fruit extended storage. Early harvest pomegranate fruit were treated with CH + 10 µM EBR by immersion method, and distilled water was used as a control treatment. The fruit were air dried and subjected to long storage for four months at 4.5 +- 0.5 °C; 85 +- 5 relative humidity (RH); quality was evaluated at 4-week intervals with additional 3-day storage at room temperature to simulate retail conditions. Aril's physicochemical and phytochemical properties, antioxidant capacity, and enzyme activities were monitored during storage. The results showed that the CH + 10 µM EBR coating significantly (p < 0.05) maintained higher aril texture, and titratable acidity (TA), with slight differences observed in total soluble solids (TSS). In addition, CH+EBR coating resulted in higher aril antioxidant capacity as indicated by ABTS + and DPPH radical scavenging activities, which is attributable to the enhanced activity of the antioxidant enzymes CAT and POD. Moreover, an enhanced accumulation of flavonoids was observed in arils from the treated fruit compared with the control fruit, contributing to the higher antioxidant capacity. These results suggest that chitosan-24-epibrassinolide (CH-EBR) composite coating is a promising natural preservation technique to maintain the quality of arils during the long-term storage of pomegranate fruit. However, more studies are still required to understand the mode of action involved and optimize the coating formulation.

Session: PHU7c-2

Postharvest tools to enhance blood orange quality by reducing the chilling injury symptoms and maintaining anthocyanin content

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Abstract

Blood oranges are characterized for the reddish pigmentation of both skin and segments due to the presence of anthocyanins, although low temperatures of storage are necessary to stimulate. On the other hand, cold-temperature can induce chilling injury (CI) incidence in blood oranges. In this work, several postharvest technologies could alleviate CI and in turn prolong the blood orange storability period. In this work, the role of several tools, such as Brassinosteroids (BRS), Glycine Betaine (GB) and γ-Aminobutyric acid (GABA), will studied and their influence on the preservation of quality and anthocyanin concentrations in blood oranges. Overall, these postharvest treatments were effective on enhancing the anthocyanin biosynthesis, by increasing the enzyme phenylalanine ammonia-lyase, and preventing the CI of blood oranges during prolonged cold storage.

Session: PHU7c-3

A UV-B irradiation approach for modulating the quality parameters during postharvest in Green Basil (Ocimum basilicum L.)

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Abstract

UV-B irradiation is a potential approach to modulate and sustain the concentrations of antioxidant profile in plants. This study was carried out to investigate the postharvest response of green basil towards a single UV-B wavelength and to record the fluctuations in the quality determinants of the produce. In an indoor UV-B chamber equipped with an aluminium reflector realized with vega ® UV, a PVD surface specifically developed to optimize the reflectance in the UV bandwidth, a wavelength of 315 nm was subjected on green basil during cultivation, in two different UV-B treatments of 43.2 KJ/m 2 and 86.4 KJ/m 2 for varying time span respectively. Non destructive in vivo analysis, such as chlorophyl and flavonols estimation by using 100 Multipigment Meter (MPM) and maximum quantum efficiency of photosytem II (Fv/Fm) and performance index (PI) by using a florimeter (Handy PEA, Hansatech), were performed. Various in vitro analysis, such as chlorophyll a & b , carotenoids, phenolic index, anthocyanins, nitrates, total sugars contents, reducing sugars as well as sucrose, have been performed at 4 different stages with the first readings being recorded at harvesting stage (T0) , then after three days (T3) , 7 days (T7) and 10 days (T10) of cold storage (6 °C). An increment in the chlorophyll as well as flavonols was recorded by MPM-100 at harvesting stage (T0) in both UV-B treated basil compared to the control which eventually subsides in an irregular pattern during postharvest until T10, where the control sustained higher estimates of chlorophyll and flavonols than both UV-B treatments. A slight increase has also been noticed while measuring the Fv/Fm values of both UV-B treated basil in comparison of the control, which remained as such until T3, while at T10, the values were higher for intense UV-B treatment followed by the control and 43.2 KJ/m 2 . Plants under 43.2 KJ/m 2 depicted high performance index among all the treatments for the consecutive two timepoints T0 and T3, while this index drastically decreased for all the treatments until T10. Interestingly under in vitro analysis, an increase was observed for total sugars as well as phenolic index of UV-B treated plants at T0 which gradually decline with the later time points however, reducing sugars, sucrose, anthocyanins, nitrates, chlorophyll as well as carotenoids exhibited lower values compared to the control at this stage.Additionally at T10, 86.4 KJ/m 2 UV-B treated basil maintained higher total sugars, reducing sugars, sucrose as well as phenolic index among all the studied treatments. Furthermore, anthocyanins accumulation under 43.2 KJ/m 2 showed a remarkable increased values throughout the experiment with a slight decreased values in T0 compared to the control. Although UV-B treated basil for both treatments exhibited less accumulation of chlorophyll and carotenoids at T0 in comparison to control, yet at T3, T7 and T10 sustained a higher concentrations of these pigments, expressing a huge potential of UV-B for postharvest management. However, nitrate contents, a definite commercial indicator of the quality, remained lower in UV-B treated plants compared to the control throughout the experiment. Keeping the above mentioned results in mind, it can be concluded that there is a potential of UV-B irradiation in prolonging the postharvest antioxidant modulation and maintenance of the overall quality while keeping the intensity and time exposure of UV-B under check.

Session: PHU7c-4

Combined postharvest treatments to reduce chilling injury and maintain quality during 'Hass' avocado (Persea americana Mill.) storage

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Abstract

Avocado (Persea americana Mill.) is a subtropical climacteric fruit with a high sensitivity to low temperatures. During cold storage chilling injury (CI) symptoms expressed in avocado fruit are abnormal ripening, darkening of the mesocarp, hardening of vascular strands, 'off flavours' due to lipids oxidation, pitting and darkening of the skin which causes weight loss as well making the commercialization impossible. These symptoms develop after fruit are subsequently kept at room temperature. For this reason, we have studied the effect of different postharvest treatments (1-methylcyclopropene and γ-aminobutyric acid) alone and combined to increase CI tolerance in 'Hass' avocados. For this purpose, avocados were stored for 0, 7, 14, 21, 28 and 35 days at 5°C plus 5 days at room temperature. Results showed that the treatments applied in combination improved several parameters of the general quality of the fruit in comparison with control fruit and with those treated individually during storage. The combined treatment delayed the postharvest deterioration process through maintenance of fruit colour, titratable acidity and soluble solids and decreased weight losses but with no significant effect on respiration rate. CI symptoms was also minimized possibly due to a reduced electrolyte leakage. For this reason, the synergistic effect of the combination of treatments may be recommended as an effective alternative strategy to prolong the postharvest quality of avocado during refrigerated storage.

Session: PHU7c-5

Comparative analysis of mature green banana volatile compounds during development of chilling injury as influenced by 1-MCP

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Abstract

The potential role of ethylene in the chilling injury (CI) response of mature green (MG) bananas in terms of volatile organic compound (VOC) biogenesis was investigated using the ethylene action inhibitor, 1-methylcyclopropene (1-MCP). Volatile profiles of the peel and pulp tissues were measured by GC-MS in fruit treated with 0 or 50 μg L -1 1-MCP and stored at 5 ºC for 0, 12 or 72 h then transferred to 20 ºC for 2 d. The VOC compositions of the peel and pulp during the 72-h chilling storage and after 2-d re-warming were affected both by the severity of chilling stress (i.e., duration of exposure to 5 ºC) and 1-MCP treatment. Principal components analysis indicated that the VOC profiles under different amounts of chilling stress were affected more in the peel than the pulp, suggesting that peel tissue is more susceptible to CI. Aldehydes, especially hexanal and (E)-2-hexenal, were the major volatile compounds observed at the MG stage. Greater production of green leaf volatiles (GLVs) [e.g., hexanal, (E)-2-hexenal, hexanol, (E)-2-hexenol] was elicited during 5 ºC storage, persisting even after 2-d of re-warming at 20 ºC. The amounts of GLVs were positively associated with the severity of CI symptoms, but peel and pulp tissues of 1-MCP-treated fruit emitted less GLVs than without 1-MCP. These results suggesting better chilling stress tolerance in 1-MCP-treated fruit during early CI development support a role for stress ethylene in the development of banana CI. The changes in VOC production during chilling stress could be a potential indicator for stress evaluation but there is a need for further verification.

Session: PHU7c-6

Biochemical and molecular analysis of CaCl2 postharvest treatment on strawberry cell wall

metabolism

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Abstract

The softening of fleshy fruits is largely due to changes in the structure and composition of the primary cell wall, which is a dynamic structure capable of adapting to various biotic and abiotic stimuli. Pectic polymers in strawberry (Fragaria x ananassa, Duch.), can reach up to 60% and they are the main components of the middle lamella. Calcium immersion treatments have been shown to be effective in extending the quality and shelf life of strawberries during storage. However, the molecular and biochemical mechanisms underlying the effects of calcium on the cell wall of these fruits were not clear until recently. In this study, we investigated the influence of CaCl2 treatment on the expression patterns and activities of enzymes highly linked to the metabolism of the strawberry cell wall. Ripe strawberries (80-90% of red surface coloration) of cv. Aroma were treated with a 10 g L-1 CaCl2 solution at 25°C for 30 min, while another group was submerged in distilled water at the same temperature and duration (control). Fruits were separated immediately after treatment (initial time) and after storage for 8 days at 4 °C + 2 days at 4 °C (final time). We analyzed the firmness and pectic polymer content of the cell wall, as well as the activities of pectin methyl esterase (PME) and polygalacturonase (PG) enzymes. We also measured the relative expression of key genes involved in the degradation (FaPG1, FaPLA, FaPLB, and FaPLC) and stabilization (FaPME1) of pectins by Real-Time PCR. Our results showed that the calcium treatment inhibited PG hydrolyzing activity while increasing the PME pectin stabilizing activity, corresponding to a lower degree of esterification found in treated fruits compared to controls. The expression of the FaPME1 gene increased, whereas the expressions of FaPG1, FaPLB, and FaPLC decreased at the initial time. Fruits treated with calcium after storage had higher firmness and a higher content of pectins bound by ionic interactions, indicating that Ca2+ ions preserved the structure of pectins through positive regulation of FaPME1 and PME activity and negative regulation of genes involved in the disassembly of the strawberry cell wall

Session: PHU8a-1

System genetics approach disclosed the genetic architecture of the chilling injury disorder superficial scald in apple

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Abstract

To promote fruit quality and storability, fruit, after harvest, are stored at low temperature to slow down the general metabolism towards the prevention of over-ripening processes and fruit decay. The lowering down of temperature can, however, also stimulate the onset of chilling injury phenomenon, such as the superficial scald that can severely compromising the fruit marketability, especially in apple. To this end, the Euregio project "ScaldCold" aimed to comprehensively dissects the superficial scald physiology in apple, initially through a transctiptome-metabolite investigation on two varieties distinguished by a different behaviors, shedding light on the role of the polyphenol oxidase and its interaction with the hydroxycinnamic acid, as primary mechanism involved in the control of superficial scald. The genetic control of this disorder was further investigated employing a System Genetic approach, understanding the flow of biological information underlying this disorder and providing a global overview of the molecular architecture of the superficial scald control. In this regard, a bi-parental segregating population was employed to perturbate the system of this postharvest physiological disorder, integrating the genetic variome with different intermediate physiological and metabolic phenotypes together with a wide-transcription profiling in a genetical-genomic investigation. The results obtained by this holistic approach revisited past concepts and disclosed the role of new mechanism, such as the protecting role played by specific categories of fatty acids. This information can be now exploited to improve the final quality of stored fruit or to design novel molecular markers to support the breeding in the selection of new varieties distinguished by a superior storability.

Session: PHU8a-2

Low oxygen atmosphere storage reduces chilling injury in tomato

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Abstract

Tomato fruits (Solanum lycopersicum) are susceptible to chilling injury (CI) at temperatures below 12 °C and consequently, has limited possibility to benefit from low temperature storage to prolong shelf-life and maintain quality. Low oxygen atmosphere storage inhibits CI incidence by restricting oxygen availability for maintaining low singlet oxygen induced oxidative stress. The research aimed at finding low oxygen concentrations that will reduce chilling injury in low temperature storage at different maturities. Mature green, MG; light red, LR; and red, R tomatoes were stored at 2 °C under five low oxygen levels (7 kPa; 5.5 ; 4.5 . 2.5 ; and 1 kPa) and 21 kPa O 2 served as a control, combined with 0 kPa CO 2 at respective oxygen level for 14 days followed by 14 days shelf-life at 20 °C. The extent of chilling injury were evaluated by measuring colour development, weight loss, firmness behaviour, surface pitting and decay rate over time. Results showed that in general 1 kPa O 2 reduces CI and the efficacy depends on maturity. In MG and LR tomatoes, 1 kPa O 2 reduced CI manifested as lower lycopene synthesis and accelerated weight loss. Fruit chilled at 1 kPa O 2 developed most intense red colour and showed a trend of lower weight loss at the end of shelf-life. In LR and R tomatoes, 1 kPa O 2 retained higher firmness at the end of shelf-life. In terms of decay prevention in R tomatoes, 1 kPa O 2 was not the best treatment compared to 5.5 kPa O 2 . For all maturity, 21 kPa O 2 experienced the most intense CI symptoms. The extent of improved chilling tolerance indicated by 1 kPa was only partially reflected by superoxide dismutase (SOD) measurement. 1 kPa O 2 had a lower SOD activity immediately after cold storage and at the end of shelf life implying low level of oxidative stress throughout chilling and shelf-life. However there was no clear correlation between low oxygen and SOD level at other low O 2 levels. The result suggests that storage at very low oxygen prevent lycopene oxidation and maintain firmness and membrane integrity useful in reducing chilling sensitivity. Further biochemical and analyses are underway to reveal the mechanisms that allow low oxygen to protect against CI. In conclusion, low oxygen storage areduces CI in tomato.

MSession: PHU8a-4

Comparative investigation of superficial scald disorder in 'Granny Smith' and 'Ladina' apple varieties

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Abstract

Low storage temperature, generally used to promote fruit security and limiting fruit over-ripening and decay, can also be responsible, in specific apple cultivars, of the onset of a physiological disorder known as superficial scald. The genesis of this physiopathy and the mechanisms of action of specific post-harvest strategies, including the exogenous application of 1-methylcyclopropene (1-MCP) and storage at low oxygen concentration, were investigated in "Granny Smith" and "Ladina" apple varieties, both susceptible to superficial scald but with a different magnitude. Despite those storage conditions are effective in preventing superficial scald in 'Granny Smith', 'Ladina' displayed a reduced sensibility to the treatments, being prone to develop severe scald symptoms. The metabolite assessment was correlated with the whole transcriptome assessed by RNA-seq, revealing specific expression pattern between the two varieties. Four distinct clusters were identified through the transcriptome analysis. In 'Granny Smith', treatments can effectively regulate the expression of different genes involved in the browning process, such as polyphenol oxidase and fatty acid related genes, as confirmed by the KEGG pathway and GO enrichment analysis. The metabolomic signature revealed as the accumulation of specific secondary metabolites, flavan-3-ols (catechin, epicatechin and procyanidin B) and unsaturated fatty acids (oleic acid, linoleic acid and linolenic acid), are induced by treatments in 'Granny Smith', playing a central role a role towards the prevention of scald symptoms, enhancing antioxidant activity and membrane fluidity respectively. Whereas in 'Ladina', we observed increase accumulation of chlorogenic acid and very long saturated fatty acid (behenic, arachidonic and lignoceric acids). In both cultivars, storage at low oxygen concentration stimulated a higher accumulation of ethanol and acetaldehyde together with the expression of genes involved in anaerobic respiration. Interestingly, we observed that although the treatment with 1-MCP lead to an efficient control of the production of ethylene in both apple cultivars, the efficacy in controlling of superficial scald onset was variety dependent, underlining the effect of the different genetic background in the control of superficial scald.

Session: PHU8b-1

Modelling of ethylene permeance through perforated packaging film using dimensionless correlation

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Abstract

Ethylene is a ripening hormone, biosynthesized by fruit and vegetables, that can accumulate inside the package and accelerate ripening in fresh produce which, in turn, affects its shelf-life. Ethylene transmission through the packaging plays a vital role in determining the ethylene concentration inside the fresh produce package. Several investigations describing the oxygen and carbon dioxide transmission in modified atmosphere packaging have been studied and modelled previously; however, there is a lack of studies on the modelling of ethylene permeance. Hence, this study was aimed at the modelling of ethylene permeance through a perforated polypropylene packaging film using dimensionless correlation. The ethylene permanence of perforated film was determined at different film thicknesses (20-30 µm), perforation diameters (500-980 µm), cooling air velocities (1-18 cm s -1) over the package and temperatures (6 to 23°C). The correlation was developed using a Stanton number, Peclet number and Schmidt number for predicting the ethylene permeance of perforated polypropylene packaging film which is commonly used in fresh produce packaging. The developed correlation (P= 0.04+0.5D 1.05 /v 0.05 L 0.25 d 0.8) was a function of diffusivity (D) which is dependent on temperature, film thickness (L), perforation diameter (d) and cooling air velocity (v). The correlation showed that cooling air velocity moderately influenced the ethylene permeance in the correlation. The experimental validation showed a coefficient of determination (R 2) more than 0.90. This study would be useful for determining the ethylene accumulation in the perforated package.

Session: PHU8b-2

Evaluating the role of the perforation cross-section profile on the gas exchange through microperforated packages

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Abstract

The main objective of this work was to evaluate the impact of the perforation cross-section geometry on the gas transport of microperforated modified atmosphere packages. A 3D numerical model, that considers a space-time and pressure dependence of the gas composition, was adapted to simulate the gas concentration profiles around the microperforation, considering both diffusive and convective flows. The model was implemented in COMSOL Multiphysics® for eight case studies consisting in microperforations with different cross-section geometries (circular, squared, triangular, trapezoidal, and the actual geometry of a microperforation obtained from SEM images), maintaining the same minimal area (7420.6 µm 2). A custom-built experimental system composed by two chambers was designed to measure the gas transport through microperforations. The upper chamber was filled with a 20.95% CO 2 -0.05% O 2 -79% N 2 gas mixture, while the lower chamber was initially filled with air. The perforation was attached between the two chambers, and a CO 2 sensor was placed in the lower chamber. The results for the actual cross-section geometry were successfully verified with experimental data. In this case, the final concentration of CO 2 was 12% and the root mean squared error of the simulation values was 0.01%. The model predictions revealed the importance of properly characterizing the cross-section profile, since the CO 2 concentration at the end of the simulation (216 h) varied between 10% to 13%, depending on the geometry. The influence of slight variations in the atmospheric pressure on gas exchange through microperforations was also analysed. For this purpose, two cases were considered: constant and variable atmospheric pressure according to the data recorded experimentally. From the results obtained with these simulations it can be concluded that small fluctuations in the atmospheric pressure affect the gas exchange through the microperforation since the concentration of CO 2 at constant pressure was 3% less than at variable pressure.

Session: PHU8b-3

In the light of the facts: a review on photoactivable nanomaterials applied on fruit

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Abstract

In recent years, researchers involved in the food sector started to look at nanotechnologies with growing interest. Nanostructures can in fact convey different types of substances, such as antibacterial and anti-maturation ones, allowing for their gradual and controlled release. Furthermore, they can be functionalized in order to release their content only when in contact with a certain target or after a certain event, such as a photo-activation inductor . Paradoxically, nanostructures are widely studied and used in medicine, as vectors of drugs against cancers and other local diseases while, on the contrary, applications to food is still at embryonic stage , due to harm for healthy safety for consumers. Indeed, the European Food Safety Authority (EFSA) prohibited the use of nanocarriers smaller than 100 nm of food because they could be a risk for health . This review aims to analyze which photosensitive compounds can be used in the form of nanostructures to increase shelf life of fruits. In particular, we focus our attention on berries, which have a shorter shelf life, a very delicate and thin peel and also an high added value. Photoactivation consists in generating Reactive Oxygen Species (ROS) elicited by illumination with visible (in general blue light) or ultraviolet (UV) light. Such ROS generation leads to the inactivation of many bacterial strains, especially Gram-positive ones, included multi-drug-resistant pathogens as Enterococcus faecium, Staphylococcus aureus and Enterobacter. Many natural substances are photosensitive and already used in medicine as Porphyrin (blue light), Chlorins and Phthalocyanines (red light). However, our research focused on natural compounds already used in food, i.e. curcumin, melatonin, hypericin, carbon , indocyanine and essential oils . Among them, curcumin, a component of Curcuma longa, showed very effective to improve the shelf life of berries because its antioxidant properties and its antibacterial effects also on Gram-negative bacteria. Moreover, new formulations of nanostructures proposed as coatings for berries will be investigated, showing their strengths and weaknesses.

Session: PHU8c-1

Controlled Atmosphere Temperature Treatment: progress in sustainable control of insects, mites or nematodes on harvested fresh plant products

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Abstract

While international trade of fresh horticultural produce (fruits, vegetables, ornamentals) has increased in the past decades, available measures to prevent/mitigate phytosanitary risks have been reduced. For example, the effective and wide-spectrum chemical methyl bromide has been banned because of resulting depletion of earth's protective ozone layer, phosphine is scrutinized for development of pest resistance, waste disposal- and lethal human accident issues. Other chemical treatments often have efficacy, phytotoxicity, residue or acceptance/registration issues. In Europe, consumer aversion against food irradiation prevents the use of this safe technology for phytosanitation. This leads to increasing numbers of phytosanitary interceptions, disrupted trade and added costs in fresh plant product chains. Even organisms used for biological pest control during cultivation sometimes create issues in international trade. An overview of available phytosanitary treatments will be presented, with special focus on Controlled Atmosphere Temperature Treatment (CATT). This combination of a temperature treatment with adapted O 2 / CO 2 concentration is commercially applied in the Netherlands for the postharvest eradication of strawberry mites (Phytonemus pallidus) on strawberry plants since 2009. Since then, many plant product-pest combinations have been screened for their efficacy and effects on product quality. For tulip bulbs infested with dry bulb mites (Aceria tulipae) and Chrysanthemum flowers with western flower thrips (Frankliniella occidentalis) CATT-recipes were developed up to practical scale. For other plant-pest combinations high mortality could be achieved without phytotoxic effects, as for others, no suitable CATT-treatment conditions could be found. The potential role of heat- cold- or CATT- treatments as part of a phytosanitary systems approach will be discussed. In classic phytosanitation, single end-of-pipe treatments require minimally Probit 9 mortality (=99.9968%). In a systems approach, cumulative effects of multiple control measures that act independently can result in a similar effective risk reduction, opening the way to the development of less stringent and more sustainable treatments with less risk of phytotoxicity.

Session: PHU8c-2

Application of instance segmentation and occlusion recovery algorithm for autonomous harvesting of greenhouse vegetables

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Abstract

Computer vision studies such as image recognition, object detection, and instance segmentation made a significant contribution to vision systems for autonomous harvesting of greenhouse vegetables. However, these tasks are limited to visible parts of the object in the image. Moreover, they pose a challenge in detecting green vegetables with the subtle color differences in the neighborhood of targeted vegetable. In this sense, especially the nature of cucumbers makes them hard to detect. To address this issue, we conducted a study for reconstruction of occluded part of the cucumber to help autonomous robots detect and locate the picking point position. A dataset with cucumber images from two different farms located in South Korea was generated. The dataset was superimposed with synthetic leaf patches to simulate the occlusion effect. Using this dataset, we proposed an amodal segmentation model with a auto-encoder network. The model consists of a course mask segmentation module for bounding box regression and classification, a visible mask segmentation module for refining visible masks, and an amodal segmentation module for refining the amodal mask. Finally, the refined amodal mask and refined visible mask were concatenated and trained with auto-encoder network. The final performance was evaluated and compared between the conventional models and amodal segmentation model in terms of average precision and inference time.

Session: PHU8c-3

The responses of ‘Zesy008’ kiwifruit to controlled atmosphere conditions

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Abstract

A red-flesh kiwifruit (Actinidia chinensis var. chinensis cv. Zesy008) has novel flesh colour and high sweetness. However, the storage life of 'Zesy008' is relatively short compared to commercially developed 'Hayward' and 'Zesy002' kiwifruit cultivars. Controlled atmosphere (CA) storage (2-3% O 2 ; 2-5% CO 2) has previously been illustrated to delay ripening development and extend storage life of other kiwifruit cultivars. Responses to atmospheric conditions are known to be cultivar specific, hence, investigating a wide range of CA conditions to identify the more optimal gas composition is required. In this work, 'Zesy008' kiwifruit from 3 orchards were stored under 8 different atmospheres that represented a wide range of O 2 (1-21%) and CO 2 (0-15%) concentrations for up to 8 weeks at 1 °C. A continuous experiment set-up was used. Quality assessments were carried out fortnightly within 24 h of removal from storage and after five days at 20 °C. The results show that 'Zesy008' kiwifruit stored in 1% O 2 + 2% CO 2 retained the highest firmness during storage. However, rapid softening occurred within five days post-storage at 20 °C for all CA conditions. The highest physiological disorder incidence was observed for fruit stored in 5% O 2 + 15% CO 2 , most likely as a result of CO 2 injury. The present study shows that 1% O 2 + 2% CO 2 is an appropriate CA condition for storage of 'Zesy008' kiwifruit for up to 6 weeks. Future investigations will focus on extending this storage duration and delaying post-storage softening with additional postharvest techniques.

Session: PHU9a-1

Transcriptome Analysis of the Effect of Packaging Conditions on the Quality of Edamame

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Abstract

Edamame, "immature, green soybeans", is consumed in many countries in recent years because of its nutritional benefits. Because of its high respiration rate, the edamame loses its quality very rapidly after harvest. In the present study, the effect of packaging conditions including modified atmosphere packaging (MAP) on the transcription behavior of edamame was investigated. Edamame pods with five different packaging conditions (unsealed oriented polypropylene (OPP) pouch as the control, CTL; polyethylene net, Net; micro-perforated MA film pouch, MAP; heat sealed OPP, HS-OPP) were stored at 10 ̊C until 7 days. A total of 20 samples of total mRNA extracted from edamame seeds stored for 0, 2, 4, and 7 days was analyzed by using microarray for soybean(Glycine max). Data on relative gene expression were analyzed using a microarray data analysis software. Four genes showing the distinct expression patterns depending on the packaging conditions and periods of storage were identified. Other genes showing the similar expression patterns were also selected based on the similarity indexes. A hierarchical cluster analysis on 100 genes including 4 representative genes succeeded to identify the clusters related to quality alterations depending on the conditions and periods of the storage. We have previously reported the relationship between the expression of stachyose synthase-encoding gene and the content of stachyose which is one of the senescence marker molecule of the edamame. Further gene ontology (GO) analysis will provide the information on other marker genes for quality alteration of edamame.

Session: PHU9a-2

Evaluation of the Effectiveness of Biodegradable vs Conventional Packaging Materials in Shelf-Life Extension of Round and Cherry Tomatoes

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Abstract

This study investigated the effects of biodegradable packaging and conventional packaging materials on shelf life extension of round and cherry tomatoes. The fruits were stored in cold (12℃) and ambient (20℃) for a period of 28 days. The quality attribute of tomatoes such as physiological weight loss, fruit firmness, total soluble solids (TSS), pH, colour and marketability were assessed. Generally, both packaging materials and storage conditions are significantly ($p<0.05$) superior to those stored at ambient (20℃) conditions. The results indicated that for the surface colour of tomatoes there was no significant difference ($P>0.05$) between the packaging groups. Biodegradable and conventional packaging materials generated a mean value of Hue angle of 45 h°. Polypropylene perforated plastic bag gave the highest mean value of hue angles. Pulped Paper Tray (biodegradable) which was used to package cherries gave the least hue angle mean value of 36^0h. The Kramer shearing force for round tomatoes was the highest with Stamped Paper Tray, covered with PVC Cling wrap (11 N.g-1) followed by Polypropylene perforated plastic bag (9 N.g-1) which is a conventional material. For cherries Glued Paper Tray gave the highest Kramer shearing force of 8.5 N.g-1. For puncture Stamped Paper Tray covered with flow wrap gave the highest mean value of 7.8 N. For cherry tomatoes Glued Paper Tray gave the highest puncture force of 6.2 N, followed by Polypropylene perforated plastic with 5.6 N. However, the was no significant difference ($P>0.05$) observed between conventional and biodegradable materials in terms of firmness. The pH and TSS of tomatoes increased throughout the storage duration. For pH there was no significant difference ($P>0.05$) across the packaging materials. Zibo Punnet for cherries at ambient gave the highest TSS of 4.8 $Brix^0$ and 4.55 $Brix^0$ at cold storage. For round tomatoes Polypropylene Perforated Plastic bag gave the highest TSS of 5.1 $Brix^0$ at ambient and 4.8 $Brix^0$ at cold storage. The highest physiological weight loss (13.5%) was recorded on Polypropylene Plastic (15.64%), followed by EPT-F (Expanded Polystyrene covered with flow wrap (14.39%). The highest marketability of was recorded with Stamped Paper Tray covered with flow wrap (82%) at cold and 60% at ambient. Polypropylene Perforated Plastic bag gave the lowest marketability of 10% at ambient and 20.12% at cold storage. For cherry tomatoes Pulped Paper Tray gave the highest marketability of 77% at cold and 63% at ambient. Zibo Punnet gave the lowest marketability of 62.04% at cold and 42.18% at ambient. Th overall analysis of the results showed that biodegradable packaging and cold storage treatment extended the shelf life of tomatoes. Tomatoes packed in biodegradable materials showed better physiochemical attributes as compared to tomatoes packed in conventional materials. The figures below showed that the effects of biodegradable and conventional packages were only perceptible with the physiological weight loss and marketability of tomatoes. For other variables, these two groups of packages did not exercise any remarkable influence. Based on the results of the study it can be concluded that Stamped Paper Tray covered with PVC cling wrap for (round tomatoes) and Pulped Paper Tray covered with Zibo Punnet for (cherry tomatoes) resulted in longer shelf life.

Session: PHU9a-3

Impacts of modified atmosphere packaging on the storage quality of summer squash

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Abstract

Freshly harvested squash is very sensitive to storage conditions. This study was conducted to test the possibility of improving the storability of squash cv. "Alba" fruits with the applications of modified atmosphere packaging (MAP) alone or in combination with essential oils of Origanum syriacum . Studies were conducted with four treatments and fifteen replications were used for each treatment. All fruits were washed with pure water for 1 min and then air dried for 30 min before the experiments. The treatments of this study are i) MAP, ii) MAP + EO (0.1 ml O. syriacum / bag), iii) MAP + EO2 (0.5 ml O. syriacum / bag), and iv) control (no additional application except washing). Application of the oils was performed by using filter papers. The 0.1 or 0.5 ml oils were dropped on the filter papers and these papers were closed into the MAP bags together with the fruits. After the application of the treatments, fruits were stored at 8 +- 1 °C and 95% relative humidity for 15 days. Quality parameters were measured with 5-days interval. Five fruits were taken out at each measurement day and the parameters were measured. Results showed that the modified atmosphere packaging is very beneficial in preserving the storage quality of squash fruits. It was noted that the weight loss of control fruits reached 19.6% in 15 days at the control fruits, while at the same time, the weight loss of the fruits treated with MAP, MAP+EO and MAP+EO2 were only 9.7%, 7.9% and 9.7%, respectively. These results suggested that the incorporation of essential oil of O. syriacum into the MAP bags is a better way for storing the squash fruits. Similar results were noted for other quality parameters, such as fruit firmness, soluble solids concentration, titreatable acidity, ascorbic acid content, chlorophyll content and carotenoid content. Results also showed that the MAP application has significant impacts on the prevention of fruit decay and chilling injury. These results can be explained with the reduced respiration rate of the packed fruits. Overall, results suggest that the modified atmosphere packaging is an important application for the improvement of the storage quality of squash fruits, while the incorporation of O. syriacum oil into the bags could improve the benefits of MAP bags.

Session: PHU9a-4

Effect of shellac coating on the properties of egg white protein (EWP) films for cherry tomato packaging

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Abstract

Egg white protein (EWP) films have limited applications for the modified atmosphere packaging of fresh fruits and vegetables due to their poor water vapour barrier properties compared to commonly used petroleum-based polymers. There are some strategies to improve this drawback such as nanoparticles addition, layer intercalation, or coatings application. Shellac is a natural non-toxic polymer with good film-forming properties, biodegradability, and noted moisture resistance. For these reasons, in this study shellac was used as coating material for EWP films obtained by compression moulding and was applied in two thicknesses (24 and 40 µm) on one or both sides of the film. The objective was to improve the barrier properties of these films and bring them closer to those of bio-based commercial films such as polylactic acid (PLA), and to compare them with those of petroleum-based materials such as oriented polypropylene (OPP). At 23 °C, the oxygen transmission rate (OTR) of EWP films was lower than that of PLA and OPP films, while the water vapor transmission rate (WVTR) was significantly higher. Shellac coating reduced the WVTR of EWP films up to values close to those of PLA and did not change OTR at 50% relative humidity. The colour of coated EWP films differs from that of commercial films, especially in lightness and in yellowish tone, which decreased and increased, respectively, with the thickness and number of coating layers. Cherry tomatoes were kept for 20 days at 4 °C in bags made with these films to verify with real-product situations these improvements. The product experienced a similar weight loss in shellac-coated EWP packages compared with that of PLA, so in this regard it could be considered an alternative to this commercial film. However, further improvement needs to be addressed in order to make them comparable to water barrier properties of OPP.

Session: PHU9b-1

Developing and applying post-harvest technological solutions for reducing food loss and waste along the EU supply chain: our contribution to the SISTERS project

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Abstract

In 2017, global food loss and waste (FLW) accounted for 29% of the total primary food production (about 1.9 Gt of food) corresponding to 2.6 Gt CO2-eq. of greenhouse gas emissions (1). Such loss negatively affects air, soil, and water pollution, and consequently, impacts adversely biodiversity and climate (2). Reducing FLW is critical to achieve healthy diets and sustainable food systems, and it has been recognized by the UN as a key pathway to reach different Sustainable Development Goals. The EU SISTERS project aims to design and implement a set of innovative tools to reduce FLW generated in the Food Value Chain in Europe. In this work we would like to give a project overview by focusing on the undergoing activities and the preliminary results obtained in the postharvest domain. In the fresh produce sector, food packaging can help reducing FLW and extending product shelf-life by preventing damage during transportation, enabling heat dissipation, maintaining its flavor and nutritional value and preventing pathogen contaminations and dehydration (3,4). However, due to environmental concerns for littering and plastic in the oceans, social resistance to plastic packaging materials is raising. Bio-based and home compostable (BBHC) packaging is an innovative solution that could help both reducing plastic waste problem and preserving food freshness (5). In this vein, the project is developing a new packaging containing polybutylene adipate terephthalate (PBAT) an enzyme additive to enhance materials composability and antioxidants extracted from food waste. The packaging performance will be validated by microbiological (challenge tests) chemical and sensory analysis. In parallel, the project is investigating EU consumers' engagement and BBHC acceptance. A literature review was conducted to identify and analyze the main barriers to the spread of BBHC packaging indicating that the five main barriers for consumers are: lack of knowledge and understanding, negative beliefs and skepticism, concern and neophobia towards new technologies and materials, poor engagement on the "green" theme and a lack of access to appropriate waste management infrastructures. A consumer's survey (N > 1000) is currently ongoing in 6 European countries to investigate behaviors, attitudes and knowledge of the European consumer regarding food waste and eco-sustainable packaging. Finally, a new logistic solution for fresh products transportation has been developed (i.e. Bulkbox). By combining passive modified atmosphere packaging (MAP) and an innovative sensors system the Bulkbox is a reusable container which aims to reproduce ideal transport conditions. By logging the most important storage parameters including temperature, relative humidity, CO2 and O2 concentrations and other relevant volatile organic compounds (VOCs) like ethylene, the sensor system allows a constant monitor of

transport conditions. The Bulkbox performance in extending the shelf-life of fruits and vegetables is currently under validation by performing truck container transportation (> 1700 km) and shelf-life testing both at refrigerated and room temperatures of four fresh products: mushrooms (Agaricus bisporus), bell peppers (Capsicum annuum) , spinaches (Spinacia oleracea) and strawberries (Fragaria X ananassa). Quality parameters including color, texture, respiration rates, volatile organic compounds emissions and sensory characteristics are currently under evaluation. Overall, the project results will be used to improve the sustainability of fresh produces transportations and of the packaging used to preserve food while reducing their potential negative impacts. References: 1. Guo XZ, Broeze J, Groot JJ, Axmann H, Vollebregt M. A Worldwide Hotspot Analysis on Food Loss and Waste, Associated Greenhouse Gas Emissions, and Protein Losses. Sustainability. 2020;12(18). 2. Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, et al. Options for keeping the food system within environmental limits. Nature. 2018;562(7728). 3. Verghese K, Lewis H, Lockrey S, Williams H. Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain. Packag Technol Sci. 2015;28(7). 4. Atta OM, Manan S, Shahzad A, Ul-Islam M, Ullah MW, Yang G. Biobased materials for active food packaging: A review. Food Hydrocoll. 2022;125. 5. Almenar E, Samsudin H, Auras R, Harte J. Consumer acceptance of fresh blueberries in bio-based packages. J Sci Food Agric. 2010;90(7). 6. Herbes C, Beuthner C, Ramme I. Consumer attitudes towards biobased packaging n A cross-cultural comparative study. J Clean Prod. 2018;194.

Session: PHU9b-2

Inhibition of mango fruit ripening process using 1-methylcyclopropene (1-MCP) on preservation after irradiation

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Abstract

The use of ionizing irradiation has been demonstrated as an effective commercial phytosanitary treatment prior to export to the international market in the USA and Australia. Quality deterioration of irradiated mango is an inherent aspect of the advancement in senescence and loss in fruit quality during storage. The 1-methylcyclopropene (1-MCP) was used for extending shelf life and quality is targeted to delay the ripening process through downregulating ethylene action. In this study, we focused on the effect of 1-MCP fumigation after irradiation on the physico-chemical properties of mango cv. Nam Doc Mai No#4 compared with the control. The gamma-irradiated mangoes were exposed to 0, 500, and 1,000 ppb 1-MCP for 12 and 24 hr. Then all treated and control fruit were stored at 13 +- 2°C, 80-90 %RH. The data showed that 1-MCP treatment maintained their color development, pulp firmness, delayed respiration, and ethylene. Total soluble solids and titratable acidity ratio was effectively maintained in treated mango fruit. These results suggest that the delayed ripening of mango fruit is via the concentration of 1-MCP fumigation after exposure to gamma radiation for up to 24 days. In addition, 1-MCP suppressed anthracnose disease by directly inhibiting contamination on their peel, thus supporting a promising strategy for disease control.

Session: PHU9b-3

NEW STRATEGIES TO CONTROL AND IMPROVE THE POSTHARVEST QUALITY OF LEMON FRUITS

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Abstract

Lemon fruits are highly appreciated by consumers and have a high content of bioactive compounds. They are susceptible to suffer different disorders leading to quality losses during storage. Fungicides have been commonly used to alleviate this effect. However, the development of different alternative natural treatments is currently being studied. γ-aminobutyric acid (GABA) is a natural elicitor composed of four-carbon non-proteinoaceus with different functions in plant metabolism, such as signalling, modulation of growth and development, pH regulation and induction of stress tolerance. GABA is currently acquiring increasing interest, applied in pre-harvest or post-harvest, for its effects in delaying senescence and increasing tolerance to oxidative stress or chilling injury in many fruits. This study was aimed to evaluate the effect of GABA on lemon trees as a preharvest treatment on crop yield as well as on its quality parameters, including functional quality, at harvest and during storage at 10º C. Thus, (Citrus lemon L.) of 'Verna' were treated with GABA, at 10, 50 and 100 mM, by foliar spray at three key points of on-tree fruit development. Results showed that treatments were effective on increasing crop yield and quality parameters such as firmness or reducing weight losses as well as greater phenolic compounds content and total antioxidant activity. These results suggest that preharvest application of GABA at different doses tested on lemon trees could be a useful tool to increase crop yield, fruit quality parameters and bioactive compounds at harvest and maintain them during storage, delaying quality losses and decay incidence.

Session: PHU9b-4

Investigating the Effects of Novel Postharvest Treatments on the Shelf-life of Georgia-grown Blackberries

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Abstract

Blackberries are highly perishable fruit due to their susceptibility to water loss, softening, mechanical injuries, and postharvest diseases. The shelf-life of freshly-harvested blackberries is around 7-10 days when cooled immediately and stored at 1°C. A high demand for fresh-market blackberries exists, but fruit availability for extended periods of time is the limiting factor. Controlled atmosphere (CA) storage is a technique in which the oxygen levels are reduced while substituting it with nitrogen and/or increasing the amounts of carbon dioxide. Ozone is a strong oxidizing agent which is effective over a wide spectrum of microorganisms. Gaseous ozone treatments can extend the shelf-life of many products by guarding against mold and bacteria growth during cold storage. Furthermore, ozone can oxidize ethylene and slow down senescence. A potential drawback to relying solely upon ozone is that the exposure to ozone can trigger a stress response altering the fruit metabolism thus damaging the visual quality of the fruit. Despite the use of ozone as a postharvest treatment on many crops, its potential benefits and limitations during the postharvest storage of blackberries have not been fully documented. Our team performed a thorough investigation on the storability of three Georgia-grown blackberry varieties (Ponca, Osage and Caddo) which were held under alternative atmosphere storage regimes for up to 14 days at the University of Georgia, Tifton. Overall, there were significant differences in the responses to CA and O 3 treatments between the three varieties tested. Controlled atmosphere storage was the most beneficial treatment when it comes to visual quality ratings. Other quality measurements performed included respiration rates, weight loss and firmness changes, further elucidating the effects of the alternative treatments. The results will assist in determining the efficacy of CA storage along with the value of ozone in extending the shelf-life and marketability of fresh-market blackberries.

Session: PHU9c-1

Peltier element for real-time heat flow measurement between fresh produce and surrounding air during postharvest storage

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Abstract

Peltier elements are inexpensive and non-invasive sensors that detect heat flow in surfaces when a temperature difference is created. Once food behaves as a hot body inside the refrigerator, small Peltier elements are suitable for heat flow monitoring in food. During the initial cooling process, the flow of thermal energy in food occurs through a conduction process from the inside to the surface of the food, followed by dissipation through convection to the surrounding cold air, where air velocity plays a vital role in heat removal. In this context, the aim of this study was to develop a novel sensor to measure heat flow from the fruit surface to its surroundings. For this reason, Peltier elements were attached to the fruit surface in order to monitor, in real-time, the cooling kinetics of apples during postharvest storage. Experiments were conducted inside a wind tunnel under controlled air temperature (1°C), relative humidity (80%) and air velocity (0.5 to 4.0m/s). Temperature sensors were also attached to the fruit in order to monitor and collect data from the core and surface of the apple. As a result, the lower the air velocity, the longer it takes for the apple to reach the air temperature, as shown by the 7/8 cooling time. Cooling time varied from 3.23h to 1.13h with corresponding convective heat transfer coefficients of 7.8 to 19.2W/(m 2 K) at an air velocity of 0.5 and 4.0m/s, respectively. Results obtained with the Peltier element showed a faster reduction in heat flow, from fruit to the surroundings, by applying a higher air velocity. These findings suggest a novel sensor for detecting heat flow in food that can lead to improved design of refrigeration systems and energy-saving strategies during postharvest storage.

Session: PHU9c-2

Investigating the ethylene adsorption performance of scavenger films for potential application in fresh produce packaging

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Abstract

Ethylene scavenging in fresh produce packaging has been shown to have multiple benefits in terms of shelf life elongation and quality maintenance in fresh produce storage. Different types of scavengers are often used in granular/ power forms and incorporated into sachets inside packaging. In recent years, there has been an increased interest in research directed at incorporation of such scavenging materials in polymer matrix. Many commercial packaging films are also being launched into the market for ethylene scavenging in fresh produce packaging. This study is an attempt to investigate the ethylene scavenging properties of such films against ethylene scavengers normally used inside sachets. Ethylene scavenging properties of scavengers in granular form and after incorporation into films was compared at fixed humidity and temperature (0 % RH and 20°C). Furthermore, five scavenging films, two developed in laboratory and three bought commercially were also tested for ethylene removal. The study showed that incorporating the scavenger in polymer matrix drastically reduced their ethylene removal potential. Most commercial films did not absorb ethylene except PrimePro® which showed more than 85 % ethylene removal at low humidity at 20 °C. However, the ethylene absorption by PrimePro® was significantly reduced at high humidity. Overall, the study shows that packaging films with embedded ethylene scavengers may not be beneficial in terms of ethylene removal compared to using scavengers inside sachets.

Session: PHU9c-3

The effect of static and dynamic low oxygen regimes during postharvest storage on 'Granny Smith' apple is disclosed by transcriptome and metabolic surveys

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Abstract

Apple is subjected to long-term cold storage to preserve its quality features and to ensure a year-round availability on the market . The most common strategy employed to delay the ripening progression is based on the use of low temperature, that, interfering with the normal fruit physiology can trigger the development of serious chilling injury type of disorder, such as superficial scald . To prevent the onset of this physiopathy, one of the most effective technologies is controlling the storage atmosphere, by lowering down the concentration of oxygen. To monitor the possible consequences of low oxygen regimes an integrated survey was carried out profiling the transcriptome variation together with three categories of metabolites (phenolics, lipids and VOCs) in samples of 'Granny Smith' stored under static controlled atmosphere and under dynamic hypoxic conditions for 5 and 7 months, respectively. High concentration of chlorogenic acid and enhanced expression level of MdPAL and MdPPO were detected in samples affected by superficial scald. RNA-seq analysis revealed 8100 differentially expressed genes categorized in three main functional groups, highlighting the deep transcriptional reprogramming observed at the superficial scald onset in combination with the storage conditions. Moreover, DEG-network analysis allowed to identify a distinct number and type of transcriptomic hubs , depending on the storage time.