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APPLE

Dou, Y., Routledge, M. N., Gong, Y., & Abiso, E. (2021). Efficacy of epsilon-poly-L-lysine inhibition of postharvest blue mold in apples and potential mechanisms. *Postharvest Biology and Technology*, *171*, 111346. doi: 10.1016/j.postharvbio.2020.111346

Abstract

Penicillium expansum is a major postharvest fungal pathogen and is the causal agent of blue mold decay in apples. Epsilon-poly-L-lysine (ε-PL) is a naturally-occurring polypeptide that has strong antimicrobial activity. It is primarily used to suppress foodborne pathogens in bread, beverage, meat products, etc. The potential application of ε-PL in the management of fungal postharvest diseases of fruit, however, has not been explored. In the present study, the inhibitory effect of ε-PL against blue mold (P. expansum) disease of apples and its potential mechanism of action were investigated. Results indicated that 600 mg L− 1 of ε-PL could effectively inhibit mycelial growth of P. expansum in apples. Concentrations of ε-PL > 200 mg L− 1 also inhibited germination of conidia and germ tube growth of P. expansum in potato dextrose broth (PDB). The inhibitory effect increased with increasing concentrations of ε-PL concentration. Further studies indicated that the possible mechanisms involved of ε-PL inhibition of P. expansum included the activation of defense-related enzyme activity and gene expression in apple fruit tissues. This included polyphenol oxidase (PPO), catalase (CAT), peroxidase (POD) and phenylalanine ammonia lyase (PAL). ε-PL stimulated the production of intracellular reactive oxygen species (ROS) and degraded the integrity of the cell wall and plasma membrane of conidia, resulting in the death of conidial spores of P. expansum or their germination.

Keywords: /Apple/ /Blue mold/ /Induced resistance/ /Epsilon-poly-L-lysine/ /Membrane integrity/ /ROS/

Han, S., Liu, H., Han, Y., He, Y., Nan, Y., Qu, W., & Rao, J. (2021). Effects of calcium treatment on malate metabolism and γ-aminobutyric acid (GABA) pathway in postharvest apple fruit. *Food Chemistry 334*, 127479. doi: 10.1016/j.foodchem.2020.127479

Abstract

Calcium treatment effects on malate metabolism and the GABA pathway in ‘Cripps Pink’ apple fruit during storage were investigated. Postharvest apple fruit treated with 1% and 4% calcium chloride solutions were stored at 25 ± 1 °C. The 4% calcium treatment suppressed declines in titratable acidity and malate content and increased succinate and oxalate concentrations. Calcium treatment also reduced the respiration rate and decreased ethylene production peak during storage. Moreover, 4% calcium treatment significantly enhanced cyNAD-MDH and PEPC activities and upregulated *MdMDH1*, *MdMDH2*, *MdPEPC1* and *MdPEPC2* expression while inhibiting cyNADP-ME and PEPCK activities and downregulating *MdME1*, *MdME4* and *MdPEPCK2* expression. Surprisingly, calcium treatment changed the content of some free amino acids (GABA, proline, alanine, aspartic acid and glutamate), two of which (glutamate and GABA) are primary metabolites of the GABA pathway. Furthermore, calcium application enhanced GABA pathway activity by increasing *MdGAD1*, *MdGAD2*, *MdGABA-T1/2* and *MdSSADH* transcript levels.

Keywords: /Apple/ /Organic acid/ /Amino acid/ /Calcium signal/ /Ethylene/ /Postharvest storage/

Liu, J., Jiang, Z., Qi, Y., Liu, Y., Ding, Y., Tian, X., & Ren, X. (2021). MdCAX affects the development of the 'Honeycrisp' bitter pit by influencing abnormal Ca distribution. *Postharvest Biology and Technology*, *171*, 111341. doi: 10.1016/j.postharvbio.2020.111341

Abstract

Bitter pit (BP) is a physiological disorder of calcium deficiency in apple fruit and has not been fully characterized. The Ca^{2+}/H^{+} exchanger (CAX) is a kind of Ca^{2+} transport protein. In this study, we analysed mineral contents in different parts of fruit, the expression levels of genes related to Ca transport and the functional roles of *MdCAXs*. The results showed lower water-soluble Ca content and significantly higher ratios of water-soluble P/Ca and (K + Mg)/Ca in the calyx-end flesh of BP and normal fruit than the peduncle-end flesh of them. The expression level of *MdCAX11* increased as the severity of BP increased, and the expression profile was negatively correlated with the water-soluble Ca content. Yeast growth assays showed that both *MdCAX11* and *MdCAX5* have the function of transporting Ca to vacuoles. Subcellular localization analysis showed that MdCAX11-GFP and MdCAX5-GFP were colocalized on the vacuole membrane with a tonoplast marker. Taken together, the results of this study indicate that high expression levels of *MdCAX11* and *MdCAX5* may cause an influx of Ca from the cytosol into vacuoles, which may be related to the occurrence of BP.

Keywords: /*Malus domestica*/ /Bitter pit/ /CAX/ /Calcium distribution/ /'Honeycrisp'/

Rojas-Candelas, L. E., Chanona-Pérez, J. J., Méndez Méndez, J. V., Perea-Flores, M. J., Cervantes-Sodi, H. F., Hernández-Hernández, H. M., & Marin-Bustamante, M. Q. (2021). Physicochemical, structural and nanomechanical study elucidating the differences in firmness among four apple cultivars. *Postharvest Biology and Technology*, *171*, 111342. doi: 10.1016/j.postharvbio.2020.111342

Abstract

A study of the physicochemical, structural, nanomechanical properties at macro, micro and nanometric scales was carried out to determine which features have the greatest influence on the firmness of selected apple cultivars (Golden Delicious, Granny Smith, Gala and Red Delicious). Physicochemical assays, microscopy techniques, image analysis, nanoindentation and spectroscopy were used to characterize the properties of the four selected apples. The data were analyzed using principal component analysis, Pearson analysis and multiple linear regression to classify apple cultivars. These techniques were also used to identify which physicochemical, micro, and nanostructural as well as nanomechanical features were most associated with apple firmness. This allowed for the creation of a mathematical model (R2 = 0.97) for the prediction of apple firmness from evaluated variables. It was determined that the cellular architecture, stiffness of cell walls and crystallinity index of cellulose fibers were the most important factors in explaining the variability of firmness in the studied apples. This research provides novel and valuable information for understanding the role of cellular architecture, micro and nanostructure, as well as nanomechanical properties in the firmness of the studied cultivars.

Keywords: /Microscopy and spectroscopy techniques/ /Cellular architecture/ /Nanoindentation nanostructure/ /Multivariate analysis/ /Malus domestica/

Singh, V., Gamrasni, D., Parimi, P., Kochanek, B., Naschitz, S., Zemach, H., & Friedman, H. (2021). Postharvest calcium treatment of apple fruit increased lenticel breakdown and altered cuticle structure. *Postharvest Biology and Technology*, *171*, 111331. doi: 10.1016/j.postharvbio.2020.111331

Abstract

Lenticel breakdown (LB) mainly occurs in susceptible 'Gala' and 'Red Delicious' apples following storage. Postharvest calcium treatment increased LB of both cultivars as well as the less susceptible 'Orleans' and 'Granny Smith'. Calcium increased the number and size of damaged lenticels. Callose was deposited in the sub-lenticular cells and the cuticle of the damaged lenticels, as well as in non- damaged lenticels. Suberin was deposited in the sub-lenticular cells, but only in the most severely damaged lenticels, and especially in calcium-treated fruit. Postharvest calcium treatment increased the micro- cracking of the skin surface and removed the epicuticular wax following storage. It also decreased the thickness of the cutin and wax layers. Gene expression, mainly of those involved in the wax biosynthesis and cutin and wax transport, were reduced in peel of calcium-treated fruit. Our study suggests that the deleterious effect of calcium on fruit skin occurs due to a decrease in cuticle deposition during storage, resulting in a thinner cuticle, leading to micro-cracks, which culminates in increased lenticel damage.

Keywords: /Calcium/ /Callose/ /Cuticle/ /Lenticel/ /Suberin/ /*Malus domestica/*

Sun, C., Huang, Y., Lian, S., Saleem, M., Li, B., & Wang, C. (2021). Improving the biocontrol efficacy of *Meyerozyma guilliermondii* Y-1 with melatonin against postharvest gray mold in apple fruit. *Postharvest Biology and Technology*, *171*, 111351. doi: 10.1016/j.postharvbio.2020.111351

Abstract

Apple gray mold caused by Botrytis cinerea can reduce postharvest shelf-life and quality of apple produce, and thus causes serious economic losses. In this study, we investigated the biocontrol efficacy of Meyerozyma guilliermondii Y-1 with and without its combination with melatonin (MLT) against B. cinerea in the postharvest apple fruit, and the underlying physiological and molecular mechanisms. Our results showed that the combination of M. guilliermondii Y-1 (1 × 108 cells/mL) and MLT (100 μmol/L) synergistically and significantly reduced the decay incidence and lesion diameter. MLT improved the ability of strain Y-1 to colonize in apple fruit wounds and surface whether at 22 or 4 ◦C. Moreover, M. guilliermondii Y-1 and MLT treatment markedly increased the defense-related enzyme activities, including catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), phenylalanine ammonia-lyase (PAL), and polyphenol oxidase (PPO), as well as the total antioxidant capacity (TAOC), total phenolics and lignin contents. As expected, the expression levels of four pathogenesis-related (PR) genes (MdPR1, MdPR5, MdGLU, and MdCHI) and two jasmonic acid (JA) signaling pathway related genes (MdPDF1.2 and MdCOI1) were significantly increased in response to strain Y-1 and MLT treatment. Furthermore, the most pronounced and/or rapid increase was observed in the combined than individual treatments of either strain Y-1 or MLT. Our results suggest that the effective combination of strain Y-1 and MLT might be a reliable alternative against B. cinerea postharvest infection in apple fruit.

Keywords: /Meyerozyma guilliermondii Y-1/ /Melatonin/ /Botrytis cinerea/ /Apple fruit/ /Biocontrol mechanism/

Sun, Yingjie, et.al. (2021). Effects of preharvest regulation of ethylene on carbohydrate metabolism of apple (*Malus domestica* Borkh cv. Starkrimson) fruit at harvest and during storage. *Scientia Horticulturae*, 276, 109748. https://doi.org/10.1016/j.scienta.2020.109748

Abstract

The main purpose of this study was to investigate the effects of preharvest regulation of ethylene on apple fruit carbohydrate metabolism and quality at harvest and during storage. The positive regulation of ethylene was achieved by Ethephon, and the negative regulation was by Harvista, a kind of sprayable 1-methylcyclopropylene (1-MCP). 'Starkrimson' apple were treated with Harvista or Ethephon 7 d before harvest, respectively, and then stored at 0 °C for 180 d. The contents of starch, sucrose, glucose, fructose, and related enzymes activities and gene expression levels of sucrose phosphate synthase (SPS), sucrose synthase (SUSY), acid invertase (AINV), neutral invertase (NINV), cell wall invertase (CWINV) and amylase (AMY) were determined. The results showed that Harvista inhibited the starch degradation, retarded the increase of soluble sugar, reducing sugar, sucrose, glucose and fructose contents before 120 d of fruit storage, while no obvious difference was observed in these sugar content after 120 d of storage among three treatments. The enzyme activities of SPS, AINV, CWINV and AMY were also inhibited by Harvista at the early period of storage, and the expression levels of MdSPS, MdAINV, MdCWINV and MdAMY were positively correlated with their enzyme activities. In addition, Harvista reduced the fruit dropping rate at harvest and maintained the fruit firmness, while Ethephon showed the opposite effect. These results indicated that the preharvest regulation of ethylene effectively altered the carbohydrate metabolism and the quality of 'Starkrimson' apple fruit, and Harvista may be a useful tool applied at preharvest to maintain fruit quality at harvest and during storage.

Keywords: /Fruit quality/ /Ethylene/ /Carbohydrate/ /StorageApple/

BLACK CHOKEBERRY

Witczak, T., Stępień, A., Gumul, D., Witczak, M., Fiutak, G., & Zięba, T. (2021). The influence of the extrusion process on the nutritional composition, physical properties and storage stability of black chokeberry pomaces. *Food Chemistry*, *334*, 127548. doi: 10.1016/j.foodchem.2020.127548

Abstract

The study examined the influence of the process of extrusion on the physical properties and nutritional composition of black chokeberry pomaces. It has been determined that the extrusion process resulted in a reduction of the content of anthocyanins and fibre, but an increase of the contribution of simple sugars. In order to assess the phase transitions occurring in the products, a state diagram was utilized, which was constructed using the freezing and vitrification curve and values characterizing the conditions of maximum cryoconcentration. The determined values of critical water activity (based on *water activity concepts*) indicate that pomaces and extrudates retain crispiness in storage under moderate environmental relative humidity conditions. However, in the case of the *glass transition concept*, the determined values of water activity indicate that products stored in room temperature must be protected against the influence of humidity.

Keywords: /Pomace/ /Extrusion/ /State diagram/ /Glass transition/ /Sorption isotherms/ /Critical temperature concept/ /Black chokeberry/

BLUEBERRY

Wang, H. Cheng, X., Wu, C., Fan, G., Li, T., & Dong, C. (2021). Retardation of postharvest softening of blueberry fruit by methyl jasmonate is correlated with altered cell wall modification and energy metabolism. *Scientia Horticulturae*, *276*, 109752. https://doi.org/10.1016/j.scienta.2020.109752

Abstract

The effects of methyl jasmonate (MeJA) on fruit firmness, cell wall modification and energy metabolism on postharvest blueberry were investigated. Results showed that MeJA delayed softening of blueberry. Compared with the control, MeJA-treated fruit exhibited higher levels of chelate-soluble pectin, sodium carbonate-soluble pectin, hemicellulose and cellulose and lower level of water-soluble pectin. Moreover, the activity and transcript level of cell wall degrading enzymes were markedly inhibited by MeJA treatment, including carboxymethyl cellulase, polygalacturonase, pectin methylesterase and β-galactosidase. Levels of adenosine triphosphate, adenosine diphosphate and energy charge in MeJA-treated fruit were significantly higher than those in control fruit. Activities and expression levels of the enzymes involved in energy metabolism, including H+-adenosine triphosphatase, Ca2+-adenosine triphosphatase, cytochrome C oxidase and succinic dehydrogenase, were elevated in MeJA-treated blueberry. These results suggest that MeJA delays the softening of postharvest blueberry by restraining the degradation of cell wall materials and maintaining energy metabolism.

Keywords: /Blueberry/ /Methyl jasmonate/ /Softening/ /Cell wall materials/ /Energy metabolism

BROCCOLI

Aghdam, M.S., & Luo, Z. (2021). Exogenous application of phytosulfokine α (PSKα) delays senescence in broccoli florets during cold storage by ensuring intracellular ATP availability and avoiding intracellular ROS accumulation. *Scientia Horticulturae*, 276, 109745. https://doi.org/10.1016/j.scienta.2020.109745

Abstract

During postharvest life, broccoli suffers from florets yellowing, which reduces its economic and nutritional value. We investigated the mechanisms employed by exogenous phytosulfokine α (PSKα) applying at 150 nM for delaying senescence in broccoli florets stored at 4 °C for 28 days. The results showed that the SnRK1 gene expression was higher in broccoli florets treated with 150 nM PSKα, which may warrant sufficient intracellular availability of ATP, resulted from a higher activity of H+-ATPase, Ca2+-ATPase, succinate dehydrogenase (SDH), and cytochrome c oxidase (CCO). In addition, avoiding H2O2 accumulation by higher expression of alternative oxidase (AOX) and uncoupling protein (UCP1) genes may arise from higher SnRK1 gene expression. Additionally, lower mitochondrial permeability transition pore (mPTP) opening may avoid ROS accumulation in broccoli florets treated with 150 nM PSKα. Taken together, our results assume that exogenous PSKα application as signaling bioactive peptide could be considered as a promising procedure for delaying senescence of broccoli florets during cold storage.

Keywords: /Alternative oxidase/ /Florets yellowing/ /Intracellular ATP availability/ /mPTP opening/ /Phytosulfokine α/

CHESTNUT

Hou, L., Zhang, S., & Wang, S. (2021). Numerical analysis of disinfesting and quality of chestnuts during combined radio frequency and hot air heating based on single particle approach. *Postharvest Biology and Technology*, *171*, 111340. doi: 10.1016/j.postharvbio.2020.111340

Abstract

Radio frequency (RF) heating has been considered as one of the most potential thermal treatment technologies to disinfest post harvest agricultural products. A three-dimensional model was established based on a single particle approach using a finite element software, COMSOL, to analyze temperature distribution and product quality, and mortality of *Conogethes punctiferalis* in chestnuts during combined RF-hot air heating. The established model was verified by comparing the calculated average temperatures at three layers in the container, chestnut quality, and insect mortality with experimental results during RF-hot air heating. Because the relative percent error was less than 3 %, the simulated average temperatures of three layers in the container matched the experimental results well. The equivalent heating time of *C. punctiferalis* slowly increased at ramp time but sharply at holding time, resulting in a similar trend for the mortality of *C. punctiferalis*. The chestnut quality showed an opposite trend with the equivalent heating time and mortality of *C. punctiferalis*. The results showed that the 100 % mortality of *C. punctiferalis* was obtained after RF-hot air heating to 50 °C with two mixings and holding for 3 min using simulation and for 5 min using experiment. No significant change was found in quality of treated samples since the change of color index (CI) was less than 5 %. Using the verified model, the *C. punctiferalis* was completely controlled at 50 and 52 °C for holding a given time with acceptable chestnut quality. The verified model can help to optimize process parameters for RF-hot air or other thermal treatments in industrial-scale applications.

Keywords: /RF-hot air heating/ /Chestnut/ /Disinfesting/ /Quality/ /Simulation/

CHILI

Musky, B., Bhattarai, R., Bhattarai, G., & Shrestha, N.K. (2021) Post-Harvest Quality of Fresh Akabare Chili (Capsicum chinese) as Affected by Hydrocooling, Package Modification and Storage Temperature. *International Journal of Food Properties*, *24*(1), https://doi.org/10.1080/10942912.2020.1865399

Abstract

Akabare chilli (Capsicum chinese) is a high-value crop in the eastern hills of Nepal. Akabare growers faced the problem of its value decrement during transportation and marketing because of immediate post-harvest losses. This study was targeted for finding cheap post-harvest treatment to extend freshness and shelf life of fresh Akabare by applying post-harvest treatments like hydrocooling, refrigerated temperature storage, and perforation mediated plastic packaging. The chemical qualities (moisture, vitamin C and chlorophyll content) were studied on a regular interval of 4 days along with visual inspection for 20 days. The package modification included unperforated as well as perforated polypropylene bags having 2, 4 and 6 perforations of 2.5 mm diameter. Samples without any treatment remained fresh only for 2 days, while only hydrocooled samples retained moisture, vitamin C and chlorophyll content significantly ($p < .05$) higher than untreated, in both storage temperatures. None of the samples stored at room temperature retained freshness beyond 4 days. Thus, based on the better retention of moisture and vitamin C content, hydrocooling followed by packaging in polypropylene bag (four perforations) and storage at refrigerated temperature could be considered the best post-harvest treatment and packaging.

Keywords: /Akabare/ /Hydrocooling/ /Packaging/ /Vitamin C/ /Chlorophyll/

CLEMENTINE

Strano, M.C., Timpanaro, N., Allegra, M., Foti, P., Pangallo, S. & Romeo, F.V. (2021). Effect of ozonated water combined with sodium bicarbonate on microbial load and shelf life of cold stored clementine (*Citrus clementina* Hort. ex Tan.). *Scientia Horticulturae*, *276*, 109775. https://doi.org/10.1016/j.scienta.2020.109775

Abstract

The effect of 3 mg L−1 ozonated water (O3) in combination with 3% sodium bicarbonate (SBC), on the microbial control and the postharvest quality of cold stored Clementine fruit (C. clementina Hort. ex Tan.), compared to the single treatments and the water wash, was evaluated. After treatments fruits were stored for 30 days at 5 ± 1 °C and relative humidity (RH) 90 % followed by seven days at 20 ± 2 °C and RH 75 %, to simulate retail conditions (shelf life). Microbial reduction, decay incidence, physiological disorders, weight loss, rheological properties (deformation and firmness) physical-chemical parameters (colour, total soluble solids, titratable acidity, ascorbic acid) and sensory quality were evaluated soon after treatments during fruit cold storage (T10, T20, T30) and after 7 days of shelf-life (T30 + 7). The results showed that integrated treatments (O3+SBC) greatly reduced the total viable count (more than 1 log unit), during the first 10 days of storage (T10), if compared to the other treatments. Moreover, O3+SBC reduced significantly the decay incidence during the whole storage (2.6 % at T30; 10.9 % at T30 + 7) with respect to the control (27.3 % at T30; 45.5 % at T30 + 7). In particular, the control of sour rots (Galactomyces citri-aurantii E.E. Butler) in treated fruits was observed. Our findings did not highlight noticeable changes among treatments concerning fruits weight loss, physiological disorders, chemical composition and sensory analysis.

Keywords: /Eco-friendly strategies/ /Postharvest treatments/ /Clementine/ /Fruit quality/ /Sensory analysis/

DONGBEI SUANCAI

Wang, C., Zhang, X., Gao, Y., Han, Y., & Wu, X. (2021). Path analysis of non-enzymatic browning in Dongbei Suancai during storage caused by different fermentation conditions. *Food Chemistry*, *335*, 127620. doi: 10.1016/j.foodchem.2020.127620

Abstract

A non-enzymatic browning reaction occurs easily in *Dongbei Suancai* (*DS*) during storage. Using the method of path analysis, the changes in contents of VC (ascorbic acid), polyphenol, reducing sugar, amino nitrogen, and 5-HMF (5-hydroxymethyl furfural) were investigated to analyze the direct pathways and determinants of browning caused by pre-production blanching at 100 °C (R-100), salt-addition increased from 2% to 6% (Y-6) and fermentation time extended from 30 d to 40 d (T-40), respectively. The results showed that R-100 could delay the browning by inhibiting two direct pathways of oxidative decomposition of VC and oxidation-polymerization of polyphenols, but T-40 could lead to an increase in degree of browning for which primary determinant was the interaction between polyphenol and reducing sugar, while Y-6 had no obvious effect on browning pathway and determinants. R-100 was thus deemed to be a good measure with inhibiting non-enzymatic browning in *DS* during storage.

Keywords: /*Dongbei Suancai/ /*Non-enzymatic browning/ /Fermentation conditions/ /Path analysis/

FRUITS AND VEGETABLES

Abnavi, M. D., Kothapalli, C. R., & Srinivasan, P. (2021). Total amino acids concentration as a reliable predictor of free chlorine levels in dynamic fresh produce washing process. *Food Chemistry*, *335*, 127651. doi: 10.1016/j.foodchem.2020.127651

Abstract

We establish the total amino acids (AA) concentration in wash water as an alternative indicator of free chlorine (FC) levels, and develop a model to predict FC concentration based on modeling the reaction kinetics of chlorine and amino acids. Using single wash of iceberg lettuce, green cabbage, and carrots, we report the first *in situ* apparent reaction rate β between FC and amino acids in the range of 15.3 – 16.6 M^{-1} s^{-1} and an amplification factor γ in the range of 11.52–11.94 for these produce. We also report strong linear correlations between AA levels and produce-to-water ratio (R^2 = 0.87), and between chemical oxygen demand (COD) and AA concentrations (R^2 = 0.87). The values of the parameters γ and β of the model were validated in continuous wash experiments of chopped iceberg lettuce, and predicted the FC (R^2 = 0.96) and AA (R^2 = 0.92) levels very well.

Keywords: /Fresh produce washing process/ /Free chlorine decay/ /Total amino acids concentration/ /Apparent reaction rate/ /Mathematical modelling/

Liu, K., & Zhang, C. (2021). Volatile organic compounds gas sensor based on quartz crystal microbalance for fruit freshness detection: A review. *Food Chemistry* 334, 127615. doi: 10.1016/j.foodchem.2020.127615

Abstract

In this review article, the state of the art of gas sensors based on quartz crystal microbalance (QCM) for fruit freshness detection is overviewed from the aspects of development history, working principle, selection and modification of sensitive materials, and volatile organic compounds detection of fruits. According to the characteristics of respiratory intensity at the stage of fruit ripening, fruits can be divided into respiration climacteric fruits and non-climacteric fruits. In recent years, research has mainly focused on respiration climacteric fruits, such as bananas and mangoes, etc., while related studies on non-climacteric fruits have been rarely reported, except for citrus fruits. The preparation methods and structure design of sensitive materials based on physical/chemical adsorption mechanisms are further discussed according to the odor components that affect the freshness of fruits, namely alkenes, esters, aldehydes and alcohols.

Keywords: /Gas sensor/ /Fruit/ /Freshness/ /Volatile organic compounds/ /QCM/

Yang, S. H., Panjaitan, B. P., Ujiie, K., Wann, J. W., & Chen, D. (2021). Comparison of food values for consumers' preferences on imported fruits and vegetables within Japan, Taiwan, and Indonesia. Food Quality and Preference, 87, 104042. doi: 10.1016/j.foodqual.2020.104042

Abstract

International agricultural trade in fruits and vegetables has received much attention as an effective method to create a sustainable agriculture industry for a country. This study focuses on consumers' perceptions of food values toward imported fruits and vegetables in Japan, Taiwan, and Indonesia by using the Best-Worst Scaling method. Seven food values were examined in this study: labeling product origin, food safety certification, high quality appearance, domestic rarity, price, how the product was grown, and freshness. An online survey was conducted and 1,350 total valid respondents were collected

(500 Japanese, 333 Taiwanese, and 517 Indonesian). The Latent Class Multinomial Logit model was used to analyze consumers for each country. Results revealed that food safety certification and freshness were found as the most important and second most important food values for the majority group of consumers in each of these three countries, respectively. However, the remainder of food values do not have the same importance for each country. The study should help governments and international marketers enhance their agricultural trade policies and marketing strategies for these targeted markets.

Keywords: /Best-worst scaling/ /Imported fruits and vegetables/ /Latent/ /Class/ /Multinomial/ /Logit model/ /Japan/ /Taiwan/ /Indonesia/

JUJUBE

Ozturk, B., Yildiz, M., Yildiz, K., & Gun, S. (2021). Maintaining the postharvest quality and bioactive compounds of jujube (*Ziziphus jujuba* Mill. Cv. 'Li') fruit by applying 1-methylcyclopropene. *Scientia Horticulturae*, *275*, 109671. https://doi.org/10.1016/j.scienta.2020.109671

Abstract

The aim of this research was to determine the effects of 1-methylcyclopropene (1-MCP, 312.5, 625 and 1000 nl L−1) on fruit quality and bioactive compounds of jujube (*Zizyphus jujuba* Mill. cv. 'Li') fruit during the cold storage [at 0 ± 0.5 °C and 90 ± 5% relative humidity (RH) for 60 days (d)]. Throughout the cold storage, decrease in weight and firmness losses and respiration rates were significantly delayed with 1-MCP treatments. At the end of the cold storage, firmness, L* and hue angle value of jujube fruit treated with 1000 nl L-1 1-MCP were higher than the control and the other 1-MCP treatments. During the cold storage, titratable acidity, vitamin C, total phenolics, antioxidant activity (both DPPH and FRAP assay) and phenolic compounds of jujube fruit treated with 1-MCP were higher than the control fruit. At the end of the cold storage, 4-aminobenzoic acid, 4-hydroxybenzoic acid, caffeic acid, ferulic acid, protocatechuic acid, p-coumaric acid and rutin contents of jujube fruit were better maintained with 1-MCP treatments. It was concluded based on present findings that 1-MCP could be used as an effective strategy for delaying postharvest quality losses and maintaining phytochemical compounds in jujube fruit throughout the cold storage.

Keywords: /Antioxidant/ /Epicatechin/ /Flavonoids/ /Phenolics/ /Respiration rate/ /Weight loss/

KALE

Casajús, V., Perini, M., Ramos, R., Lourenco, A.B., Salinas, C., Sanchez, E., Fanello, D., Civello, P., Frezza, D. & Martínez, G. (2021). Harvesting at the end of the day extends postharvest life of kale (*Brassica oleracea var. sabellica*). *Scientia Horticulturae, 276*, 109757. https://doi.org/10.1016/j.scienta.2020.109757

Abstract

The contribution of Brassica vegetables to health improvement is related to their antioxidant capacity. Kale, as a member of Brassicaceae family, has high concentrations of antioxidants and glucosinolates. The main problem of harvested kale leaves is their accelerated senescence that leads to yellowing and a decline in nutritional quality. Previous reports indicate that daytime cycle strongly influenced different metabolic and physiological processes of plants, so the aim of this research was to determine if postharvest shelf life was influenced by the time of day in which kale leaves were harvested.In this study, we harvested kale leaves at 8:00, 13:00 and 18:00 h (in spring crop) and analysed their postharvest behaviour during storage for 9 days at 20 °C in darkness. We measured the yellowing and senescence metabolism during postharvest storage. Results show that leaves harvested at 8:00 h present earlier

symptoms of yellowing, higher chlorophyll degradation and lower sugar content. On the other hand, the samples obtained at 18:00 h barely showed senescence symptoms with a delay in yellowing. Additionally, leaves harvested at 18:00 h present higher protein and sugar content giving evidence of the fact that harvest at 18:00 h contributes to delay kale leaves yellowing and senescence metabolism during storage.

Keywords: /Kale/ /Yellowing/ /Postharvest/ /Senescence/ /Protein degradation/

LEMON

Di Matteo, A., Simeone, G.D.R., Cirillo, A., Rao, M.A., & Vaio, C.D. (2021). Morphological characteristics, ascorbic acid and antioxidant activity during fruit ripening of four lemon (*Citrus limon* (L.) Burm. F.) cultivars. *Scientia Horticulturae, 276*, 109741. https://doi.org/10.1016/j.scienta.2020.109741

Abstract

Citrus limon (L.) Burm contains many important natural bioactive compounds, such as ascorbic acid, essential oils, and antioxidant substances. An experiment was carried out on four lemon cultivars (Ovale di Sorrento, Sfusato Amalfitano, Femminello Cerza and Femminello Adamo) from Southern Italy to study the changes in physico-chemical properties of juice during fruit ripening. Morphological characteristics of fruits, total soluble solids, pH and titratable acidity, ascorbic acid (AsA), and antioxidant activity (TEAC) of juice were tested. The concentrations of AsA in lemon juice showed significant differences among cultivars and ripening stages, with a steadily decrease along ripening stages: from 31.38 of stage I to 23.71 mg 100 g−1 of stage IV. The juice AsA concentration correlated with the colorimetric parameters of peel: L (r = −0.643), a (r = −0.719) and b (r = −0.654). The cv Ovale di Sorrento showed the highest average AsA concentration (29.91 mg 100 g-1). The level of the total TEAC showed a significant steadily decrease from the first to the fourth ripening stage that on average approached 38 %. Principal component analysis showed that lemon fruits at the ripening stages II and III were highly similar each other and well discriminated from the first and last ripening stages that also performed more distantly each other. The paper provides in-depth knowledge about the trend in AsA content and antioxidant activity of lemon juice across ripening.

Keywords: /Lemon juice/ /Antioxidant activity/ /Bioactive compounds/ /TEAC/

LITCHI

Yun, Z., Gao, H., Chen, X., Chen, Z., Zhang, Z., Li, T., Qu, H., & Jiang, Y. (2021). Effects of hydrogen water treatment on antioxidant system of litchi fruit during the pericarp browning. *Food Chemistry*, *336*, 127618. doi: 10.1016/j.foodchem.2020.127618

Abstract

Litchi fruit were exposed to 0.7 PPM hydrogen water (HW) before storage at 25 ± 1 ℃. HW treatment delayed the pericarp browning and maintained the total soluble solids (TSS) of litchi fruit. Then, a total of 25 antioxidant system-related characters were determined to evaluate the effects of HW on antioxidant system during pericarp browning. Compared with control pericarp, the pericarp of HW-treated litchi fruit exhibited higher levels of superoxide radical ($O_2^{-}\cdot$) scavenging activity, glutathione (GSH), monodehydroascorbate reductase (MDHAR), polyphenol oxidase (PPO) and total flavonoids during whole storage, higher levels of hydrogen peroxide (H_2O_2), catalase (CAT), glutathione disulfide (GSSG), ascorbate oxidase (AAO) and total phenols only on day 1, and higher levels of ascorbate peroxidase (APX), total anthocyanin, glutathione reductase (GR) and glutathione peroxidases (GPX) at later stage of storage. Those HW-induced antioxidant system-related characters might directly or indirectly enhanced

the antioxidant capacity and delayed the pericarp browning of litchi.

Keywords: /Ascorbic acid-related characters/ /Glutathione-related characters/ /‘Huaizhi’/ /Postharvest storage/ /Reactive oxygen species-related characters/ /Secondary metabolite-related characters/

LOQUAT

Munera, S., Gómez-Sanchís, J., Aleixos, N., Vila-Francés, J., Colelli, G., Cubero, S., Soler, E., & Blasco, J. (2021). Discrimination of common defects in loquat fruit cv. ‘Algerie’ using hyperspectral imaging and machine learning techniques. *Postharvest Biology and Technology*, *171*, doi: 10.1016/j.postharvbio.2020.111356

Abstract

Loquat (Eriobotrya japonica L.) is an important fruit for the economy of some regions of Spain that is very susceptible to mechanical damage and physiological disorders. These problems depreciate its value and prevent it from being exported. Visible (VIS) and near infrared (NIR) hyperspectral imaging was used to discriminate between external and internal common defects of loquat cv. ‘Algerie’. Two classifiers, random forest (RF) and extreme gradient boost (XGBoost), and different spectral pre-processing techniques were evaluated in terms of their capacity to distinguish between sound and defective features according to three approaches. In the first approach the fruit pixels were classified into two classes, sound or defect, with a 97.5% rate of success; in the second the defective features were considered internal or external defects, achieving a 96.7% rate of success; and in the third approach each type of defect, i.e. purple spot, bruising, scars and flesh browning, were considered separately with a correct classification rate of 95.9%. The results indicated that the XGBoost classifier was the best method in all cases.

Keywords: /Eriobotrya japonica/ /Quality/ /Non-destructive/ /Artificial vision Classification Multivariate analysis

MANGO

Anderson, N. T., Walsh, K. B., Flynn, J. R., & Walsh, J. P. (2021). Achieving robustness across season , location and cultivar for a NIRS model for intact mango fruit dry matter content . II . Local PLS and nonlinear models. *Postharvest Biology and Technology*, *171*, 111358. doi: 10.1016/j.postharvbio.2020.111358

Abstract

A range of modelling techniques were used in the estimation of dry matter content of intact mango fruit from short wave near infrared spectra, collected using an interactance geometry, with models developed on a data set collected across three seasons (n = 10,243) and tested on that of a fourth season (n = 1,448). Model types included Artificial Neural Network (ANN), Gaussian Process Regression (GPR), Local Optimized by Variance Regression (LOVR), Local Partial Least Squares Regression (LPLS), Local PLS Scores (LPLS-S) and Memory Based Learner (MBL), with manual tuning of parameters undertaken. Additionally, two commercially available cloud based chemometric packages for automated model development were trialled. All of these models gave a better result than use of a global PLS model. The best result (lowest RMSEP) was achieved with an ensemble of ANN, GPR and LPLS-S, with the best individual model result achieved by LOVR, with RMSEP of 0.839 % and 0.881 %, respectively, compared to the global PLS result of 1.014 %. The best precision was achieved with the LPLS model, with a SEP of 0.846 %, compared to the global PLS result of 1.012 %. LOVR was twice as fast as a generalized latent variable selection method LPLS-S-cv in prediction of independent validation set (at 58.7 × 10− 3 s compared to 163 x 10-3 s). The ANN model was satisfactory in all categories (prediction speed, model

build speed, and prediction statistics) and insensitive to tuning, e.g., 33 of the 70 parameter combinations were within 0.05 units of RMSEP of the minimum combination. However, the ANN learning rate was low. For applications that require 'real-time' prediction, such as fruit packlines, use of ANN and GPR models is recommended. For non cloud based handheld NIR devices lacking the computational power to perform local modelling, ANN is recommended, and LOVR or a model ensemble recommended in cloud based implementation. The automated cloud based systems performed well (RMSEP of 0.850 % and 0.963 % for Hone Create and DataRobot, ensemble models, respectively), without human intervention for the choosing and tuning of models.

Keywords: /Mango Near-infrared spectroscopy/ /Non-linear modelling/ /Local modelling/ /Fruit quality/

MULBERRY

Yang, L., Gao, H., Meng, L., Fu, X., Du, X., Wu, D., & Huang, L. (2021). Nondestructive measurement of pectin polysaccharides using hyperspectral imaging in mulberry fruit. *Food Chemistry, 334,* 127614. doi: 10.1016/j.foodchem.2020.127614

Abstract

Pectin polysaccharide is an important phytochemical with potential biomedical applications. It is commonly measured by time-consuming destructive chemical methods. This work demonstrates the feasibility of using visible and near-infrared hyperspectral imaging (HSI) techniques to rapidly measure pectin polysaccharides in intact mulberry fruits. Based on spatial information provided by HSI images, the representative spectrum of each whole mulberry was accurately extracted without background. The effects of storage temperature on two varieties of mulberries for model establishment were studied. The performances of two spectral ranges obtained by Si and InGaAs CCD detectors for pectin prediction were compared. The best predictions were obtained from dilute alkali soluble pectin and total soluble pectin in Dashi mulberry fruit stored at room temperature, with residual predictive deviation values of 2.317 and 1.935, respectively. Our results show that HSI is a promising alternative to the chemical method to rapidly and nondestructively measure the pectin content.

Keywords: /Hyperspectral imaging/ /Phytochemical/ /Pectin polysaccharide/ /Medicinal food/ /Mulberry fruit/ /Noninvasive prediction/

MUSHROOM

Zuo, C., Hu, Q., Su, A., Xu, H., Li, X., Mariga, A. M., & Yang, W. (2021). Nanocomposite packaging delays lignification of *Flammulina velutipes* by regulating phenylpropanoid pathway and mitochondrial reactive oxygen species metabolisms. *Postharvest Biology and Technology*, *171*, 111360. doi: 10.1016/j.postharvbio.2020.111360

Abstract

Lignification is an important inducement of quality deterioration of postharvest Flammulina velutipes. In this study, phenylpropanoid pathway and mitochondrial reactive oxygen species (ROS) metabolisms were taken as breakthrough points to investigate the lignification mechanism in harvested F. velutipes packaged in nanocomposite packaging material (Nano-PM). In comparison with polyethylene packaging material (Normal-PM) and no packaging material (No-PM), Nano-PM prevented the decrease of L* value and the increase of firmness. Nano-PM also maintained a better microstructure. Furthermore, Nano-PM reduced the deposition of lignin by suppressing the enzymes activities involved in phenylpropanoid pathway. In addition, the regulation of ROS in mitochondria alleviated the accumulation of Ca2+ and inhibited the programmed cell death (PCD) process, which ultimately delayed the lignification process.

These results indicated that Nano-PM delayed the lignification process by regulating phenylpropanoid pathway and the accumulation of ROS in mitochondria.

Keywords: /Flammulina velutipes/ /Nanocomposite packaging/ /Lignification/ /Phenylpropanoid pathway/ /Mitochondrial reactive oxygen species/ /metabolisms/

ORANGE

Pinto, L., Cefola, M., Bonifacio, M. A., Cometa, S., Bocchino, C., Pace, B., De Giglio, E., Palumbo, M., Sada, A., Logrieco, A.F., & Baruzzi, F. (2021). Effect of red thyme oil (*Thymus vulgaris* L.) vapours on fungal decay, quality parameters and shelf-life of oranges during cold storage. *Food Chemistry*, *336*, 127590. doi: 10.1016/j.foodchem.2020.127590

Abstract

This work has been aimed at studying the effect of red thyme oil (RTO, *Thymus vulgaris* L.) on the shelf-life and *Penicillium* decay of oranges during cold storage. RTO vapours significantly reduced ($P \leq 0.05$) the percentage of infected wounds, the external growth area and the production of spores in inoculated orange fruit stored for 12 days at 7 °C in a polypropylene film selected for its appropriate permeability. Among the RTO compounds, p-cymene and thymol were the most abundant in packed boxes at the end of cold storage. The RTO vapours did not affect the main quality parameters of the oranges, or the taste and odour of the juice. The results have shown that an active packaging, using RTO vapours, could be employed, by the citrus industry, to extend the shelf-life of oranges for fresh market use and juice processing.

Keywords: /Essential oils/ /Active packaging/ /*Penicillium* decay/ /GC–MS/ /Citrus fruit/ /Shelf-life/

PEA

Wattanakul, J., Syamila, M., Briars, R., Ayed, C., Price, R., Darwish, R., Gedi, M.H., Gray, D. A. (2021). Effect of steam sterilisation on lipophilic nutrient stability in a chloroplast-rich fraction (CRF) recovered from postharvest, pea vine field residue (haulm). *Food Chemistry*, *334*, 127589. doi: 10.1016/j.foodchem.2020.127589

Abstract

Postharvest, pea vine field residue (haulm) was steam-sterilised and then juiced; a chloroplast-rich fraction (CRF) was recovered from the juice by centrifugation. The stability of selected nutrients (β-carotene, lutein, and α-tocopherol) in the freeze-dried CRF material was measured over 84 days; the impact of temperature (-20 °C, 4 °C, 25 °C and 40 °C), light and air on nutrient stability was established. All three nutrients were stable at −20 °C and 4 °C in the presence or absence of air; this stability was lost at higher temperatures in the presence of air. The extent and rate of nutrient breakdown significantly increased when the CRF samples were exposed to light. β-Carotene appeared to be more susceptible to degradation than lutein and α-tocopherol at 40 °C in the presence of air, but when CRF was exposed to light all three nutrients measured were significantly broken down during storage at 25 °C or 40 °C, whether exposed to air or not.

Keywords: /β-carotene/ /Lutein/ /α-Tocopherol/ /Stability/ /Steam sterilisation/ /Pea vine/

PEACH

Chen, S., Chen, M., Li, Y., Huang, X., Niu, D., Rashid, A., Xu, C., Wang, K. (2021). Adjustments of both phospholipids and sphingolipids contribute to cold tolerance in stony hard peach fruit by continuous ethylene. *Postharvest Biology and Technology, 171*, 111332. doi: 10.1016/j.postharvbio.2020.111332

Abstract

Horticultural products, including peaches, are susceptible to chilling injury (CI), on which the effect of ethylene is still controversial, and the underlying mechanism remains elusive. Here, changes in biochemical and molecular mechanisms involved in phenolic and lipid metabolism were compared between stony hard peaches with continuous ethylene (CETH) and controls. CETH effectively compromised internal browning incidence, accompanied by the inhibited activity of peroxidase but enhanced phenolic content, and less membrane leakage with reduced H2O2 and malondialdehyde contents. Intriguingly, CETH elevated levels of phospholipids and unsaturation of their acyl chains, coincident with the lower transcript levels of phospholipase Dα1 but higher fatty acid desaturase 2/8.1, and the enhanced sphingolipid contents and biosynthesis concomitant with higher transcript levels of glucosylceramide synthase but lower inositol phosphorylceramide synthase3. Therefore, CETH can ameliorate fruit CI through adjusting phenolic and lipid metabolism, especially comprehensive remodeling of phospholipids and sphingolipids to contribute to the membrane stability.

Keywords: /Chilling injury/ /Peach fruit/ /Ethylene/ /Phospholipid/ /Sphingolipid/ /Lipidome/

Luo, M., Zhou, X., Sun, H., Zhou, Q., Ge, W., Sun, Y., Yao, M., and Ji, S. (2020). Insights into profiling of volatile ester and LOX-pathway related gene families accompanying post-harvest ripening of 'Nanguo' pears. *Food Chemistry*, *335,* 127665. doi: 10.1016/j.foodchem.2020.127665

Abstract

'Nanguo' pear is particularly renowned for its fragrance. Esters are the main components of its aroma, which are synthesized primarily by the LOX pathway. We identified the main volatile esters and critical gene family members involved in the LOX pathway by monitoring their variation accompanying post-harvest ripening and examining their roles through principal component analysis (PCA), partial least-square regression (PLSR), and correlation analysis. In pears ripening to the optimum taste period (OTP), components and contents of volatile esters reached a peak, of which ethyl butanoate, ethyl hexanoate, and hexyl acetate were most prominent. Linoleic acid and linolenic acid contents rose greatly until OTP and then declined; the activities of LOX, alcohol dehydrogenase (ADH), and alcohol acyltransferase (AAT) increased progressively until the OTP. Among the genes involved in LOX-pathway, the expressions of PuLOX3, PuADH3, and PuAAT contributed most to changes of total ester and main esters in 'Nanguo' pears.

Keywords: /'Nanguo' pear/ /Post-harvest ripening/ /Volatile ester/ /LOX pathway/

ROSE

Luca, A., Edelenbos, M., Mahajan, P.V. and Petersen, K.K. (2021). Modified humidity packaging of potted roses. *Scientia Horticulturae 275,* 109607. https://doi.org/10.1016/j.scienta.2020.109697

Abstract

Wilting of potted plants in the distribution chain is a common problem in the ornamental sector. It is attributed to water loss by evapotranspiration – a process regulated by many factors including relative

humidity (RH). Use of modified humidity packaging can be an option to reduce weight loss from potted plants by creating an optimal RH in the plant canopy. Different packaging configurations (bags and sleeves made from different packaging films) were developed and tested for potted roses. Packaged plants were first stored for 4 d at simulated transport conditions (16 °C, 86 % RH, darkness) then 7 d at simulated retail conditions (19−20 °C, 43–52 % RH, 12 h low light) and after that packaged plants were unpacked and stored for 6 d at simulated household conditions (19−20 °C, 43–52 % RH, 12 h low light). The packaging films were bi-axially oriented polypropylene (OPP), polylactic acid (PLA) and NatureFlexTM (NFX). Less water was lost by plants in bags than in sleeves made from the same films and water loss was determined by the water vapor transmission rate (WVTR) of films. WVTR was the lowest for OPP bags and the highest for NFX bags. Due to guttation and leaf wetness in OPP bags, PLA bags were chosen for a validation test. Keeping potted roses in PLA bags for up to 11 days did not exhibit any negative effect on the keeping quality (leaf yellowing/wilting and flower/bud wilting) when compared to commercial OPP sleeves but the weight loss was reduced 2.6–3.8 times. Consequently, modified humidity packaging, and PLA bags in particular, is a promising alternative packaging solution for potted roses. However, further research is needed before this technology can be implemented.

Keywords: /Potted rose/ /Modified humidity packaging/ /PLAWilting/ /Sleeve/ /Water deficit/

Sun, Y., Li, Y., Pan, L., Abbas, A., Jiang, Y., and Wang, X. (2021). Authentication of the geographic origin of Yangshan region peaches based on hyperspectral imaging. *Postharvest Biology and Technology*, *171*, 111320. doi: 10.1016/j.postharvbio.2020.111320

Abstract

Peaches from the Yangshan region, a China-protected geographical indication product (CGIIA), has high economic value because of excellent quality, and price is premium over ordinary peaches. However, authentication of the origin of peaches from this region is challenging because of adulteration in the market and the similar appearance of different cultivar. This research was aimed at developing an effective method based on hyperspectral imaging combined with a group sparse representation (GSR) classifier for the geographic origin authentication of Yangshan region peaches and to interpret the hyperspectral fingerprint with physiological metabolism using high-performance liquid chromatography (HPLC) analysis. Two cultivars, '*Baifeng*' and '*Hujing*', were collected from two peach-producing counties a short distance, from Yangshan and Nanjing regions. Higher contents of total sugars and a higher sugar-acid ratios were found in peaches from Yangshan region probably due to the large differences between day and night temperature. The effective bands for distinguishing fruit from Yangshan region in the range of 400–1000 nm were related to the contents of anthocyanin and some other pigments, while in the near-infrared range (1000–1900 nm), sucrose and acids played important roles in distinguishing different peach types. This research compared the proposed GSR classifier with five other classifiers, and the results showed that the GSR classifier achieved an overall classification accuracy of 99.3% in a few milliseconds of online authentication time. Moreover, analysis of peaches from another harvest season resulted in an average accuracy of 95.8% verification of the GSR classifier. Hyperspectral imaging combined with physiological metabolism analysis has potential for the origin authentication of Yangshan region peaches.

Keywords: /Hyperspectral imaging/ /Peach/ /Geographic origin/ /Group sparse/ /Representation classifier/ /HPLC/ /Physiological metabolism/

Zheng, B., Zhao, L., Jiang, X., Cherono, S., Liu, J. J., Ogutu, C., Ntini, C., Zhang, X., Han, Y. (2021).

Assessment of organic acid accumulation and its related genes in peach. *Food Chemistry*, *334*, 127567. doi: 10.1016/j.foodchem.2020.127567

Abstract

Fruit acidity is an important determinant of peach organoleptic quality, but its regulatory mechanism remains elusive. Measurement of organic acids in ripe fruits of seventy-five peach cultivars revealed the predominant components malate and citrate, accompanied by quinate. Organic acid accumulation increased at early stages of fruit growth, but exhibited a more dramatic reduction in low-acid cultivar during later stages of fruit development compared to high-acid cultivars. Low-acid cultivars showed citrate degradation and less transport of malate into the vacuole due to up- and down-regulation of a GABA pathway gene *GAD* and a malate transporter gene *ALMT9*, respectively. The *NAD-MDH1* gene might control the rate-limiting step in malate synthesis, while three genes, *PDK*, *PK*, and *ADH,* could affect citrate synthesis through the pyruvate-to-acetyl-CoA-to-citrate pathway. Altogether, these results suggested that malate accumulation is controlled at the level of metabolism and vacuolar storage, while metabolism is crucial for citrate accumulation in peach.

Keywords: /Peach/ /Malate/ /Citrate/ /GABA/ /Fruit Quality/

PEANUT

Gu, S., Chen, W., Wang, Z., & Wang, J. (2021). Rapid determination of potential aflatoxigenic fungi contamination on peanut kernels during storage by data fusion of HS-GC-IMS and fluorescence spectroscopy. *Postharvest Biology and Technology*, *171*, 111361. doi: 10.1016/j.postharvbio.2020.111361

Abstract

This study described the rapid determination of potential aflatoxigenic fungi contamination on peanut kernels based on headspace-gas chromatography-ion mobility spectrometry (HS-GC-IMS) coupled to fluorescence spectroscopy. Data-level and feature-level fusion strategies were introduced to integrate HS-GC-IMS and fluorescence spectra, aiming at improving the performances of identification and prediction models. The application of feature-level data fusion using first 10 PCs coupled with orthogonal partial least squares discriminant analysis (OPLS-DA) offered more accurate characterization (96.7 %) for aflatoxigenic and non-aflatoxigenic fungal infection on peanut samples. Regression models were established for predicting colony counts of peanuts infected with aflatoxigenic fungi based on independent and fused signals by partial least squares regression (PLSR). Feature-level data fusion using first 10 PCs achieved the best performances in colony counts predictions for A. flavus (R2 = 0.950) and A. parasiticus (R2 = 0.971). These results demonstrated that the combination of HS-GCIMS and fluorescence spectra might offer the feasibility for early detection of potential aflatoxigenic risk in peanuts.

Keywords: /Peanut kernels/ /HS-GC-IMS/ /Fluorescence spectra/ /Aflatoxigenic fungi/ /OPLS-DA/

PEAR

Huang, Y., Gao, L., Lin, M., & Yu, T. (2021). Postharvest Biology and Technology Recombinant expression of antimicrobial peptides in Pichia pastoris : A strategy to inhibit the *Penicillium expansum* in pears. *Postharvest Biology and Technology*, *171*, 111298. doi: 10.1016/j.postharvbio.2020.111298

Abstract

The alteration of safety-secured yeast is a crucial step before scale applications. Based on previous studies, *Pichia pastoris* showed great potential and value to improve its biocontrol ability. The original sequences of antimicrobial peptide *Ac*-AMP2 and MiAMP1 were optimized according to the preference of *Pichia pastoris* and ligated into pPICZαA plasmid which emerged as a high-performance vector for transformation and expression. The results of RT-qPCR and Western blotting could imply that pPICZαA/*Ac*-AMP2 and pPICZαA/MiAMP1 were successfully overexpressed in *Pichia pastoris* GS115. The peptide concentration of GS115/*Ac*-AMP2 reached a maximum value of 210 mg L^{-1} at 60 h while GS115/MiAMP1 was 220 mg L^{-1} at 96 h. The biocontrol experiment indicated that the recombinant strain GS115/*Ac*-AMP2 and GS115/MiAMP1 could highly suppress the pathogen *Penicillium expansum* in vivo, which was respectively 42 % (GS115/*Ac*-AMP2) and 29.2 % (GS115/MiAMP1) of incidence disease lower than the sterile distilled water treatment. In the case of the experimental results considered, the modified GS115/*Ac*-AMP2 and GS115/MiAMP1 might be promising biological agent in postharvest applications.

Keywords: /Antimicrobial peptide/ /*Pichia pastoris*/ /*Penicillium expansum*/ /Postharvest biocontrol/

Mishra, P., Woltering, E., Brouwer, B., & Hogeveen-van Echtelt, E. (2021). Improving moisture and soluble solids content prediction in pear fruit using near-infrared spectroscopy with variable selection and model updating approach. *Postharvest Biology and Technology*, *171*, 111348. doi: 10.1016/j.postharvbio.2020.111348

Abstract

To obtain robust near-infrared (NIR) spectroscopy data calibration models, variable selection and model updating with recalibration approaches were used for predicting quality parameters in pear fruit. For variables selection, interval partial least-squares regression and covariate selection approaches were used and compared. Model updating with recalibration was performed by incorporating a few new samples in the calibration set of existing batch data. The interaction of variable selection and model updating was also explored. The results showed that with variable selection, the model performance when tested on a new independent batch of fruit was greatly improved. Further, the model updating with only a few new samples resulted in a reduction of the bias when tested on the new batch. In the case of MC prediction, the variable selection reduced the bias from 1.31 % to 0.19 % and the RMSEP from 1.44 % to 0.58 %, compared to the standard partial least-squares regression (PLS2R). In the case of SSC prediction, the variable selection reduced the bias from -0.62 % to 0.07 % and the RMSEP from 0.90 % to 0.63 %, compared to the standard PLS2R. With a combination of variable selection and model updating the bias and RMSEP were further reduced. The interval-based method performed better compared to the filter-based method. As few as only 10 samples from the new batch already lead to a significant improvement in model performance. In the case of MC, spectral regions of 749-759 nm and 879-939 nm were identified as the most important region. In the case of the SSC, 709-759 nm and 789-999 nm were found to be important spectral regions. Robust models made on selected variables combined with model updating strategy can support to make NIR spectroscopy a preferred choice for non-destructive assessment of quality features of fresh fruit.

Keywords: /Interval partial least-squares regression/ /Covariate selection/ /Chemometric/ /Non-destructive/ /Fruit-quality/

PEPPER

Du, Y., Jin, T., Zhao, H., Han, C., Sun, F., Chen, Q., Yue, F., Luo, Z., Fu, M. (2021). Synergistic inhibitory effect of 1-methylcyclopropene (1-MCP) and chlorine dioxide (ClO 2) treatment on chlorophyll degradation of green pepper fruit during storage. *Postharvest Biology and Technology*, *171*, 111363. https://doi.org/10.1016/j.postharvbio.2020.111363

Abstract

Degreening indicates the ripening and senescence process of green pepper fruit, which mainly results from chlorophyll degradation. To date, however, the effect of 1-Methylcyclopropene (1-MCP) alone or in combination with chlorine dioxide (ClO2) on the chlorophyll degradation pathway of green pepper at the molecular level remains scarce. In this study, green peppers were treated with 1 μL L− 1 1-MCP, 30 μL L− 1 ClO2 alone and 1 μL L− 1 1-MCP plus 30 μL L− 1 ClO2, respectively and stored at 20 ◦C for 12 d. The results showed that 1-MCP + ClO2 combination was superior in inhibiting color changes, decreasing the respiration rate, and exhibiting chlorophyll content as compared with 1-MCP or ClO2 alone. Further study on the expression of genes related to chlorophyll degradation pathway revealed that pheophytinase (PPH), pheophorbide an oxygenase (PAO) and red chlorophyll catabolite reductase (RCCR) were suppressed by all treatments. The efficiency of the combined treatment (1-MCP + ClO2) was better than that of 1-MCP or ClO2 alone. While the expression of chlorophyllase (CLH) was not affected by ClO2, but was significant suppressed by 1-MCP and 1-MCP + ClO2. Therefore, our results indicate the different regulatory roles of 1-MCP and ClO2 on the chlorophyll degradation pathway and provide an efficient method to preserve green pepper.

Keywords: /Green pepper/ /1-Methylcyclopropene/ /Chlorine dioxide/ /Chlorophyll degradation/ /Chlorophyll degradation-associated genes/ /Gene expression/

POSTHARVEST TECHNOLOGY

Walsh, K., Lu, R., & Nicolaï, B. (2021). Special issue: Recent advances in the use of visible and vibrational spectroscopy/imaging for measurement of postharvest quality. *Postharvest Biology and Technology*, *171*, 111347. doi: 10.1016/j.postharvbio.2020.111347

Abstract

Advances in both science and industry applications are driven by technological improvements. For example, consider that the human ability to interpret nature was limited by the resolution of human eyesight until the microscope was invented. Since that time, advances in instrumentation have enabled each generation of scientists a ‘fresh view’ of existing topics. A range of non-invasive assessment technologies have been utilized both as tools to better understand fruit physiology and in commercial assessment of intact fruit quality. The late 20th century saw the adoption of load cells and RGB cameras into packlines, allowing for weight and colour sorting. While these technologies are now ubiquitous in modern packlines, their initial use was exploratory and problematic. Consider that while today everyone has a 2+ megapixel camera (i.e., a mobile phone) in hand, colour digital cameras were just arriving on the market in the 1990s and early packline adopters were building their own cameras. Likewise, a range of other detector technologies have become commercially relevant in recent decades, passing from bespoke fabrications to commercially available.

Keywords: /Visible and vibrational spectroscopy/ /Imaging/ /Postharvest quality/

POTATO

Ge, X., Zhu, Y., Li, Z., Bi, Y., Yang, J., Zhang, J., & Prusky, D. (2021). Preharvest multiple fungicide stroby sprays promote wound healing of harvested potato tubers by activating phenylpropanoid metabolism. *Postharvest Biology and Technology*, *171*, 111328. doi: 10.1016/j.postharvbio.2020.111328

Abstract

Wound healing is an inherent property of harvested potato tubers. However, the natural healing process usually needs 2-4 weeks, which increases water loss and pathogen invasion. Therefore, it is necessary to develop a technology to accelerate wound healing processing. Stroby is a biogenic fungicide with induced resistance and it has not been reported whether it can improve the wound ability of potato tubers. Potato plants (cv. Longshu 7) were repeatedly sprayed with 0.4 g L^{-1} (w/v) Stroby during tuber development, and the effect of preharvest stroby spraying treatment on wound healing in harvested potato tubers was evaluated in this study. The results showed that Stroby sprays reduced weight loss and disease index of harvested tubers inoculated with *Fusarium sulphureum*. Stroby-treated potato tubers also showed accelerated accumulation and increased thickness of the suberin polyphenolic, suberin polyaliphatic and lignin at wound sites of tubers. As the major substrates of suberin synthesis, cinnamic, caffeic, ferulic and *p*-coumaric acids were accelerated, and the content of total phenolics, flavonoids and lignin were increased along with increased activity of phenylalanine ammonia-lyase (PLA) at wound sites of harvested tubers. The results suggest that preharvest multiple sprays with Stroby on potato plants could accelerate wound healing of harvested tubers via activated phenylpropanoid pathway.

Keywords: /Stroby/ /Preharvest sprays/ /Potato tubers/ /Wound healing/ /Phenylpropanoid / /Metabolism/

Li, D., Zhang, F., Yu, J., Chen, X., Liu, B., & Meng, X. (2021). A rapid and non-destructive detection of Escherichia coli on the surface of fresh-cut potato slices and application using hyperspectral imaging. *Postharvest Biology and Technology*, *171*, 111352. doi: 10.1016/j.postharvbio.2020.111352

Abstract

The contamination of foodborne Escherichia coli in fresh-cut products has become a major problem of public health around the world, so that early and rapid detection of contamination is crucial. This study explored the potential of hyperspectral imaging (HSI) measurement of contamination on the surface of fresh-cut potato slices in visible-near infrared (Vis-NIR, 400-1000 nm) region. Four preprocessing methods and the genetic algorithm (GA) were explored to handle spectral data and select characteristic wavelengths so as to establish linear and non-linear regression models. The performance of the back-propagation neural network (BP-NN) model based on full-spectrum was satisfactory, with an overall accuracy of 97.6 % and residual predictive deviation (RPD) of 6.7. Based on the BP-NN model, the research successfully explored the optimum treatment time (20 min) of a nonthermal and environmental-friendly method to inactivate the E. coli on the surface of fresh-cut potato slices, thus confirming the potential application of HSI for the first time. The overall results showed that HSI could provide a rapid and non-destructive approach for the detection of foodborne pathogens on the surface of freshcut products.

Keywords: /Hyperspectral imaging/ /Escherichia coli/ /Fresh-cut potato slices/ /Non-destructive detection/ Sterilization method/

Tao, N., Wang, R., Xu, X., Dong, T., Zhang, S., Liang, M., & Wang, Q. (2021). Postharvest Biology and Technology Xanthosine is a novel anti-browning compound in potato identified by widely

targeted metabolomic analysis and in vitro test. *Postharvest Biology and Technology*, *171*, 111367. doi: 10.1016/j.postharvbio.2020.111367

Abstract

Enzymatic browning is the main quality issue of fresh-cut potato. In this study, a widely targeted metabolomics approach was performed to investigate the response of metabolites to pre-cutting short-term warming (SW, an anti-browning treatment) by keeping potatoes at 25 ℃ for 12 h and screen the endogenous anti-browning compounds. Metabolomics analysis suggested that in SW treated potato, 13 metabolites were significantly upregulated while six metabolites were down-regulated with multivariate variable importance in projection (VIP) and fold change values of ≥ 1 and ≥ 2, respectively. Among up-regulated compounds, xanthosine, pcoumaric acid and xanthine were selected for anti-browning function test and the browning inhibition effects of xanthosine and p-coumaric acid was confirmed in vitro test. Xanthosine at concentrations of 50, 500, and 5000 mg L–1 significantly reduced the discoloration of potato mash. At concentration of 5000 mg L–1 , xanthosine was able to completely prevent the discoloration of potato mash with no browning and the increase in discoloration degree of potato mash with moderate browning. Dipping in 1 mg L–1 xanthosine solution for 5 min also reduced the browning of potato slices. Xanthosine addition significantly reduced the polyphenol oxidase (PPO) and peroxidase (POD) activities of potato. Xanthosine could be preventing the development of brown products by reducing the activities of oxidative enzymes. This is the first report that xanthosine can inhibit enzymatic browning in potato. Our results have identified xanthosine as a novel and effective anti-browning compound for fresh-cut potato.

Keywords: /Potato/ /Widely targeted metabolomics/ /Anti-browning/ /Xanthosine/

PUMMELO

Chen, C., Nie, Z., Wan, C., Gan, Z., & Chen, J. (2021). Suppression on postharvest juice sac granulation and cell wall modification by chitosan treatment in harvested pummelo (*Citrus grandis* L. Osbeck) stored at room temperature. *Food Chemistry*, *336*, 127636. doi: 10.1016/j.foodchem.2020.127636

Abstract

Deposition of both lignin and cellulose accompanied by juice sac granulation is widespread in harvested citrus fruit. Hence, measures to suppress postharvest granulation of ‘Majiayou’ pummelo is of great importance. The fruit was treated with 1.5% chitosan and then stored at room temperature (20 ± 2 °C) for 150 d. As compared to the control fruits, chitosan coating significantly suppressed granulation index and maintained good quality. Chitosan coating inhibited lignification by suppressing the activities and expression levels of lignin synthesis-related enzymes (PAL, CAD and POD). By contrast, chitosan treatment enhanced the activities and expression levels of cell wall degrading enzymes, including PME, PG, Cx, XTH and β-Gal, which might contribute to the decrease in cellulose. In a nutshell, chitosan coating can effectively suppress juice sac granulation and fruit senescence of pummelo fruits, and play a crucial role in maintaining the cell wall modification.

Keywords: /Chitosan coating/ /Pummelo/ /Juice sac granulation/ /Cell wall modification/

STRAWBERRY

Aghdam, M. S., & Alikhani-Koupaei, M. (2021). Exogenous phytosulfokine α (PSKα) applying delay senescence and relief decay in strawberry fruits during cold storage by sufficient intracellular ATP and NADPH availability. *Food Chemistry*, *336*, 127685. doi: 10.1016/j.foodchem.2020.127685

Abstract

Herein, we employed exogenous phytosulfokine α (PSKα) for delaying senescence and lessening decay in strawberry fruits during storage at 4 °C for 18 days. Our results showed that the strawberry fruits treated with 150 nM PSKα exhibited lower expression of poly-ADP-ribose polymerase 1 (*PARP1*) gene, leading to a higher intracellular NAD^+ availability, beneficial for a sufficient provision of intracellular $NADP^+$ with the activity of NAD kinase (NADK). Moreover, higher activities of glucose 6-phosphate dehydrogenase (G6PDH), 6-phosphogluconate dehydrogenase (6PGDH), and methylenetetrahydrofolate dehydrogenase (MTHFD) may be the reason for the sufficient intracellular availability of NADPH in strawberry fruits treated with 150 nM PSKα. In addition, strawberry fruits treated with 150 nM PSKα exhibited a sufficient availability of ATP resulting from higher activities of succinate dehydrogenase (SDH) and cytochrome *c* oxidase (CCO). Therefore, our results indicate that exogenous PSKα could be beneficial for delaying senescence and reducing decay in strawberry fruits during cold storage.

Keywords: /Intracellular ATP and NADPH availability/ /PARP1 gene expression/ /Phytosulfokine α/ /Senescence/ /Strawberry fruits/

SWEET POTATO

Li, X., Liu, M., Huang, T., Yang, K., Zhou, S., Li, Y., & Tian, J. (2021). Antifungal effect of nerol via transcriptome analysis and cell growth repression in sweet potato spoilage fungi *Ceratocystis fimbriata*. *Postharvest Biology and Technology*, *171*, 111343. doi: 10.1016/j.postharvbio.2020.111343

Abstract

Ceratocystis fimbriata is the most devastating phytopathogen causing significant losses in post-harvest sweet potato. In this study, monoterpene nerol (NEL), the active compound in neroli essential oil, was found to dose dependently inhibit the mycelial growth and spore germination of C. fimbriata at a minimum inhibitory concentration (MIC) of 0.25 mL L-1. NEL vapor treatments significantly reduced the incidence and lesion diameter of black rot in sweet potato infected by the fungus and regulated the defense-related enzyme activity of phenylalanine ammonia lyase (PAL). Using RNA sequencing (RNA-seq) and biochemical assays, it was demonstrated that NEL treatment impaired cell membrane integrity via down-regulating the expression of ergosterol synthesis genes and reduced the ergosterol content. Moreover, an analysis of a series of apoptotic events revealed that NEL treatment caused mitochondrial membrane damage by reducing the mitochondrial membrane potential (MMP, Δψm), which led to down-regulation of genes involved in ATP production, then induced accumulation of intracellular reactive oxygen species (ROS) generation. Simultaneously, NEL caused nuclear chromatin condensation and concomitant DNA cleavage, which led to the up-regulation of DNA repair genes expression, and the cell-cycle arrest principally occurred at the G2/M phase in C. fimbriata. Altogether, these findings provide information about the underlying antifungal mechanism of NEL against C. fimbriata and suggest that NEL could be a useful alternative for controlling C. fimbriata in post-harvest spoilage of sweet potato.

Keywords: /Ceratocystis Fimbriata/ /nerol/ /antifungal/ /RNA-seq/ /apoptosis/

TOMATO

Guo, J., Sun, K., Zhang, Y., Hu, K., Zhao, X., Liu, H., & Wu, S. (2021). SlMAPK3, a key mitogen-activated protein kinase , regulates the resistance of cherry tomato fruit to Botrytis cinerea induced by yeast cell wall and β -glucan. *Postharvest Biology and Technology*, *171*, 111350. doi: 10.1016/j.postharvbio.2020.111350

Abstract

Induced disease resistance of fruit by bio-based compounds is a promising strategy to control fruit decay. This research was aimed at studying the resistance of cherry tomato fruit to Botrytis cinerea induced by the yeast cell wall component from Saccharomyces cerevisiae and investigate a role of MAPKs in regulating the resistance response. The disease resistance of cherry tomato fruit was effectively enhanced by yeast cell wall and β-glucan. The expression of SlMAPK3 (but not of SlMAPK1 and SlMAPK2) was significantly increased by yeast cell wall and β-glucan and reached peak at 1 h. The yeast cell wall component also induced high expression of PR genes (SlPR1, SlPR5 and SlCHI9) and the transcription factors (SlERF1 and SlPti5) that specifically bind to the promoter of PR genes. The expression of PR genes (SlPR1, SlPR5 and SlCHI9) peaked after 24 h (at 24 or 48 h). The peak of SlERF1 and SlPti5 gene expression mostly appeared at around 4 h. It supposed to be a chronological order in the peaks of gene expression profile among SlMAPK3, PR genes and transcription factors. U0126 (1,4-diamino-2,3- dicyano-1,4-bis(o-amino-phenylmercapto)butadiene) significantly inhibited transcription of SlMAPK3, PR genes and transcription factors. The yeast cell wall and β-glucan could not induce high expression of SlMAPK3 and the downstream genes of SlMAPK3 in the U0126 treatment. These findings indicated that the yeast cell wall component that acts as microbe associated molecular patterns (MAMPs) could effectively induce disease resistance in cherry tomato fruit after harvest. The mechanism of induced resistance was associated with the expression of SlMAPK3 and defense-related genes. SlMAPK3, as an important upstream signaling kinase, had a direct regulatory effect on the downstream transcriptional factors (SlERF1 and SlPti5) to activate the expression of PR genes in the yeast cell wall component-induced immune responses in cherry tomato fruit.

Keywords: /Cherry tomato/ /Yeast cell wall/ /Induced resistance/ /MAPKs/

ZUCCHINI

Jiménez-Muñoz, R., Palma, F., Carvajal, F., Castro-Cegrí, A., Pulido, A., Jamilena, M., Romero-Puertas, M.C., & Garrido, D. (2021). Pre-storage nitric oxide treatment enhances chilling tolerance of zucchini fruit (*Cucurbita pepo* L.) by S-nitrosylation of proteins and modulation of the antioxidant response. *Postharvest Biology and Technology*, *171*, 111345. doi: 0.1016/j.postharvbio.2020.111345

Abstract

Nitric oxide (NO), a major signalling molecule with various physiological functions in plants, participates in many responses to abiotic disorders such as cold stress. Chilling injury (CI) is the most costly postharvest problem in zucchini fruit (Cucurbita pepo L.), since it diminishes market acceptability and shelf life. This study investigates the effect of NO treatment on zucchini fruit during postharvest cold storage. Fruit were dipped in an aqueous solution of sodium nitroprusside (SNP; 25, 100, and 500 μM) as a NO donor and in potassium ferricyanide (a structural analogue of SNP) and distilled water, both used as controls and responding the same during postharvest cold storage. The results showed that the application of 25 μM SNP treatment reduced weight loss and CI in zucchini fruit during cold storage. S-nitrosylated proteins detected in the exocarp of NO-treated fruit were more abundant than in non-treated fruit. The application of SNP improved the quality of zucchini fruit stored at 4 ◦C, with a reduction of weight loss, electrolyte leakage, content of malondialdehyde and H2O2, and delayed loss of firmness during cold storage. NO-treated fruit showed a higher activity of superoxide dismutase, ascorbate peroxidase, glutathione reductase, and phenylalanine ammonia lyase during the first days of cold storage. Total antioxidant

capacity was higher in the NO-treated fruit during the first days of cold storage, supported also by higher concentrations of phenols. NO appeared to play a regulatory role in the antioxidant balance in zucchini fruit, maintaining the cellular redox homeostasis and thus modulating ROS toxicity, thereby improving fruit quality during cold conservation.

Keywords: /Nitric oxide/ /Sodium nitroprusside/ /Zucchini fruit/ /Postharvest Chilling injury/

Zuo, X., Cao, S., Zhang, M., Cheng, Z., Cao, T., Jin, P., & Zheng, Y. (2021). High relative humidity (HRH) storage alleviates chilling injury of zucchini fruit by promoting the accumulation of proline and ABA. *Postharvest Biology and Technology*, *171*, 111344. doi: 10.1016/j.postharvbio.2020.111344

Abstract

In order to investigate the effect of water loss on the different physiological metabolism of zucchini fruit under cold stress after harvest, two cold rooms (4 ℃) with different relative humidities (RH: 74 ± 2 % and 98 ± 2 %) were used for cold storage. The result suggested that high relative humidity (HRH) storage slowed down the increase of weight loss, chilling injury index, malondialdehyde (MDA) content and cell death rate and maintained the postharvest quality such as firmness and flesh color in zucchini fruit. HRH storage promoted the accumulation of proline and induced higher ornithine δ-aminotransferase (OAT), Δ-1-pyrroline-5-carboxylate synthetase (P5CS) enzyme activities and lower proline dehydrogenase (PDH) enzyme activity as compared with low relative humidity (LRH) storage. The content of putrescine (Put) accumulated with the progress of cold damage, which could be delayed by HRH storage due to higher activities of polyamine oxidase (PAO), diamine oxidase (DAO) and ornithine decarboxylase (ODC). Besides, chilling stress induced the biosynthesis of abscisic acid (ABA) during storage and the zucchini fruit stored in high RH with less water loss showed more accumulation of ABA and higher activity of abscisic acid aldehyde oxidase (AAO) compared to zucchini fruit stored in low RH with severe dehydration during long-term cold storage. Taken together, our results suggested that the high RH storage could reduce water loss and alleviate chilling injury in zucchini fruit after harvest by promoting the accumulation of ABA and proline.

Keywords: /Chilling stress/ /Zucchini fruit/ /High relative humidity storage/ /Proline/ /Polyamine/ /Abscisic acid/