ORAL ABSTRACTS

Food loss and waste: tensions, trade-offs, and the role of research

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In this talk, I will give an overview of the work that we undertook in the Office of the Prime Minister's Chief Science Advisor to tackle the challenging issue of food loss and waste. In particular, I will highlight: the tensions and trade-offs involved in reducing food loss and waste across the supply chain; what we know and don't know about the scale of the challenge in Aotearoa New Zealand; and how research and innovation can support a move to a less wasteful and more sustainable food system.

Postharvest challenges and the promise of genomics

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Fruits and vegetables are major contributors to food and nutritional security in addition to critical components of food culture and culinary enjoyment. Unlike many staple crops such as tubers and seed grains, fruits are prone to rapid decay resulting in significant losses of total yield, especially when means of environmental control are not available. Efforts to maintain postharvest life and quality generally take the form of early harvest, controlled environment storage and deployment of genetics that delay maturation and/or influence texture. While effective in maintaining shelf-life and essential to meet market demands for fresh produce, unfortunately such approaches can negatively impact quality. Understanding of genes and genomes has revolutionized plant breeding and provides numerous candidate genes for addressing many problems in plant production, yield and postharvest quality. While several high impact GMOs are prevalent in major staple crops, few examples of genetically modified fruit crops have made it to market despite the fact that many candidate genes have been described with seeming high potential. Nevertheless, a number of notable exceptions have made it to market in recent years and gene-editing presents new opportunities. In many instances, the genome revolution has opened the door to vast depths of untapped genetic diversity that can now be more readily exploited via genome enabled approaches to transfer novel traits more readily to elite germplasm via breeding, resulting in non-GMO crops developed through genome knowledge. An overview of postharvest fruit quality challenges will be presented with an emphasis on tomato, the predominant fleshy fruit crop model, in addition to how the genomics revolution has enabled biological discovery and presents opportunities to exploit natural genetic diversity for crop improvement.

Fruit, ripening, tomato, genomics, gene-editing, genetic diversity, GMO

Sugar metabolism as a key determinant of chilling injury development during peach cold storage and subsequent shelf-life

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Cold storage is widely used during peach (*Prunus persica* (L) Batsch) postharvest to maintain fruit quality. However, cold storage is limited by chilling injury (CI), a physiological disorder expressed during subsequent shelf-life. Sugar metabolism, besides contributing to fruit quality, might alter fruit CI tolerance. The aim of this research was to characterize and compare differences in sugar metabolism in the melting flesh 'Red Haven' peach stored at differenttemperatures throughout postharvest. Fruit was harvested at optimal maturity and stored at 0°C, 5°C, and 20°C for up to 30 days. Evaluations were conducted at harvest (0) and after 1, 3, 5, 15, and 30 days of storage, with and without 3 days shelf-life period. We examined CI incidence, transcript levels for sugar metabolism-associated genes and their associated sugar contents for all assessed storage temperatures and periods. Our results showed that fruit stored at 5°C were sensitive to CI displaying reduced expressible juice contents from 15 days onwards. Sucrose contents decreased significantly throughout storage for fruit stored at 5°C, 5°C + shelf-life and 20°C, alongside with an increase in glucose and fructose; conversely, fruit stored at 0°C and 0°C + shelf-life presented the highest sucrose and lowest glucose and fructose contents. These differences result from increased and decreased transcript accumulation of sucrose catabolism and biosynthesis-related genes, respectively, in fruit stored at 5°C and 20°C, as compared to 0°C. Sorbitol contents generally decreased throughout postharvest storage for fruit subjected to all assessed temperatures but were highest in fruit stored at 0°C and 0°C + shelf-life, which corresponded with the expression levels of sorbitol breakdown-related genes. Our results support the notion that sugar metabolism is playing key roles in chilling injury tolerance in peaches during cold storage.

Peach, sugar metabolism, chilling injury, postharvest storage

Postharvest chilling injury in ‘Lemon’ basil is accompanied by reduction in ascorbic acid content and increased browning enzyme activities

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'Lemon' basil (*Ocimum x citriodorum*) is popularly used in various cuisines due to its unique citrus flavour. Its short shelf life limits its storability while storage in low temperature only leads to chilling injury. 'Lemon' basil has been found to be very susceptible to postharvest chilling injury compared to other commercial varieties and species and yet, information about the inherent cause is scarce. To better understand the chilling sensitivity of 'Lemon' basil, leaves were stored at 5, 10, and 15°C for 6 days, followed by post-storage at 20°C for 2 days. Chilling injury was assessed together with the activity of browning enzymes such as polyphenol oxidase (PPO) and peroxidase (POD). Total phenolic content, ascorbic acid (AsA) and dehydroascorbic acid (DHA) contents were also measured. Chilling injury was highest in basil stored at 5°C, followed by the ones at 10°C, while slight chilling injury was observed in leaves held at 15°C. Leaves stored at 15°C had higher total phenolic content compared to the ones at 5 or 10°C throughout the duration of storage and following transfer to 20°C. The content of reduced AsA increased in basil leaves stored at 10 and 15°C, while it decreased in leaves held at 5°C after 6 days of storage. Total AsA followed a decreasing trend regardless of storage temperature. POD activity increased in basil leaves stored at 5 and 10°C after 6 days. Similarly in these temperatures, PPO activity increased and was highest in leaves stored at 5 C after 2 days at 20°C. Both POD and PPO activities remained low in leaves stored at 15°C throughout the duration of storage. The increased activities of browning enzymes and the decline in reduced AsA coincided with the development of chilling injury in 'Lemon' basil, specially at lower temperatures.

Basil, chilling injury, ascorbic acid, browning enzymes, low temperature storage

Managing chilling injury of subtropical and tropical fruits

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Lowering fruit temperature is the most effective means to extend storage life. However, cool storage may induce chilling injury (CI), which can significantly reduce fruit quality. Therefore, managing CI is critical to chilling-sensitive fruit. Here we use kiwifruit and dragon fruit as examples of CI-sensitive fruit to demonstrate a range of techniques to manage CI while maximising the benefits of cool storage. For kiwifruit, cold nights prior to harvest not only stimulate fruit maturation, as indicated by starch conversion to soluble sugars, but also induce chilling tolerance through acclimation. For less mature fruit harvested without sufficient acclimation, low temperature conditioning (LTC) and stepdown-cooling are effective ways to prevent CI. 1-methylcyclopropene (1-MCP) treatment prior to cool storage resulted in high incidence of CI, while delayed 1-MCP treatment reduced CI, indicating the potential roles of system I and System II ethylene in response to chilling stress. Dragon fruit have no chance of CI acclimation because of their short growth period under warm conditions. Fruit harvested during the dry season tend to have higher chilling tolerance than fruit harvested during the wet season, possibly because of heat shock proteins and elevated fruit calcium content. LTC at 6 or 10°C prior to storage at 2°C reduced CI and extended storage life of dragon fruit. Since CI symptoms usually occur during extended cool storage and develop rapidly after warming up, web-based purchasing, fast delivery and continuous cool chain facilitate more extensive use of low temperature. Overall, the use of dynamic temperature management plays a key role in extending storage life of both fruits, while mitigating the development of CI prior to consumption.

Actinidia spp. Hylocereus undatus, maturity, cool chain, low temperature conditioning

Postharvest treatments with sodium nitroprusside and methyl salicylate synergistically enhanced chilling tolerance of tomato fruit subjected to cold storage

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The exogenous application of sodium nitroprusside (SNP) as a chemical donor of nitric oxide (NO) is one of the most commons ways to study NO-mediated effects on plants. The involvement of NO in enhancing the antioxidant network in plants strongly suggests that NO-mediated applications increase abiotic stress tolerance in plants by enhancement of defences mechanisms. Furthermore, methyl salicylate (MeSA) is an endogenous signal molecule that play essential roles in regulating abiotic stress responses in plants. Tomato fruit is sensitive to develop common symptoms of chilling injury (CI) when stored at 2°C, resulting in flavour loss, surface pitting, poor firmness and discoloration. However, no information is available related to the action mechanism of SNP and MeSA as postharvest treatments, alone or in combination, on quality traits and storability of tomato fruit. Mature red tomatoes were harvested from a commercial greenhouse (Murcia, Spain) and dipped in freshly prepared solutions of SNP and MeSA (acquired from Sigma-Aldrich) at 1 mM during 30 minutes. Treatments tested were: 1) Control (distilled water), 2) SNP, 3) MeSA and 4) SNP+MeSA. Tomato fruits were dried at room temperature, divided in 4 batches with 3 replicates per batch and treatment (5 fruits per replicate, n = 3) and stored at 2°C and 80-85% of relative humidity for 20 days. The CI incidence and quality traits were analyzed each 5 d at 2°C + 2 days at 20°C (shelf-life conditions). Dipping treatments with SNP and MeSA, alone and in combination, substantially enhanced the resistance to chilling temperature in tomato fruit during low-temperature storage. Results showed that these treatments significantly reduced weight losses, respiration rate and ethylene production compared to control fruits, being the combination of SNP+MeSA the most effective treatment. In addition, the ion leakage was significantly reduced in those tomato fruits treated with SNP, MeSA and SNP+MeSA than untreated fruits. Other parameters of membrane integrity were strongly affected by these postharvest treatments during cold storage. Thus, NPS may serve as a promising agent to induce CI tolerance, acting synergically with MeSA as a stimulator of specific resistance responses in tomato fruit.

Nitric oxide, ion leakage, ethylene production, membrane integrity, shelf-life

A super-continuum laser-based, near-infrared spectroscopy system for proximal sensing of internal quality of kiwifruit

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Near-infrared spectroscopy (NIRS) is widely used for assessing the internal quality of kiwifruit. While handheld NIRS devices are applicable in orchards, they require manual contact with the fruit, restricting their capacity to assess a large quantity of fruit efficiently. Hence, there is a need for a rapid and proximal NIRS technique to facilitate high-throughput measurements across entire orchard blocks, crucial for optimal orchard management and harvest decision-making. To address this, we conducted a proof-of-concept study employing a super-continuum laser as the light source for proximal NIRS measurements. This laser offers advantages such as high-density light beams over considerable distances, owing to its superb spatial coherence and broad-spectrum illumination, which is essential for effective NIRS modelling. In our study, we constructed the proof-of-concept system using a super-continuum laser light source (FIR-20, NKT) alongside a silicon spectrometer (MMS1, Zeiss). We compared the performance of this system against that of a hyper-spectral camera (Pika XC2, Resonon), which has previously been employed for in-orchard sensing. Our results indicated that the super-continuum laser system outperformed the hyper-spectral camera in predicting the dry matter and soluble solids content of 'G3' kiwifruit. This outcome underscores the potential of super-continuum laser technology for in-orchard applications, promising enhanced efficiency and accuracy in fruit quality assessment and orchard management.

Near-infrared spectroscopy (NIRS), internal quality, kiwifruit, proximal sensing, super-continuum laser

Acoustic estimation of total soluble solids, the performance of sigmoidal and segmented regressions

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Horticultural industries desire non-destructive methods for the assessment of internal fruit quality factors like total soluble solids (TSS). Specifically, non-destructive methods can reduce fruit loss from destructive assessments and allow for continuous measurements of the same fruit throughout the supply chain. Commonly, optical methods such as NIR have been implemented and employed to assess fruit TSS non-destructively. However, it is possible that mechanical-based methods may also allow for TSS estimation. This work aims to use a non-destructive firmness assessment to estimate fruit TSS using four years of 'SunGold' kiwifruit data. Specifically, this work will focus on using Acoustic stiffness (AS) to estimate TSS whilst also comparing the performance of sigmoidal and segmented regression models. 'SunGold' kiwifruit were harvested from 11, 9, 3, and 5 orchards on multiple (3-5) occasions in 2020, 2021, 2022, and 2023 respectively. Fruit were harvested and freighted to Palmerston North overnight in a line haul truck (~5°C). Upon arrival the fruit were separated into treatments with 30 fruit per orchard assessed immediately (at-harvest), whilst another 24 fruit per orchard were assessed after two weeks of cold storage (1°C). TSS could adequately be estimated from AS using both the sigmoidal and segmented regression models. Notably, both models performed similarly in both the internal and external calibrations and validations. Therefore, this study suggests that both segmented and sigmoidal regressions could be used interchangeably to estimate TSS form AS.

Non-destructive, Zesy002, brix, acoustic stiffness, internal validation, external validation

Assessing and predicting the evolution of persimmon fruit flesh texture during cold storage using hyperspectral imaging

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Changes in the texture of persimmon fruit during storage can impact how consumers perceive them. To investigate this, hyperspectral imaging was employed in this study to predict pulp firmness and examine spectral alterations in a non-destructive way. A total of 1,750 'Rojo Brillante' persimmons were stored at temperatures of 1°C and 5°C for a duration of three months. Imaging was conducted (420-1010 nm) on 250 fruits under each condition at harvest and monthly thereafter. Subsequently, the texture analyser measured the force required to break the flesh, enabling the classification of fruits into three groups (hard, medium, and soft) using K-Nearest Neighbours. The average spectrum of each persimmon was then extracted, and the samples were randomly split into a 70% training set and a 30% test set. Three predictive models Partial Least Squares Discriminant Analysis (PLS-DA), Support Vector Machine (SVM), and XGBoost were trained, all achieving prediction accuracies exceeding 98%. Additionally, significant differences in spectra were observed, particularly in the water region (970 nm) due to cellular degradation, as well as in chlorophyll (680 nm) and carotenoid (475 nm) peaks. Consequently, the optimal storage temperature for persimmons was determined to be 1°C.

Hyperspectral imaging, persimmon, storage, texture

Assessment of harvest maturity in loquat through non-destructive prediction of soluble solid content and titratable acidity using NIR spectroscopy

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The loquat fruit must be harvested at its optimal maturity stage. As in other fruits, maturity in loquat is traditionally based on parameters such as soluble solids content (SSC) and titratable acidity (TA) evaluated through destructive analyses. Therefore, the maturity index used to harvest loquat fruits is the external colour, since it is correlated with the internal sugar content. Nevertheless, the visual and subjective estimation of colour as an indicator of maturity poses challenges due to the fruit colour heterogeneity and differences among varieties. Thus, non-destructive tools are required to estimate the internal fruit maturity accurately and objectively. This study evaluated the potential of non-invasive technologies based on near-infrared spectroscopy (NIRS) to determine the optimal harvest time for loquat fruit. A total of 480 loquats from two cultivars (cv. Algerie and Xirlero) were harvested for four consecutive weeks during the commercial harvest period. Once fruits were harvested, spectral data of each fruit was acquired in reflectance mode, and SSC and TA measurements were performed using destructive methods for use as reference values. Models were developed using partial least squares (PLS) to establish correlations between the measured NIR spectra and reference values. The full studied spectrum (450-1600 nm) and two spectral ranges (600-1000 nm and 700-1700 nm) were studied. The best prediction of SSC achieved an R^2 of 0.82 and 0.64 for Algerie and Xirlero, respectively. Regarding acidity, both cultivars showed an R^2 of 0.74. These results reveal the potential of this technology for evaluating the internal quality of loquats, facilitating accurate determination of harvesting maturity.

Fruit quality, fruit inspection, internal properties, chemometrics

Effect of gaseous ozone pre-treatment on the storability of fresh onions ‘Bianca di Margherita di Savoia- PGI’

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Ozone has gathered much attention as a potentially effective method for preserving fresh horticultural produce, owing to its strong oxidative characteristics and notable antibacterial efficacy. This study investigated the effect of gaseous ozone pre-treatment on quality preservation of fresh onion bulbs of the variety 'Bianca di Margherita di Savoia` which is recognized with a Protected Geographical Indication (PGI) label. Gaseous ozone was adjusted to a concentration of 0.5 ppm in the different chambers kept at 20°C for a duration of 17, 24, 36, or 48 hours. After treatments onions were stored at 20°C for 23 days. The results showed that after 16 and 23 days of storage, the onions treated at 20°C for 48 hours, demonstrated the least incidence of decay (5%) and the lowest loads for mesophilic and mould population were seen after the 9 and 16 days, resulting in a good quality, when untreated bulbs showed an incidence of decay higher than 20% after 23 days of storage. Moreover, the ozone exposure did not have any negative effect on the physicochemical parameters of the onions. Our results suggest that gaseous ozone can be an effective postharvest solution for maintaining quality of fresh onion bulbs 'Bianca di Margherita di Savoia PGI` controlling decay and deterioration of onion bulbs safely.

Damage, shelf-life, microbial infection, physicochemical parameters

Application of cold atmospheric-pressure gaseous plasma technology in potato tubers and its effect on wound healing metabolism

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Cold atmospheric-pressure gaseous plasma (plasma) is typically generated in a reactor where atmospheric air or inert gas is partially ionized using high-voltage electrodes. Therefore, a mixture of electrons, ultraviolet photons, reactive radicals, and other excited/ground-state molecules are formed. These reactive molecules can be perceived by plants as the so-called damage-associated molecular patterns (DAMPs) leading to healing wounds and defence mechanisms activation. The objective of this study was to investigate the impact of a post-harvest application of cold plasma on wound healing metabolism of stored potatoes. In 2023-2024 storage season, 'Clearwater Russet' potatoes were harvested and immediately treated with a single dose of plasma (4200 V) and various exposure times (0, 20, 40, and 60 minutes) along with untreated control (UTC) tubers. Samples were collected periodically during curing at 12.7°C and 95% relative humidity (RH) on days 0, 2, 4, 8, and 16 to determine weight loss, respiration rate, phenylalanine ammonia-lyase (PAL) activity, and total phenolics. For this 1-year study, the weight loss showed a significant interaction between treatments and curing period, with UTC potatoes losing more weight than tubers treated with 60 minutes of plasma. The respiration rate started higher and decreased throughout the curing period without being affected by the treatments. The plasma treatments did not affect PAL activity, nor phenolic deposition. In conclusion, it appears that plasma application rate and timing used in this study does not impact wound healing metabolism.

Phenylalanine ammonia-lyase (PAL), total phenolics, respiration rate

Effect of the combination of postharvest treatments $CaCl_2$ and blue LED on strawberry (*Fragaria x ananassa,* Duch) quality parameters

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Despite its exceptional sensorial characteristics, strawberries are prone to excessive softening postharvest, making them susceptible to damage and decay. Calcium chloride ($CaCl_2$) is one promising treatment for extending strawberry shelf-life, as it was observed that its application on certain cultivars arrested the postharvest firmness loss. On the other hand, blue LED radiation was proposed for increasing fruit pigments content and nutritional value. This study investigated the impact of combined postharvest treatments, $CaCl_2$ spray at 20°C and blue LED (140 µmol m^{-2} s^{-1}) at 5.5°C, on strawberry quality parameters. Strawberries (cv Sonata) were harvested at commercial stage (90 - 95% red surface colour) and subjected to the following treatments: Calcium: 1 g L^{-1} $CaCl_2$ + darkness; Blue: water + 6 hours blue LED; Combined: 1 g L^{-1} $CaCl_2$+ 6 hours blue LED; and Control: water + darkness. The four groups were stored at 5.5°C for 10 days. Fruit appearance, firmness, weight loss, colour, anthocyanins, TSS, acidity and pH were assessed on days 1 and 10, and a sensorial panel was performed on day 4. The results revealed that the combined treatment (calcium + blue) effectively maintained the fruit firmness and appearance compared to individual treatments. No differences in weight loss, colour and anthocyanins were observed between treatments. Blue-treated fruit showed the highest visual quality and higher TSS levels at the end of the storage. Only combined treatment decreased acidity on day 10. Notably, both $CaCl_2$-treated groups (Calcium and Combined) were less preferred than the blue LED-treated fruits in the taste panel, possibly due to enhanced sweetness in the blue-treated group or the perception of calcium salt. As conclusion, the combined treatment has the potential to mitigate strawberry postharvest softening and senescence without adversely affecting other quality parameters. Future research will explore the effect of the combined treatment on strawberry nutritional value by experimenting with different light intensities and exposure times to blue LED.

Strawberry, postharvest, calcium, blue LED, quality, sensory panel

Multiomics analyses of the effects of LED white light on the ripening of apricot fruits

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Apricot (*Prunus armeniaca L.*) fruits are highly perishable and prone to quality deterioration during storage and transportation. To investigate the effects of LED white light treatment on postharvest ripening of fruits using metabolomics, transcriptomics, and ATAC-Seq analysis. Fruits were exposed to 5 μmol m -2 s -1 LED white light for 12 hours followed by 12 hours of darkness at 20°C daily for 12 days. The effects of the treatments on the physiological and nutritional quality of the fruits were evaluated. LED treatment activated pathways involved in ascorbate and aldarate metabolism and flavonoid and phenylpropanoid biosynthesis. Specifically, LED treatment increased the expression of UDP-sugar pyrophosphorylase (USP), L-ascorbate peroxidase (AO), dihydroflavonol 4-reductase (DFR), and chalcone synthase (CHS), leading to the accumulation of caffeoyl quinic acid, epigallocatechin, and dihydroquercetin and the activation of anthocyanin biosynthesis. LED treatment also affected the expression of genes associated with plant hormone signal transduction, fruit texture and colour transformation, and antioxidant activity. The notable genes affected by LED treatment included 1-aminocyclopropane-1-carboxylate synthase (ACS), 1-aminocyclopropane-1-carboxylate oxidase (ACO), hexokinase (HK), lipoxygenase (LOX), malate dehydrogenase (MDH), endoglucanase (CEL), various transcription factors (TCP, MYB, EFR), and peroxidase (POD). The results obtained in this study provide insights into the effects of LED light exposure on apricot fruit ripening. LEDs offer a promising approach for extending the shelf life of other fruits and vegetables.

Light-emitting diodes; transcriptomics; metabolomics; ATAC-Seq

Pinking in lettuce, chemistry, genetics and sensory analysis highlight a complex relationship with polyphenolics

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Lettuce is a major worldwide from with a short shelf life. Shelf life is primarily limited by visual factors, wilting from dehydration and by discolouration, both oxidative browning, and by an uncharacterised pinking which particularly affects iceberg and crisphead types. This is particularly a concern in prepackaged cut lettuce due to the increased cut edges. Chemically the pink discolouration is mostly believed to be the result cell damage releasing free o -quinones with other cell components. This discolouration is itself not harmful, but we demonstrate in sensory trials that it lowers consumer perception of quality leading to food waste. Using the sal x ice genetic mapping population developed by Warwick University we analysed a range of polyphenolics throughout shelf life, as these compounds are obligate precursors of the highly reactive o -quinones. The trial population was grown in the UK in two trials, harvested June and August as an early and late harvested trial. Chemical analyses were conducted by HPLC-MS at three time points, at cutting, one day after cutting and 3 days after cutting. Nineteen QTL were identified in the early trial. One at day 0, four at day 1, and fourteen at day 3. Nine of these polyphenolics co-located to a single locus on chromosome 6. This locus has previously been associated with pinking. Only two QTL were identified in the late trail, neither of which have clear association to previously published pinking. Data for total quinones did not map to any QTL. Other research within the group shows an inconsistent relationship between measurable polyphenols o -quinones and pink discolouration. Further attempts to isolate the pink pigment chemically indicate that the pigment is found almost exclusively in the xylem, and it is conjugation of phenylpropanoid products with cellulose in the phloem that leads to a distinct red pigment.

QTL analysis, Lactuca sativa, polyphenolics, quinones

GABA and amino acid changes in rambutan during storage

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Fruit is not considered a primary source of Gamma-aminobutyric acid (GABA) and amino acids, fruits that contain adequate levels of GABA and amino acids could potentially serve as an alternative source. The aim of this research was to determine the factors influencing gamma-aminobutyric acid (GABA) and amino acids concentrations in rambutans. Our findings revealed variations in GABA levels among different cultivars and maturity stages. A postharvest study monitored GABA and amino acid levels in rambutans over a 6-day storage period, demonstrated that levels of GABA exhibited an increase in fruits stored in modified atmosphere packaging at 12°C and in fruits stored at room temperature. However, the quality of fruits stored at room temperature deteriorated. Phenylalanine and glutamic acid were identified as the most abundant amino acids in rambutans. Alanine and aspartic acid levels increased in rambutan fruits stored in modified atmosphere packaging at 12°C, while other amino acids remained relatively stable during storage.

GABA, amino acid, rambutan, postharvest

Physicochemical and organoleptic properties of solar and freeze-dried okra (*Abelmoschus esculentus*)

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Okra (*Abelmoschus esculentus*) is a nutritious underutilized vegetable, whose production is characterized by poor postharvest management, unavailability in large quantities all year round, and lack of awareness of its nutritional quality. To effectively promote okra and mainstream it into the diets of consumers especially urban dwellers in Ghana, there is a need to evaluate technologies that can be used to extend its shelf life, thereby making it available all year round while maintaining its quality. This study sought to evaluate the effectiveness of technologies such as solar and freeze drying to extend the shelf life of okra. A 2x3x2x3x2 factorial design with three replications was used. The factors were size of cut okra, preservative technologies, blanching, use of additives and storage temperature. All samples were packaged and stored for up to 42 days. Indices measured were proximate analysis, colour, calcium, sodium, iron and zinc. The data was subjected to analysis of variance. Results obtained showed that all treatments extended the shelf-life of okra whilst maintaining the quality. There were significant differences observed in the nutritional content as well as colour of samples studied. The dried samples had significantly higher nutrient concentration compared to the fresh samples due to loss of moisture. The solar-dried samples treated with sodium metabisulfite, and potassium nitrate had a colour change from green to greyish white. This could be attributed to the exposure of the okra to heat and sunlight leading to the degradation of chlorophyll and other pigments. Sensory evaluation revealed an overall acceptability of fresh and freeze-dried samples and consumers also indicated a willingness to purchase the freeze-dried okra. The study therefore shows that value addition of okra using technologies such as freeze drying can extend the shelf life, maintain quality attributes, and make them available to urban dwellers all year round.

Okra, underutilized vegetables, indigenous vegetables, freeze-drying, solar drying, postharvest loss

Simple and Effective: The alginate-gelatin biosensor for quick *B. subtilis* detection in foods

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This study introduces a novel biosensor system designed for the rapid and specific detection of *Bacillus sereus* (*B. sereus*) in various food matrices, addressing the critical need for enhanced food safety measures. Recognizing the global prevalence of foodborne illnesses and the role of B. cereus as a contributor, this research focused on developing a sensor capable of operating effectively in complex food environments. The biosensor, utilising a gelatin layer, demonstrated a high degree of specificity and sensitivity, distinguishing *B. cereus* from other common foodborne pathogens like *Staphylococcus aureus*, *Bacillus subtilis* and *Escherichia coli*. Through rigorous testing, the biosensor showed a distinct and rapid response to *B. subtilis*, even at lower bacterial concentrations (e.g. 10 cells/mL), highlighting its potential for early detection of contamination. The study also explored the sensor's response across different food types, revealing the influence of food composition on pathogen detection efficacy. The results confirmed the biosensor's capability to adapt to varying food matrices, maintaining accuracy and reliability. This research contributes to the field of food safety, offering a practical solution for timely pathogen detection. The development of this biosensor represents a step forward in ensuring food quality and public health, providing a tool for the food industry to rapidly identify and mitigate potential contamination risks. The findings pave the way for future advancements in on-site testing technologies, promising to revolutionize food safety protocols and practices.

Food security, food pathogens, biosensors, point of care devices

Comparative efficacy of dynamic controlled atmosphere against five postharvest pathogens of pome fruit

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The semi-arid climate of central Washington State is suitable for cultivating organic fruit while minimizing biotic stresses. However, storing organic fruit for more than five months presents a significant challenge due to postharvest diseases, which can result in up to 50% losses of organic pome fruit. Currently, there are no effective bio-fungicides available for postharvest use and packers have been relying on organic fungicides applied preharvest and on postharvest sanitation. Organic packers, particularly in the U.S. Pacific Northwest (PNW), have increasingly turned to dynamic controlled atmosphere (DCA) to minimize physiological disorders and extend the shelf life of organic fruit. However, it remains unknown whether postharvest fungal pathogens that cause postharvest diseases can grow and remain virulent under ultra-low O_2 and/or high CO_2 concentrations. In this study, we report on the efficacy of DCA (0.8 to 0.4% O_2), static CA, and regular atmosphere (RA) in reducing the incidence and severity of postharvest diseases caused by *Penicillium expansum*, *Botrytis cinerea*, *Neofabraea perennans*, *Mucor piriformis*, and *Phacidiopycnis washingtonensis*. Fuji apples were wounded and inoculated with spore suspensions of each pathogen at a concentration of 10^5 spores/mL. Additionally, we assessed the efficacy of DCA, CA, and RA on non-wounded inoculated and non-inoculated organic apples. Our results indicate that there is variability among the five different pathogens in terms of their ability to cause fruit decay during storage. Overall, we observed reductions of 5% to 50% in disease incidence under DCA conditions compared to CA or RA. Impact on fruit quality is discussed.

Apple, organic, postharvest diseases, dynamic controlled atmosphere, fruit quality

Optimizing heat treatment and storage condition for ‘Chiin Hwang’ mango

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Mango (*Mangifera indica L.*) is an economical crop over the world, but faces a formidable adversary in anthracnose disease, caused by *Colletotrichum* species. Anthracnose disease could decimate commercial value of mangoes about 30-60% during production-distribution supply chain. Heightened awareness of food safety and environmental concerns has spurred the quest for non-chemical solutions, leading to the exploration of physical treatments for postharvest disease. Therefore, the objectives of this study were (1) to establish the optimal methods of heat treatment; (2) to evaluate the efficacy of heat treatments against anthracnose for 'Chiin Hwang' mangoes; and (3) to set up the suitable storage conditions for 'Chiin Hwang' mangoes. After artificial inoculation, these mangoes were exposed to vapor heat treatment or hot water brushing with different duration. Furthermore, the optimized storage conditions for 'Chiin Hwang' mangoes were tested in a wide range of temperatures. After ripening, the mangoes were moved to individual cool rooms at 1, 5, 10, or 15°C for 15 days and removed to room temperature for 3 days. The results showed that optimal treatment for hot water brushing was at 55°C for 5 min and vapor heat treatment was at 48°C for 1.5 hours. Treated mangoes significantly had the lower severity of anthracnose and sustained firmness as compared with control groups. Thus, heat treatment is a promising and non-chemical method for mitigating postharvest disease in 'Chiin Hwang' mangoes. Moreover, the recommended storage temperature is 10°C preventing from chilling injury and minimizing anthracnose incidence. This study expresses an effectively method with heat treatment and low-temperature storage to maintain the quality and market value of 'Chiin Hwang' mangoes.

Mango, heat treatment, anthracnose, hot water brushing

Comparing *in vitro* and molecular methods for detection of QoI fungicide resistance in *Colletotrichum* spp. associated with avocado in Australia

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Anthracnose is an economically important postharvest disease of avocado caused by several species of fungi in the *Colletotrichum* genus. Copper formulations and strobilurin (quinone outside inhibitors, QoI) fungicides are frequently employed as spray applications within orchards as a key component of the disease management strategy. Current in vitro techniques for evaluating the resistance or sensitivity to fungicides include the traditional amended media plate and more rapid microplate assays. This study will evaluate these two methods and will be compared with results obtained from a molecular assay to detect single site mutation in the cytb gene, known for inferring resistance to strobilurin fungicides. Isolates will be grown on amended media plates and microplates containing PD broth amended with strobilurin fungicide at several concentrations. A selection of sixty *Colletotrichum* spp. isolates from major avocado growing regions in Australia which have been collected and identified to species level will be utilised for the study. The history of strobilurin fungicide use has been recorded for each of the source orchards. Molecular assay revealed that twenty-six of these isolates carry at least one of the mutations responsible for QoI resistance. The objective of this work is to assess the resistance of *Colletotrichum* spp. to strobilurin fungicides through a comparative analysis of amended media plate, microplate, and molecular assay. A fast and effective method for assessing QoI fungicide resistance/sensitivity within *Colletotrichum* spp. will inform industry and grower decisions on in field and post-harvest management options.

Colletotrichum, fungicide resistance, resistant gene, avocado, postharvest, anthracnose

Fungicide resistance in postharvest pathogens and its management as a tool to prevent food losses

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Postharvest pathogens possess a potential threat towards harvested crops, vegetables, and fruits during their transportation from field to farm, handling, and storage. The use of preharvest fungicides applied a few days before harvest or postharvest fungicides applied in the packinghouses remains the most important method to control them and safeguard crop yield and quality, despite efforts to develop novel management techniques. However, over time, resistance to many of the most effective fungicides has emerged and spread in postharvest pathogen populations, compromising disease control. Fungicide resistance development is a serious and important postharvest problem which needs to be actively managed in the packing shed to minimise any potential losses. This review describes the development of resistance using case histories based on important post-harvest pathogens (i.e. *Botrytis cinerea*, *Penicillium expansum*, *Penicillium digitatum* and *Monilinia fructicola*). Emphasis will be given on the molecular mechanisms associated with resistance that include either target site alterations or increased expression of efflux transporters. These mechanisms result in different and varying levels of resistance to fungicides. In addition, resistance management approaches based on robust scientific evidence will be discussed as they are vital to prolong the effective life of fungicides and represent.

Blue mould, brown rot, chemical control, DMIs, grey mould, QoIs, SDHIs

Participant insights from a long-term plant-based dietary intervention in Aotearoa New Zealand

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The He Rourou Whai Painga (HRWP) programme was a long-term dietary intervention exploring whether people at risk of cardiometabolic disease will benefit from an intervention providing an allocated dietary pattern that supports behavioural change. The allocated dietary pattern features a preponderance of plant-based foods (vegetables, legumes, fruits, unrefined cereals, nuts), together with lean protein from seafood and smaller portions of lean red meat and dairy. Over a 12-week period, participants received meal-kit deliveries for their entire family, and stayed on the trial, with ongoing behavioural support, until the 52nd week to allow for the observation of long-term dietary choices, and measurements of relevant biomarkers. In-depth interviews were conducted online with 37 index participants at three time points (6 weeks, 12 weeks, 24 weeks), with seven online focus groups undertaken at approximately 40 weeks. The views of participants were explored, including pre-intervention eating habits, perceptions of healthy foods, potential enablers and barriers, and family involvement, to understand what may underlie longer-term adoption of the plant-based eating pattern. An online survey of all index participants was conducted at the end of the trial to measure post-intervention perceptions and behaviours. Despite their diverse eating habits, participants typically responded well in the early 'honeymoon period' towards food they received. However, by the late delivery phase, clear differences emerged regarding self-reliance abilities and resilience to challenges. Following the final interview, distinct groupings of participants emerged regarding perceived ongoing adoption of the pattern given their differing motivations, emotions, cognitive processes, and resilience to challenge. Nevertheless, many participants reported increased consumption of fruits and vegetables and reduced intake of unhealthy snacks and red meat in the survey. The findings showed that behavioural change towards healthy eating depends on a complex set of characteristics, for example, personal attitude (cognitive, emotional, behavioural), and essentially, the desire to succeed. Environmental factors, for example, family resources, cultural, social, and situational, need to work together to promote the long-term adoption of a healthier dietary pattern.

Plant-based diet, long-term adoption, family involvement, behavioural change, dietary intervention

How much of the nutrients in sustainable healthy diets are supplied by horticultural produce? A dietary modelling perspective

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As consumers become more aware of the environmental impact of their dietary choices and transition towards more sustainable eating patterns, there is increasing focus on horticultural produce, namely fruits and vegetables. Simultaneously, consumers lean towards including more fruits and vegetables in their diets as their awareness of the health benefits linked with these foods grows. Nevertheless, according to the New Zealand Health Survey 2021/22, about half of New Zealand adults fail to meet their recommended daily fruit intake and nearly 90% do not meet the recommended vegetable intake. Using The iOTA Model®, a dietary optimisation tool developed by Sustainable Nutrition Initiative® (SNi), healthy and sustainable diets were simulated to meet nutritional needs while minimally deviating from current dietary patterns. The iOTA Model® was constructed using mixed integer linear programming, integrating New Zealand-specific data obtained from various open-access sources including but not limited to New Zealand's Food Composition Database (FOODfiles), New Zealand Total Diet Study and the nutrient reference values published by the Ministry of Health. Where applicable, bioavailability of nutrients was accounted for so that optimised diets capture the true nutritional value of food, beyond raw nutrient content. We examined how fruits and vegetables contribute to intakes of over 30 nutrients in optimised diets. The iOTA Model® suggests an increase in intake of leafy vegetables and salad greens for both female and male consumers while maintaining most of the fruits and vegetables already present in their typical diets. Overall, horticultural produce continues to play a significant role in supplying nutrients in the optimised diets, providing 61% of weekly vitamin C needs, 58% of vitamin K, 25% of folate, 21% of potassium and 17% of fibre. Results also showed that such diets generate at least 19% less greenhouse gas emissions than a current typical diet. This reduction was mainly achieved by eliminating or reducing consumption of foods that are less efficient in providing nutrients than other parts of the diet (e.g. discretionary foods such as sweets and salty snacks) and selecting those that are most effective in forming nutrient adequate diets. The iOTA Model® stands as a powerful tool for broadening our understanding of what sustainable healthy diets may look like and how various foods fit into such diets. Developed as a tool that can be accessible to all, it provides evidence-based insights about sustainable healthy diets and consequently, the future direction that industries should take to meet the expectations of increasingly conscientious consumers.

Sustainability, linear programming, fruits and vegetables, nutrient adequacy, dietary optimisation, plant foods

Growing impact: Evaluating global investments in fruit and vegetable production for healthier diets

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Objective: This horticulture opportunity study seeks to quantify and qualify public and private investments, alongside identifying challenges and opportunities in horticultural research and development, aimed at facilitating high-level policy engagement. This research is led by the Feed the Future Innovation Lab for Horticulture, in collaboration with the World Vegetable Center, the One CGIAR Initiative on Fruit and Vegetables for Sustainable Healthy Diets (FRESH), and various university partners. Background: Despite widespread recommendations to increase fruit and vegetable consumption - endorsed by 93% of Food-Based Dietary Guidelines - significant barriers remain. These include limited access, high costs, and entrenched dietary preferences, alongside inadequate global production that disproportionately impacts low-income and Global South populations. Addressing these issues is vital for enhancing nutrition and income, particularly through the empowerment of small-scale farmers in the Global South, where fruits and vegetables often represent women-managed crops. Methods: This study spans several countries including Cambodia, Philippines, Nepal, Sri Lanka, Benin, Ghana, Tanzania, Kenya, Guatemala, USA, and Germany. It employs a mixed-methods approach, beginning with a Delphi questionnaire distributed among key stakeholders from government, academia, international NGOs, and the private sector. Subsequent in-person workshops facilitate discussions on investment estimates and the dynamics of horticultural investments in each country using a Q-methodology. The inaugural workshop in Nairobi, Kenya, gathered 18 local experts who provided critical investment insights and validated the use of Delphi and Q methodologies for this study. During this session we share preliminary data and analysis from workshops held from June - August 2024. Impact: The study aims to illuminate the economic and social impacts of investing in fruit and vegetable production, focusing on enhancing accessibility and affordability. It also addresses environmental considerations such as land use, aiming to support sustainable agricultural practices. By bridging gaps in horticultural investment, the study intends to foster supportive environments that enhance fruit and vegetable production and consumption, thus contributing to the Sustainable Development Goals. Conclusion: This study underscores the critical need for enhanced investment in horticulture to overcome systemic barriers to fruit and vegetable consumption, thereby improving global health and economic outcomes, especially for vulnerable populations in the Global South. The outcomes are expected to guide policy decisions and stimulate further research and development in the horticulture sector.

Sustainable development, healthy diets, fruits and vegetables, food systems, policy

Advances in apple maturity assessment and storage decision making: Insights from multi-‘omics studies

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Apple (*Malus domestica*) is the second largest fruit export crop from New Zealand and exporters depend on delivering high quality products to consumers through a complex supply chain. To minimise losses and guarantee that fruit are delivered in prime condition, apples must be picked at optimal maturity prior to storage and shipping. Accurate assessment of apple fruit maturity at harvest is required, since fruit harvested too early or too late are susceptible to physiological disorders or excessive softening during subsequent storage. Parameters currently used to measure maturity or used as a harvest index are not reliable indicators of storage performance. Comparisons of harvest date and between orchards have shown that other factors must be involved. If testing of new indicative measures could be implemented, orchardists would be able to predict optimal harvest time several weeks in advance and th us arrange their logistical planning. This would also enable informed storage decisions, directing fruit with better storage potential to long-term storage and facilitating earlier marketing for less-optimal batches. New biomarkers of 'Royal Gala' fruit maturity around the harvest period and predictors of high eating quality value for post storage were identified using a multi-'omics study (LC-MS- and GC-MS-based metabolomics, hormone analysis, enzyme activity analysis, proteomics and transcriptomics) across two seasons. The accuracy of these biomarkers was then tested on two additional seasons in multiple orchards across New Zealand, validating their robustness. Additional efforts are now being deployed to develop a comprehensive understanding of the effects of pre-harvest environmental conditions and stress tolerance on the biological pathways influencing postharvest fruit quality as ultimately delivered to the consumer.

Apple, maturity, storage, multiomics

Interrelation analysis of fruit state at harvest and the storage duration on the ripe fruit quality of 'Hass' avocado: An example of confusing statistics

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Peru is the second-largest producer and exporter of 'Hass' avocados worldwide. Commercially, the main parameter for harvest is the dry matter content, starting at 21.5% up to 29%, and due to quality demands from importers, the Peruvian industry requires more parameters to ensure high-quality fruit. Numerous trials have been conducted to investigate the relationship between harvest conditions, fruit composition, storage duration, and ripe fruit quality. However, the large number of variables, and substantial variability in such trials, can lead to challenges in the interpretation of the statistical analysis. This study focuses on a storage trial conducted by ProHass Peru in 2022, utilising fruit from both early- and late-season harvests from 10 orchards across three regions. Following harvest, 20 fruit were randomly selected from each orchard to determine both pulp and skin's calcium and nitrogen contents, with an additional 20 fruit taken for dry matter assessment. The remaining fruit were stored at 5°C for 20, 30, or 40 days before ripening at 20°C. The number of fruit per orchard, harvest season, and storage duration ranged from 40 to 68. The fruit were evaluated immediately out of storage and when eating-ripe for a range of quality indicators after storage, and disorders such as body rot, stem end rot, and fibrosis post-ripening. The statistical analysis confirmed the expected increase in fruit disorders with longer storage durations but also revealed significant variation among orchards, both in the initial indicators at harvest and in disorders after ripening. This orchard variation obscured the influence of harvest indicators on ripe fruit quality. Further analysis, supplemented by knowledge of avocado biology, elucidated the strength of the trends in fruit quality based on the at-harvest assessment. It was confirmed that these trends were not qualitatively significant for these fruit that were harvested at commercial dry matter content.

Persea, disorders, defects, rots, generalised linear mixed models, clustering analysis

Optimizing export quality of red dragon fruit from Banyuwangi, Indonesia based on growth location and harvest time

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The quality of red dragon fruit (*Hylocereus polyrhizus*) is influenced by growth location and harvest time. In Banyuwangi, East Java, Indonesia, red dragon fruits for export purpose are cultivated across various latitudes and harvested at different intervals. This study aimed to determine the optimal red dragon fruit varieties for export by considering their growth locations and harvest times. Dragon fruits cultivated in highland (500 m above sea level), middle plains (100 to 500 m above sea level), and coastal plains, adhering to standard cultivation practices, were harvested at 31, 33, and 35 days after anthesis and subsequently stored at 8°C for 35 days. Brix value, weight loss, colour and firmness assessments were conducted at harvest and every 5 days throughout storage. Results showed Brix value variation based on location and harvest age, stabilizing during storage. Coastal fruits harvested earlier displayed higher Brix values, while highland fruits had lower weight loss. Despite initial differences in red colour values, all fruits showed similar values after storage. Highland fruits harvested earlier exhibited deeper red flesh colour at harvest and throughout storage. Firmness did not differ among locations and harvest times. These findings suggest potential for export of red dragon fruits from higher latitudes, with ongoing biochemical assays to further elucidate location and harvest time dynamics.

Dragon fruit, quality, growth locations, harvest time

Evaluating the effects of different harvesting intervals on the postharvest quality of fresh-market blueberries

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Blueberry consumption has been increasing in the recent years which has led to significant increases in the acreage of blueberries grown around the world. Blueberry producers in the United States are facing high input costs and labour shortages, which have forced them to increasingly mechanize harvesting. Even though new, more affordable technologies have emerged in recent years, several parts of the process still require improvements. One of the issues caused by the adoption of mechanical harvesting is increased harvest intervals compared to traditional hand-picking. The shortage in machine harvesting equipment is attributed to the high capital expenses associated with the purchase of such machinery that in turn leads to limited availability of harvesters to perform the harvest in a timely fashion. This trend may compromise berry quality, particularly in the Southeastern United States, where high temperatures and humidity are the typical weather conditions during blueberry harvest. Firmness is a critical factor in determining consumer preference, as well as shelf life, and market value of fresh blueberries. The postharvest quality of blueberries is influenced by various other factors, including genotype, postharvest handling, and harvest conditions such as harvest intervals. This study aimed to investigate the impact of different harvest regimes on fruit quality and storability of 'Brightwell' blueberries. The experiment was conducted at the University of Georgia Alma Blueberry Research Farm, located in South Georgia, USA, with a randomized complete block design. Fruit was hand-harvested at different intervals: T1: every 2 days, T2: every 3 days, and T3: every 7 days. Each treatment was replicated four times, resulting in nine harvests across all treatments. Following the harvest, the berries were sorted for defects, packed in clamshells, and stored at 1°C and 85% relative humidity. Fruit quality parameters: firmness, fruit size, colour, total soluble solids, titratable acidity, and fruit rot evaluation were evaluated at four different intervals: 1, 7, 14, and 21 days after harvest. Preliminary results indicate that fruit from the second and third harvests, T1 and T2 exhibited higher firmness readings at harvest compared to T3. Throughout the storage period, the firmness of the fruit was consistently higher in T2 compared to other treatments. A bigger fruit size was obtained at the first harvest of all treatments which declined after 14 days of storage in all three treatments. At the second harvest, T2 had the highest total soluble solids but after 21 days of storage, TSS declined and T1 had the highest TSS after 21 days of storage in all three harvests. Additionally, T3 had a higher fruit rot incidence, and wet, sunken berries in the second and third harvests. In conclusion, optimizing harvest intervals is crucial for maintaining fruit quality and storability, as evidenced by the observations of the different harvesting regimes in this study.

Machine harvest, shelf-life, storability

The role of age on potato phenotype as impacted by storage condition and time

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As an asexual propagule, the potato's (*Solanum tuberosum L.*) productive potential is highly affected by the environment and storage time. The goal of this study was to identify the role of production environment, time, and storage condition on seed tuber physiological age (PAGE). Two crop generations (GenI & GenII) were investigated for two years each. In GenI, the cultivation period (120 days) for cvs. Russet Norkotah and Shepody was modified (early, mid, and late) to expose developing tubers to different environmental backgrounds. Postharvest, a subset of tubers were subjected to heat treatments (32°C for 21 days) to assess the impact of PAGE on the chronological age. In Gen I, early cultivation produced ca. 40% fewer stems/plant than late cultivation ($P<0.001$) and subjected the crop to an additional 43-day storage period before GenII production. Further, the cultivation timing significantly altered heat unit accumulation during key tuber developmental points. Tubers from the late cultivation accumulated 11% more air and 5% more soil growing degree days (GDD) compared to the early cultivation. Interestingly, GenI GDDs had no impact on GenII's average stem number/plant phenotype. Alternatively, storage duration and postharvest heat treatments had a significant impact on average stems/plant in GenII. Longer storage periods between GenI early and late cultivation increased average stems/plant by ca. 38% ($P<0.001$). Postharvest heat treatments also increased the average stems/plant in GenII by ca. 45% ($P<0.001$), though the effectiveness of the storage heat treatments increased with prolonged storage intervals (51% and 35% for early and late cultivation in GenI, respectively). These data demonstrate while production environment is important for tuber quality and productivity, the storage interval and condition have the most impact on average stems/plant as a marker of age. This information will help growers assess ideal seed production regions for target markets and will help future studies investigating the molecular and biochemical basis of tuber age.

Potato, age, storage, heat, environment

When postharvest technologies can’t prevent waste is insect bioconversion the answer?

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Despite our best efforts, the global fruit and vegetable industry, which generates an estimated 8-10% of global greenhouse gas emissions, suffered estimated postharvest losses of 22% in 2016. There is growing global interest in using insects to bioconvert organic waste into added-value products including insect ingredients for feed and food applications and biofertilisers for improving soil quality and productivity. At Plant and Food Research we have established an Insect Bioconversion Facility to investigate the role insects may play in Aotearoa-New Zealand's waste bioconversion and circular bioeconomy. Our current focus is the black soldier fly (*Hermetia illucens L.*), a tropical species found throughout the world including in Australasia. In our facility we are working to maximise insect (e.g. egg and larval) production as well as to understand how we might be able to 'dial up' larval composition for specific livestock feeds. This presentation will introduce the concept of insect bioconversion and outline our recent research focused on helping solve the problem of organic waste from our horticultural industries. 1. United Nations Environment Programme (2024). Food Waste Index Report 2024. Think Eat Save: Tracking Progress to Halve Global Food Waste. https://wedocs.unep.org/20.500.11822/45230. 2. 2019. Food Loss Index. Online statistical working system for loss calculations (available at http://www.fao.org/food-loss-and-food-waste/ flw-data)

Insect bioconversion, black soldier fly, waste, circular bioeconomy

Sustainable alternatives to low temperature postharvest management reducing supply chain energy demands through physiological manipulation

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Current supply chain practice is reliant on cold-chain handling to reduce nutritional and physiological quality loss, contributing to the high energy demand and environmental impacts of our food systems. We herein sought to develop alternative postharvest approaches that would reduce energy demand by facilitating warmer storage conditions without compromising produce quality retention. We examined responses of climacteric and non-climacteric fruit (tomato, strawberry) and vegetable (cabbage) crops to modified gaseous treatments such as control atmosphere (CA) treatment under elevated storage temperatures. Whilst increasing temperatures from 5°C to 10°C under air was detrimental to cabbage quality, this was offset by storing heads under CA treatment (1.5 kPa CO_2/6 kPa O_2). CA was more capable of reducing respiration rates than cooling, with a two-fold reduction in respiration under CA/10°C treatment compared with chilling to 5°C alone in cabbage, contributing to improved colour retention and suppression of developmental quality loss through disease and adventitious rooting. CA treatment modified senescent regulation through changes in regulatory gene control and hormonal coordination. Abscisic acid accumulation was significantly suppressed under CA treatment, while expression of the senescence-coordinating transcription factor ORE15 was reduced in cabbage whilst reducing downstream expression of catabolic Pheophytinase and Subtilisin Protease enzymes. Our results also indicated that these effects could be linked to hypoxic stress responses, which can be further manipulated to enhance quality retention. Findings from strawberry and tomato experiments are juxtaposed with these results. We have demonstrated that physiological manipulation can be exploited to enable warmer storage conditions of up to 5°C, reducing energy consumption and food loss risks from supply chain perturbations.

Postharvest storage, atmospheric modification, senescence, plant growth regulators, cabbage, tomato, strawberry

Integrating sustainability into modelling for horticultural packaging systems

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The global fresh produce industry is under societal pressure to focus on sustainability and eliminate plastic use throughout the supply chain. Packaging systems in the supply chain will need to be reimagined to meet these sustainability demands. Fresh produce storage often relies on the use of plastic packaging as a moisture barrier for prevention of moisture loss and subsequent product loss through 'dehydration'/shrivel. Alternative strategies or materials that reduce plastic usage need to be considered across a range of sustainability metrics. The objective of this study is to develop a mathematical model that will allow future optimisation of packaging formats to deliver sellable kiwifruit while fulfilling sustainability demands. The model will be created through sub-models which predict internal conditions within the packaging system for any given combination of dimensions, material selection and dynamic conditions in the supply chain. Fruit loss (as dictated by weight loss) will be estimated using these sub-models. A consequent Life Cycle Assessment model will quantify the resulting environmental impact of packaging choice including fruit loss. An optimisation model will be developed to computationally determine the best balance between the use of materials and their role in preventing kiwifruit loss. This model can be used as a basis for continual development of sustainable packaging systems and supply chains that best meet specific market demands.

Sustainability, packaging materials, supply chain, fruit loss, packaging formats, dehydration

Sustainably cropping system for better quality in vegetables

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To facilitate good plant growth the soil should maintain four main functions, carbon transformations, nutrient cycles, soil structure and regulation of pests and diseases. Due to high production intensity in agriculture, high tillage intensity and little use of crop rotations the basic soil functions are challenged, and more attention should be focused into the potential benefits in plant quality a healthy soil may provide. Cover crops are plants grown following or together with the main crops for the protection and enrichment of the soil. Cover crops are known to have a beneficial impact on soil health including impacts on nutrient retention, erosion, soil compaction, soil carbon storage and soil biodiversity. Further, cover crops could have beneficial impacts on plant health and the occurrence of soilborne plant pathogens. Surface mulching with chopped fresh plant material is commonly applied in organic vegetable production. The method suppresses annual weeds, decreases evaporation, and regulates the soil temperature amplitude. Furthermore, biological activity in the soil increases as well as the supply of oxygen to the roots and improves soil structure. supplies crops with nutrients and thus increases vegetable yields. More attention should therefore be paid to the connection between use of cover crops or mulching and crop yield and quality. Results from studies into crop yield, quality and storability following surface mulching, use of cover crops or low tillage methods in the cropping system are presented. Mulching with chopped fresh plant material in onions was thought possible to increase rot due to the increased moisture maintained around the bulb. Our results from two experiments found no differences in the storage loss or quality reductions by applying fresh mulch. However, higher biological activity for a number of variables were found in the treatment receiving mulch. Cover crops sown as a co-crop seems to influence yield and quality in cauliflower as well as in broccoli. While sown as a residual crop following crop harvest, we found no negative effect on crop quality. Low soil tillage compared to high intensity tillage methods may negatively influence carrot quality. However, if rye is used as cover crop compared to Phacelia the negative effect is reduced. Selection of cover crop species is important to avoid transmission of plant pathogens between susceptible species. In an ongoing screening we look into the beneficial impact of selected species of cover crops on reducing soil borne pathogens and contribute to increased plant health.

Carrot, broccoli, cauliflower, cover crops, soil health, mulch, tillage intensity, postharvest

Innovative shelf life solutions for grapes: sustainable films from carrageenan, bacterial cellulose, and essential oils to improve the grapes longevity

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This study focuses on developing biodegradable packaging films using carrageenan, Jamun based bacterial cellulose, and vetiver essential oil to extend the shelf life of grapes while addressing environmental concerns with petroleum-based packaging. The films were designed to reduce microbial growth and oxidative degradation in grapes, with addition of vetiver essential oil. Various concentrations of these components were used to develop the films, which were then applied as coatings on grapes. The coated grapes were evaluated for weight loss, CO_2 respiration, and microbial growth at a storage condition of 4°C. Mechanical, chemical, morphological, and physical characterization of the films were performed to assess their suitability as packaging materials. The tensile strength of the films ranged from 1.2563 MPa for control starch films to 31.99 MPa for carrageenan films with 2% bacterial cellulose, demonstrating that bacterial cellulose enhances film strength. However, adding vetiver essential oil (0.25-0.75%) reduced the tensile strength to 4.788- 8.295 MPa. FTIR analysis confirmed the presence of key functional groups, while XRD revealed an amorphous structure with some crystalline phases, indicating flexibility. SEM imaging showed that bacterial cellulose improved surface morphology, creating a fibrous and porous structure. The films' moisture content ranged from 5.99% to 11.74%, with water activity values between 0.447 and 0.529. Bacterial cellulose reduced water activity, while vetiver essential oil had no significant effect. Solubility tests indicated that bacterial cellulose decreased film solubility, with control carrageenan films showing the highest solubility at 81.90%. The biodegradability of the films was monitored over 12 days, showing initial water uptake followed by weight loss, indicating degradation. Results from the study indicate that the carrageenan-based films, when combined with vetiver essential oil, effectively reduce the rate of spoilage in grapes, thereby extending their shelf life. The findings suggest that such biodegradable films could serve as a sustainable alternative to conventional plastic packaging, offering both environmental benefits and improved food preservation especially in grapes.

Understanding the mechanisms of calcium deficiency disorders

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Calcium deficiency disorders have been studied for over a century but continue to reduce the quality of harvested fruit. Application of key nutrients during fruit growth and avoidance of water stress provide partial control. The mechanisms underlying the development of these disorders have been poorly understood, but breakthroughs have been made over the past 15 years through research in my laboratory and many others. The highlights of these results and future research directions are presented. It is now recognised that decreases in soluble calcium in the fruit's apoplast are linked to increased incidence of calcium deficiency disorders, which can be caused by limited fruit calcium uptake and/or increased amounts of calcium bound to cell wall pectin and/or sequestered in the vacuole. Research has illustrated that growth regulators and/or changes in calcium-associated gene expression altered the incidence of calcium deficiency disorders and the localization of calcium within plants, fruit and/or cells. Calcium deficiency disorders have been difficult to study due to confounding factors at the whole plant and fruit levels that made it difficult to direct treatments to and observe responses of relevant tissues during disorder development. A recently developed and validated tomato pericarp disc method for studying blossom-end rot (BER) has provided the first causative evidence that calcium and ascorbic acid are protective against BER symptom development. In addition, direct application of abscisic acid or gibberellins to tomato discs did not influence BER development, while whole plant applications did. Experiments with this disc system also demonstrated that high concentrations of calcium applied to fruit tissue were still protective against BER development, while similar overapplication of calcium to the soil increased BER incidence through salt stress. These results highlight the importance of both calcium and oxidative stress regulation and reveal mechanisms that can be exploited to control these disorders.

Blossom-end rot, ascorbic acid, oxidative stress, tomato, abscisic acid

Testing strategies for sprout control in different potato varieties for long-term storage

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Long-term storage of high-quality potatoes requires good control on storage conditions during the entire storage period. Sprouting is a major challenge, which can be controlled by lowering storage temperatures, using plant growth regulators, or selecting varieties with long dormancy periods. Since CIPC (chlorpropham) was banned in the EU in 2020, there has been an increased focus on and need for testing alternative sprout control strategies. Under Norwegian conditions, which has a shorter growing season and colder climate, the tubers are less mature at harvest than under other growing and climatic conditions. This may result in the possibility to reduce the total dosage of the sprout suppressant. In this study, the aim is to develop new, robust and sustainable strategies for long-time storage of frying potatoes under Norwegian conditions. Testing alternative plant growth regulators and strategies with lower doses or no use of sprout suppressants is the ultimate goal, and the possibilities for this is investigated through testing of new varieties which accumulates less sugar during cold temperature storage conditions. With new available sprout suppressants, the stores must remain closed for at least 48 hours to ensure optimal absorption of the active in tubers. This can result in buildup of CO_2 in the stores. There is little documentation on the importance of air composition in storage for the accumulation of sugar and the formation of acrylamide. We know that the CO_2 level during periods of the storage season can rise due to cold weather conditions outside, where fresh air is not drawn into the store, or during treatment with sprout inhibitors, where the store is closed to intake of fresh air for two to three days. The effect of elevated CO_2 levels during storage on frying quality was investigated. Experiments were carried out in experimental stores in the storage seasons 2021-2022 and 2022-2023 to investigate the efficacy of different plant growth regulators including 1,4-sight (1,4-Dimethylnaphthalene), Biox-M and Argos at different doses, combinations and timing of treatment compared with a control without. The varieties Innovator, Peik, Fontane, Oleva, Lady Claire and Kiebitz were included in the experiments. Different temperature strategies were also investigated in small scale stores. Cold storage at 4, 6, 7 and 8°C were tested in 7 different processing varieties. Compared to the control, potatoes treated with plant growth regulators had significantly shorter of sprouts. Doses and timing of the treatment affected the growth length at the end of the storage season. Other quality parameters such as frying colour and sugar accumulation was not affected by treatment. There was no definite effect of CO_2 treatment in terms of frying colour, sugar content and acrylamide.

Sprout suppression, anti-sprout, temperature, CO_2

The functions of plant hormones and their interactions with ethylene during infection and development of *Botrytis cinerea* on cut rose flowers

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Plant hormones, including ethylene (ET), jasmonic acid (JA), and salicylic acid (SA), play important roles during plant senescence and responses to disease. This study aimed to investigate their roles in regulating the resistance of cut roses to *Botrytis cinerea* (*B. cinerea*) infection through the analysis of their signalling gene expressions and grey mould disease (GMD) development following hormone treatment and fungal inoculation. Our results showed that GMD infection increased the expression levels of ET, SA, and JA signalling-related genes in cut roses. MeJA treatment reduced the GMD infection rates in cut roses by suppressing the *B. cinerea* growth and downregulating genes associated with ET and SA signalling in petals. Conversely, ET and SA treatments exacerbated GMD infection in cut roses, except for ET and B. cinerea -insensitive cultivars. Treatment with ET biosynthesis and binding inhibitors resulted in reduced GMD infection rates and disease symptoms, while SA biosynthesis inhibitor did not influence the susceptibility of cut roses to *B. cinerea*. Furthermore, ET and SA treatments upregulated the expression of ET and SA signalling genes while concurrently suppressing the JA signalling pathway, except for ET and *B. cinerea* -insensitive cultivars. These results suggest a synergistic interaction between ET and SA signalling pathways in determining cut rose susceptibility to GMD infection, depending on the ET and disease susceptibility profiles of rose cultivars. Whereas the JA signalling pathway acts independently of the ET and disease susceptibility characteristics of rose cultivars. We also propose a working model for the involvement of ET, JA, and SA signalling in response to *B. cinerea* infection in cut roses with different ethylene and disease susceptibility. This finding is relevant to allow the translation of molecular mechanisms obtained in this model into various rose cultivars to aim for reduced GMD infection in cut roses.

Cut rose, ethylene sensitive, grey mould disease, jasmonic acid, postharvest quality, salicylic acid, signalling

Detection of internal heat damage and identification of techniques to prevent the expression of the disorder in cold-stored Laetitia plums

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Internal heat damage in cold-stored plums is a regular occurrence which is on the increase. Heat damage led to substantial losses from 2018 onwards. Previous trials with plums showed that rapid cooling to -0.5°C after harvest can induce internal disorders and that internal browning can be prevented with 1-MCP. Thus, the 1st objective of this research was to determine if a risk assessment method could be developed to ascertain propensity to internal heat damage in Laetitia plums. Plums exposed to extremely high ambient temperatures, to the extent that external heat damage was visible were harvested. Fruit was cooled rapidly (within 6 hours) or slowly (within 24 hours) to -0.5°C and subsequently stored for 3 and 2 days, respectively, then examined for internal heat damage. A second examination was conducted after 2 days ripening at 20°C. The 2nd objective was to determine if internal heat damage can be reduced in Laetitia plums by 1-MCP and/or slower cooling rates. Fruit from the same source used for Objective 1 were cooled to -0.5°C within 6, 24, 48 or 72 hours. Half of the fruit of each cooling treatment were treated with 1-MCP. Fruit cooled within 6 hours served as reference. The results indicated that the rapid cooling risk assessment method can be used as a quality management tool for Laetitia. This is: 6 hours rapid cooling, 3 days storage at -0.5°C, followed by 2 days at 20°C. It was confirmed that rapid cooling may exacerbate internal heat damage in pre-disposed Laetitia plums. Cooling using 48 and 72 hour rates gave lowest internal heat damage. 1-MCP assisted flesh firmness maintenance in slow cooled fruit.

Heat damage, plum, cold storage, cooling, 1-MCP, Laetitia

Utilising genetic extremes in susceptibility for storage disorders to advance knowledge on regulatory mechanisms

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The mechanisms regulating development of physiological disorders are poorly understood for most crops. Current knowledge gaps limit both design of new postharvest treatments to reduce disorders, and development of molecular markers to cull susceptible selections from breeding programmes. In contrast, knowledge of developmental processes associated with maturation, ripening and senescence is relatively more advanced with more control options available. The sporadic nature of disorder expression contributes to our limited understanding: not every fruit develops the problem when stored in the same conditions, nor does all tissue respond the same way. The sampling of tissue to understand changes before the disorder is visible is often compromised by not knowing which tissues will express the disorder. Commercial cultivars may not always be the best models for investigating mechanisms associated with disorder development, as incidence can often be too low and variable. We will discuss the potential for using genotypes with extreme susceptibility to postharvest disorders as model systems for overcoming some of these challenges. We will highlight examples for apples and pears, and present a case study showing how this approach, when combined with QTL mapping and pedigree analysis of a susceptible parent, has resulted in a short-list of twenty candidate genes associated with susceptibility to internal browning. This research also highlights the advances that can be made by multi-disciplinary teams that span postharvest physiology, breeding, molecular genetics, transcriptomics, and chemistry.

Apple, internal browning, phenotyping, physiological disorders, pear

Integration of transcriptomics and metabolomics to unravel exocarp blackspot disorder in avocado cv. Hass

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The fresh fruit export industry faces numerous challenges in providing consumers with high-quality fruits, particularly those in distant markets, as prolonged cold storage adversely affects fruit quality and diminishes postharvest life. Avocado (*Persea americana Mill.*), a subtropical crop renowned for its nutritional value, health benefits, and escalating global demand, is not exempt from such challenges. Within this context, avocado blackspot exocarp disorder manifests as brown or black-coloured blotches following extended cold storage under conventional air conditions, while leaving the mesocarp tissue unaffected. Despite limited research on the etiology of avocado blackspot disorder, studies indicate that cold storage under controlled atmosphere conditions mitigates its occurrence. This study aimed to elucidate the molecular regulatory mechanisms governing the incidence of blackspot disorder in avocado fruits stored under both conventional air and controlled atmosphere conditions, employing a multiomics integration approach. Through a comprehensive analysis integrating hormonal, transcriptional, and metabolic data, a strong correlation emerges between elevated levels of long-chain fatty acids and lignins and the blackened exocarp characteristic of avocado blackspot diseased fruits, concomitant with heightened levels of jasmonic acid and salicylic acid. Conversely, the absence of blackspot incidence in avocado fruits stored under controlled atmosphere conditions warrants attention, as it coincides with the accumulation of indole-3-acetic acid and isopentenyladenine hormone levels, potentially constituting key components of the molecular mechanisms preserving avocado exocarp integrity and averting blackspot disorder. (This research was supported by ANID-Fondecyt N 1220223 and ANID-ICN2021_044)

Persea americana, physiological disorder, transcriptomics, metabolomics, hormones, fruit losses

Factors influencing maintenance of postharvest table grape quality

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Postharvest decay of table grapes is predominantly caused by *Botrytis cinerea*, *Penicillium expansum*, *Alternaria alternata*, *Cladosporium spp.* and *Aspergillus spp.* especially when specific weather conditions favour decay development. South Africa experienced logistical problems in the supply chain due to power outages and delays at the harbour, which resulted in prolonged shipment and/or storage of table grapes beyond eight weeks before reaching retail stores. Reduced grape quality and increased decay development is exacerbated in such instances. This presentation conveys recent findings relating to postharvest table grape quality, and the influence of packaging on quality maintenance and decay control. SO_2; sheets which are used fairly successfully to limit decay development during storage, however, may have limitations and influence arrival quality and potential storage. Packaging combinations affect SO_2, in-box concentrations. The box dimensions, air vents and position in the pallet, in combination with SO_2; sheets, liner bags, moisture absorbent membranes (MAMs) and cooling conditions, collectively influence decay control, cooling rate and ultimately fruit quality. Rapid cooling and high SO_2; emissions can also negatively affect fruit quality. The postharvest handling chain may further compromise the quality of grapes, triggering enhanced deterioration and decay development if not managed correctly from farm to retail. The significance of all these factors on post storage grape quality of table grapes will be discussed.

Postharvest, table grape quality, decay, quality maintenance, Botrytis, packaging material combinations, control strategies, storage, cold chain, handling

Incentive regulatory tools for expansion of Kenyan avocado exports: Agriculture and Food Authority (AFA) experience

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Kenya is among the major players in the world fresh avocado export market that contributes significantly to the foreign exchange earnings of the country. In 2023, the avocado export earnings alone exceeded KES 20 billion in comparison to the KES 157 billion collected from the whole horticulture industry. The country exports ‘Hass’, ‘Pinkerton’, ‘Fuerte’, and ‘Jumbo’ varieties mainly to Europe and the Middle Eastern countries. With the fruit being recognized as the 'green gold' of the future, the Regulator Agriculture and Food Authority (AFA) through its Directorate of Horticultural Crops (HCD) faces a myriad of challenges which comprise, insufficient clean planting materials, limited crop management practices, pest and disease infestation, limited postharvest handling practices, poor feeder roads, poor market information. The two major challenges giving the Regulator sleepless nights are harvesting of immature fruits and fluctuations in market prices. To avoid tarnishing of the Kenya's reputation in international markets due to immature fruit, the Regulator has devised regulatory tools for use. These tools include publishing of the Crops (Horticultural Crops) Regulations, 2020; use of Time to Harvest Model; Fruit Dry Matter (DM%) Sampling as well as restricting shipping of fruit via sea freight during off-season (November to March of every year). This paper examines the rationale behind the regulatory tools/strategies adopted by AFA in attempts to expanding the Kenyan avocado export market as well as shed light on how they go about implementing policy and interacting with other actors along the value chain.

Persea americana mill, fruit management, regulatory strategies, partnerships

Factors affecting adoption of technologies and practices for postharvest loss reduction: Focus on mango value chain in Kenya

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It is estimated that 40-50% of the fruits and vegetables produced for human consumption are lost between harvest and consumption. In Africa, most of the losses occur upstream, between production and retail. The causes of these losses can be addressed through various interventions including technologies, best practices and capacity building of the value chain practitioners. There is evidence of existence of applicable technologies and practices to reduce postharvest losses (PHL) in fruits and vegetables. However, there is low adoption of the technologies due to various factors. This study was conducted to identify the factors that affect adoption (or non-adoption) of recommended technologies and practices for PHL reduction in fruit supply chains. The study focused on the mango supply chain and was conducted in three mango producing counties in Kenya namely Makueni, Machakos and Embu. The study sought to determine the causes of PHL and level of awareness of existing technologies and practices for PHL reduction. In addition, factors that affected adoption (or non-adoption) of these technologies and practices were documented. Various actors in the mango value chain were targeted including farmers, aggregators and traders. The study employed various data collection methods including household surveys (using a structured questionnaire), key informant interviews and expert observations. Among the farmers, the main causes of PHL were identified as lack of market, pests & diseases and non-use of postharvest technologies and recommended practices. On the other hand, traders identified lack of storage, poor quality and mechanical injuries as the major causes of losses. Overall, lack of market was identified as the main reason for non-adoption of applicable technologies and practices among farmers. Therefore, linking farmers to markets was identified as a key incentive to adoption of PHL reduction technologies and practices among the farmers. Adoption of PHL reduction technologies and practices by farmers would positively impact loss reduction at the trader level. In addition, more awareness is key to enhance adoption of PHL reduction technologies and practices.

Mango, postharvest, technology, adoption, market access

Impact of technology intervention on mango postharvest handling in Vietnam

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Fresh, high-quality mangoes are clearly optimal for modern retail trading but the proportion of such fruit in the harvest is limited by poor postharvest handling at the field, packhouse and retail in Vietnam. This study investigates the impact of technology interventions on mango postharvest handling within Vietnam's Mekong Delta. Cat Hoa Loc mango was selected to apply postharvest technology before delivering to a supermarket chain in Ho Chi Minh City, Vietnam. Cat Hoa Loc mangoes underwent sap-burn using on-farm electronic trolleys, hot water treatment and the provision of six-pack cartons to retail the mangoes. The results show that sap-burn impact was significantly lower through the chain with the de-sapping treatment, and the trolley showed the ability to move operations around the orchard efficiently, which also proved to be time efficient. Hot water treatment (HWT) was more successful in controlling diseases if it could be used in conjunction with the fungicidal treatment. The retail packaging of mangoes supplied in six-pack cartons, as well as appearance and quality, are important in gaining price premiums and attaining consumer and retail sector confidence in the mangoes. Therefore, a combination of sap-burn, hot water treatment and packaging is considered a solution for collectively extending the shelf life of mangoes and sourcing high-quality fruit for the premium retail market. The postharvest technology intervention brought the farmers and the supermarket benefits from the value chain, while the packhouse/vendor incurred a loss.

Food loss along the value chain of taro: a look at postharvest handling practices of taro in Samoa and Tonga

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The food loss and waste crisis represent a complex and multifaceted global issue that has created far-reaching impacts on the global economy, social welfare, and environmental sustainability. This study looks at food loss along the taro value chain, with a focus on postharvest handling procedures in Upolu, Samoa and Tongatapu, Tonga. The objective of the study is to gain a better understanding of these procedures and identify strategies for reducing food loss, improving economic outcomes, and promoting better nutrition for households involved in the taro value chain. The study also compares and contrasts the postharvest handling practices and losses between the two locations to gain insights into the similarities and differences in taro farming practices in Samoa and Tonga. Data for this study were collected through fieldwork, including interviews with farmers, sample collections, and laboratory observation. A total of 80 farmers were surveyed with a few farmers shadowed from harvest to point of sale. The study findings contribute to knowledge on how to reduce food loss and waste in the taro value chain and promote sustainable agriculture practices in Samoa and Tonga. By answering these research questions, we hope to gain a better understanding of the postharvest handling procedures of Taro in Samoa and Tonga and identify strategies for reducing food loss and improving the economic and nutritional outcomes for households involved in the Taro value chain. Also, by comparing the postharvest handling practices and losses between the two locations, the study contributed to a better understanding of the similarities and differences in taro farming practices in Samoa and Tonga.

Food security, postharvest loss, taro, value chain, sustainability

Storage optimization of haskap berries

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The increasing demand for fresh produce has emphasized the importance of emerging crops such as haskap (*Lonicera caerulea*) fruit in countries like Canada, the United States, China, Japan, and New Zealand. Haskap is valued for its rich bioactive compounds and delightful flavour. Nevertheless, growers face challenges in establishing appropriate postharvest practices and storage strategies, which hinders their ability to enter the fresh produce market. To fill this gap, the study presents two designs for testing storage conditions by monitoring temperature and humidity. In the first experiment, three temperatures (0, 4, and 8°C) and 90% RH were tested over 28 days. In the second experiment, the decay of haskap quality was monitored over time (1, 10, and 20 days) at three temperatures (0, 4, and 8°C), with two levels of RH (90% and 95%) using a randomized design and a predictive profiler to optimize storage conditions. The study monitored various quality attributes, including firmness, colour, weight loss, acidity, and% TSS. Additionally, physiological parameters including ethylene production and respiration rate, as well as antioxidant enzymes like catalase (CAT), superoxide dismutase (SOD), and ascorbate peroxidase (APX) were evaluated. The highest firmness and weight loss degradation occurred at 8°C (53.4% and 22.7%, respectively). Ethylene production peaked on day 15 at 8°C, reaching 1747.38 pmol $C_2 H_4$ kg^{-1} s^{-1}, while respiration rate of fruit reached its maximum level at 1129.65 nmol CO_2 kg^{-1} s^{-1} after 20 d of storage at 4°C. The highest values of CAT and SOD were recorded at 0°C, with 8.69 U g^{-1} protein and 38.10 U mg^{-1} protein, respectively. APX activity showed a significant increase at 0°C and 4°C, with values of 6.38 and 6.32 U g^{-1} protein respectively. This paper provides practical guidance for postharvest storage of haskap.

Haskap, Cold-Storage, Emerging crops; enzymatic activity

KEYNOTE: Fresh produce postharvest losses and food safety: a perspective on the adoption rate of postharvest research technologies and innovations

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Postharvest losses are a major global concern affecting food production, leading to food insecurity and economic losses. Studies have shown that approximately one-third of food produced is lost or wasted. Fruits and vegetables are the most affected contributing to 45% of the total postharvest losses and waste. These losses relate to both quantitative and qualitative aspects, affecting quality, food safety and nutrition. The onset of the COVID-19 pandemic further aggravated postharvest losses, highlighting the crucial need to ensure sustainable systems to prevent losses and ensure sustainable food supplies. Several postharvest innovations and technologies have since been developed to improve fresh produce handling practices thus enhancing food security, reducing waste, and mitigating environmental impacts. This review aimed to determine the adoption rate of postharvest technologies and how they impact food security and food safety. The adoption rate of postharvest technologies varies across different regions and crop systems. Research has shown that the adoption of postharvest technologies also varies depending on the farmer's knowledge. Despite extensive technological developments, their adoption rate remains low, especially among small-scale farmers. The findings reflect on the importance of effective technology adoption particularly at the small-scale farmer level. This review will further show the integration of these technologies in different fields of postharvest fresh produce handling.

Postharvest losses, Food security, Food Safety, Postharvest technologies

An in-field postharvest fungicide applicator in pome fruit: evaluation on disease control and food safety

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Applying fungicides via drench to apples and pears at harvest to protect them from decay during storage has long been a prevalent practice in the Pacific Northwest. Starting around 2015, the industry began embracing themonebulization (TNB) as a standard method for postharvest fungicide application. Each technology exhibits its own set of benefits and limitations. Drenching may provide superior protection, but cross-contamination can be a concern when the same tank is reused to treat up to 800 bins, whereas TNB has some limitation with providing inform fungicide levels. In this study, we present a new applicator that can apply postharvest fungicides immediately after harvest in the orchard or at packinghouse facilities. This innovative method avoids the need to recycle fungicide suspensions and effectively eliminates the risk of cross-contamination. 'Honeycrisp' apples from four lots (consisting of four bins each) were subjected to treatment using a field applicator in a single-pass in 2021 and 2022. The treated apples were then compared to an equal number of bins from the same lots that were treated using a traditional packing house drencher. An additional set of bins from the same lots was left untreated to serve as a control. Prior to and following each treatment, apples were collected from various locations within the bins to analyze levels of fungicide residue and surface microflora. In addition, a total of 400 apples were collected for each treatment and stored at a temperature of 2.7°C. These apples were inspected monthly to determine the occurrence of postharvest diseases. Our findings demonstrate that the field applicator offers fruit coverage that is comparable to that of a drencher. Additionally, it has been observed that the incidence of disease is lower when using the field applicator as opposed to the packing house drencher. This innovative applicator holds the potential to create new possibilities for minimizing the use of fungicides while simultaneously increasing the overall packout.

Applicator, Fungicides, food safety, diseases, postharvest

Investigation into alternative postharvest fungicides as a backup strategy against imazalil resistance

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The particular efficacy of imazalil (IMZ) against the citrus postharvest pathogen *Penicillium digitatum* is of immeasurable importance world-wide. There exists a concern that important export markets such as the European Union, which could in future terminate the use of this active. More in-depth understanding of the optimal application conditions for use of alternative actives currently registered for use in aqueous application of postharvest treatments of fresh citrus, was therefore a priority. The actives, azoxystrobin (AZO), fludioxonil (FLU), 2-orthophenylphenate (OPP) and propiconazole (PPZ), pyrimethanil (PYR) and thiabendazole (TBZ) were included in this trial. These six actives do not have a comparable three-pronged efficacy to IMZ and are not routinely applied as primary disease control measures. Imazalil has well-established application conditions that allow optimum action by IMZ. The study was conducted using lemons, navels and soft citrus ('Leanri' mandarins). Optimal chemical performance is dependent on the temperature and pH of the aqueous environment, as well as the exposure time to the active. The parameters evaluated for aqueous application of above mentioned active in the packhouse were: three temperatures (25, 35, 45°C), pH 5.5 (incoming municipal water, adjusted), and three inoculation time points (6, 12, 18 and 24 h), with a single exposure time of 1 minute. The tests were conducted on the single actives as well as combinations of every single active with every other single active. In the case of the combinations, and based on logistical feasibility, it was decided to complete all combination trials at 35°C only. While most of the single actives tested were disappointing in their action against *Penicillium digitatum*, several of the combinations were as effective as IMZ (> 80% control). Combinations of these actives had good synergy, thus increasing the number of alternatives that can be used for the South African citrus industry for postharvest green mould control.

Imazalil, postharvest management strategies, Penicillium digitatum

Green mould control under lower chemical residue limits on citrus

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The maximum residue of traditional fungicides used to control postharvest diseases of citrus fruit are under review to be lowered. These fungicides applied at lower concentrations may have a reduced efficacy against postharvest diseases such as green mould. This study therefore focused on the control of green mould under lower fungicide concentrations when combined with Generally Regarded as Safe (GRAS) chemicals. 'Eureka' lemon fruit were wound-inoculated the day before treating the fruit with the fungicides applied alone, at South African registered dosages, as well as at lower dosages, applied alone and in combination with postharvest GRAS chemical formulations [carbohydrate derived fulvic acid (CHD-FA, 0.53%) and potassium sorbate (0.3-0.75%)]. The fruit were evaluated for green mould 14 days after inoculations. Potassium sorbate combined with lower dosages of pyrimethanil (500 ppm; 95.83±4.56% control), showed significantly increased control of green mould compared to when pyrimethanil was applied alone at the registered dosage (1000 ppm; 61.11±16.39% control). Similarly, potassium sorbate applied with lower dosages of azoxystrobin (843.75 ppm; 95.83±4.56% control) significantly increased control of green mould compared to when azoxystrobin was applied alone at the registered dosage (1125 ppm; 66.67±20.41% control). Carbohydrate derived fulvic acid and potassium sorbate applied with lower dosages of imazalil increased control, but this was not statistically higher. The same was true for when CHD-FA was applied with lower dosages of pyrimethanil and thiabendazole. These chemical combinations may be used to increase control of green mould, and reduce resistance development of postharvest pathogens where these chemicals are applied at lower dosages. Further investigation will be conducted to study resistance development of postharvest pathogens, and how the addition of GRAS chemicals may influence the residue loading of the fungicides.

Citrus, green mould, Penicillium digitatum, postharvest

AC20010 – a novel fungicide for postharvest uses

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AC20010 is a novel fungicide being developed by AgroFresh, Inc. solely for postharvest uses. The active ingredient has a unique mode of action vs. any other fungicide used in agriculture and has been granted a unique FRAC code. This will provide a valuable new tool for resistance management and a needed addition to the limited number of fungicides available for postharvest uses. AC20010 is being developed primarily for use on high value fruits, such as pome fruits, table grapes and berry crops. It has demonstrated a broad spectrum of activity, controlling important diseases caused by pathogens such as *Botrytis*, *Penicillium*, and *Phlyctema* spp.. Specific formulations are being developed to accommodate various application methods and industry needs. The characteristics of AC20010, mode of action, and representative performance data are described in this presentation

Fungicide, postharvest

Effect of chitosan as a basic substance on postharvest pathogens and shelf life of sour cherries

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Most commercial chains have their own system of requirements regarding plant protection chemicals and their residues. The usage of chemicals is more and more limited, and residues are strictly checked to fulfil consumer requirements. In addition, due to the presentation of the European Green Agreement (Green Deal), researchers are looking for more environmentally friendly alternative solutions in plant protection. Basic substances, including chitosan, are active natural compounds. The European Union was the first to allow its use as a plant protection agent in organic farms and in integrated plant protection. However, we do not yet have information about the effectiveness of chitosan against sour cherry postharvest decay or in sour-cherry plant protection strategies. From the surface of stored cherries, a list of decay-causing fungi were isolated and identified morphologically and also based on their internal transcribed spacer (ITS) sequences as *Alternaria alternata*, *Botrytis cinerea*, *Cladosporium herbarum*, *Colletotrichum clavatum*, *Fusarium solani*, and *Penicillium expansum*. Two chitosan products were tested on the different decay-causing fungi isolated from the surface of sour cherries in *in vitro* tests at 0,1%, 0,5% and 1%. In the orchard the most effective 1% chitosan solution was also used as preharvest treatment, and harvested fruits were dipped in a 1% chitosan solution. Fruit were stored 7 days at 20°C, and disease incidence was calculated. The fruit firmness of the samples was obtained in Durofel index. The surface mould number was determined. All tested chitosan concentrations inhibited the mycelial growth of the tested decay-causing fungi. Chitosan treatment increased the fruit firmness of 'Újfehértói fürtös' cultivar, while no significant effects on reducing decay were observed. The work was developed within the framework of the FoodWaStop COST CA22134 Action.

Basic substance, chitosan, postharvest, shelf life, sour cherry

KEYNOTE: Postharvest phytochemical exploration in fruits and vegetables for health

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Fruits and vegetables are key components of the human diet, containing a range of phytochemicals that enhance human health. Their regular consumption is often linked to lower levels of inflammation and a lower risk of chronic illnesses such as cardiovascular disease, as well as improved immune function and mental health. These benefits may be amplified by appropriate growing and harvesting practices and technological advances, benefiting human health and encouraging the production of the crops required for food security. These practices can be considered a "Harvest to Health" approach and include choosing quality cultivars and optimizing growing conditions, location, harvest maturity, and post-harvest handling practices for improving health-promoting phytochemicals. In our studies, we applied these techniques to various commodities, including onion, melon, grapefruit, and tomato varieties, prior to measuring the levels and biological activities of key phytochemicals. For example, in mature grapefruit, D-limonene, and furanocoumarins were found to inhibit critical liver CYP 3A4 and CYP 1B1 isoenzymes required for drug metabolism. Our cell culture studies suggested that citrus bioactives, including limonoids (limonin and other derivatives) and nomilin, were effective in inhibiting the proliferation of colon cancer and MCF-7 breast cancer cells and promoting apoptosis through suppression of NF-κB-mediated inflammatory signalling. We also found that citrus juices help to increase bone density and might prevent osteoporosis, following the modulation of antioxidant enzymes and lipids in orchidectomized rats. In our onion seed nano-priming studies, we measured increased levels of quercetin di-/mono-glucosides and found that these bioactives reduced the severity of oxidative damage, which previous studies showed to have anti-atherosclerosis activity in vitro and in vivo . Lycopene is a beneficial carotenoid, and we demonstrated that it inhibits proliferation in rat prostate cancer cells. In our ongoing tomato study, we increased lycopene biosynthesis in tomatoes by supplementing with UV radiation in greenhouse conditions. We are now investigating the prebiotic potential of phytochemicals for gut health. These investigations aim to test whether phytochemicals can enhance the growth of key gut microbes or the production of microbial metabolites such as short-chain fatty acids and antimicrobial compounds for combating foodborne pathogens. Future studies will focus on gut microbial metabolomics to better understand gut bacterial activity and the overall health benefits of fruits and vegetables. Overall, our previous and ongoing research provides valuable insight into how pre- and post-harvesting conditionings influence the phytochemical abundances of nutritional and health-promoting compounds in F&Vs. This work was supported by USDA-SCRI-TDA-GSC2022075 and USDA-NIFA-SCRI-2017-51181-26834 through the National Center of Excellence for Melon at Vegetable and Fruit Improvement Center and partially funded by the Texas A&M Institute for Advancing Health Though Agriculture.

Plant bioactive, health promotion, degenerative diseases, postharvest quality, secondary metabolite

The spatial distribution and storage conditions influencing of glucosinolates metabolism in fresh-cut broccoli

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Broccoli (*Brassica oleracea* var. *italica*) is a rich source of glucosinolates, some degradation products of which have strong anticancer activities. Fresh-cut broccoli with unique nutritional and convenient ready-to-eat characteristics is in increasing market demand. However, fresh-cut produce yields mechanical damage and accelerated loss of glucosinolates. In this study, we analysed the spatial distribution of nutrients in different organs of broccoli and the effects of storage conditions on glucosinolates metabolism in fresh-cut broccoli. The results showed that there were significant differences in metabolite composition among different organs (including leaf, petiole, flower bud and stem) of broccoli. Glucosinolates are potential biomarker among different organs, of which the contents of glucoraphanin and glucobrassicin in flower bud were much higher than other parts. Low temperature effectively delayed the change trend of metabolites in broccoli, especially in flower bud. After cutting, a large number of metabolites were up-regulated in the cut surface to enhance the resistance to damage stress, and then some metabolites were enzymatic hydrolysed. Fresh-cut led to sharp increase of endogenous jasmonic acid and some indole glucosinolates. Exogenous methyl jasmonate (MeJA) treatment with 20 μmol L^{-1} significantly up-regulated the content of indole glucosinolate neoglucobrassicin. MeJA treatment might put broccoli in a "priming" state, allowing it to respond more quickly to damage stress, with glucosinolates involved in this process. These findings provide technical support for bioactive compounds preservation and nutritional quality improvement of fresh-cut broccoli.

Glucosinolates, fresh-cut, broccoli, storage condition, nutritional quality

Untargeted metabolome scale genome-wide association studies reveal genetic control and biochemical insights into metabolites of apple fruit

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Apple (*Malus x domestica*) fruit is one of the most popular fruits grown and consumed worldwide, contributing to human health with significant amounts of polyphenols and other bioactive compounds, and providing positive impacts on the economy and society. To reveal genetic control mechanisms of apple metabolites, we conducted an untargeted metabolomic analysis with an ultra-high-performance liquid chromatography-mass spectrometry (UPLC-MS) to investigate thousands of semi-polar chemicals (mainly phenolic compounds) in 502 apple accessions from an apple diversity population, and quantified 2066 and 2500 features with positive and negative ion modes, respectively. We further performed genome-wide association studies (GWAS) on quantified mass features with approximately 280,000 single nucleotide polymorphisms (SNPs). GWAS identified over 600 significant hits in positive mode alone. The significant associations revealed not only a wide spread of loci on the apple genome contributing to phenolic compound abundances but also several strong and intensive hotspots for various groups of known and unknown phenolic compounds in apples, including flavonones, dihydrochalcones, flavonoids and hydrodynamic acid-related compounds. This study showed genetic control of abundance and complicity of phenolic chemicals in apples, and revealed the possibility using genetic data to verify and classify the biochemical nature of the unknown metabolites. The metabolomics-GWAS data set provides important insights to link the apple metabolome with genes and biosynthetic mechanisms, and establishes a foundation for establishing marker-assisted breeding and gene editing to improve and modify phenolic compounds for human health in apples.

Apple (Malus x domestica), untargeted metabolomic, mass spectrometry, GWAS, phenolic compounds, omics, genetic improvement

Diallel analysis, heterosis and heritability of selected cowpea genotypes for grain yield and yield components

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Cowpea is a nutrient-dense grain and vegetable legume crop, with a significant potential to improve food and nutritional security in sub-Saharan Africa and beyond. Cowpea grain yield in South Africa remains low, hence, it is important to embark on research aiming at developing high yielding and stable varieties. Understanding the mechanisms governing the genetic combination of selected parents is important in cowpea genetic improvement. Therefore, the objectives of this study were to determine the parental combining ability, mid-parents heterosis and identify best parental combiners for grain yield and yield components. A total of 55 cowpea genotypes consisting of 10 parents and 45 first generation progenies were planted in a randomised complete block design with three replications at two different field environments in the 2021 and 2022 cropping seasons. Data were collected for grain yield and yield components. All data were subjected to a half-diallel analyses to determine the combining ability and heritability using AGD-R software. The results observed significant general combining ability and specific combining ability effects for all traits measured, which indicated that both additive and non-additive gene action were involved in the expression of the traits. Genotypes TV13953 and IT96D-602 were the best combiners for grain yield, hundred seed weight, number of pods per plant and number of seeds per plant and these parents could be further used for cowpea improvement. Six crosses (TVU13953 x Glenda, ITOOK-1060 x TVU13953, 98K-5301 x Glenda, 98K-5301 x TVU13953, IT96D-602 x Glenda and IT96D-602 x TVU13953) were superior for grain yield and yield components. The positive and significant mid-parent heterosis for grain yield observed suggests the importance of either dominant or partial dominant genes in expression of grain yield. The current study revealed that both additive and non-additive gene effects were involved in the inheritance of all traits measured in cowpea genotypes. The selected parents could be used as basic parental breeding materials for future cowpea breeding and the crosses could be evaluated at multiple locations to confirm general adaptation and/ or specific adaptation in South Africa.

Combining ability, cowpea progenies, gene action, heterosis

Stability of ascorbyl glucoside in crab apples under cold storage and heat stress

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The importance of ascorbate (vitamin C) for humans, as well as its critical and diverse role in plants, is well known. Ascorbyl glucoside is a stable derivative of ascorbate that has been found to naturally occur in numerous crop species, including crab apple fruit. Ascorbyl glucoside has been demonstrated to be stable under oxidative conditions through in vitro studies, yet there is a lack of understanding of its stability in living systems. This study aims to determine the stability of ascorbyl glucoside in crab apples under long-term cold storage and heat stress applied through hot water treatments. The findings will bring insights as to the potential advantage of breeding crops with ascorbyl glucoside as a source of pro-vitamin C that remains stable under postharvest storage.

Ascorbate, vitamin C, apple, crab apple, postharvest, health

Understanding the transcriptional regulation of the tomato fruit ripening-to-senescence process due to chilling

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Tomatoes are widely consumed due to their sensory attributes, nutritional profile, and cultural importance. However, storage at low temperatures is often used to extend shelf life and reduce loss and waste, even if fruit quality is sacrificed. While 12.5°C is considered safe, temperatures below this can induce chilling injury, as tomato, like almost all species that originated from tropical regions, is sensitive to cold storage. Our aim is to understand how low-temperature postharvest conditions affects the physiological and molecular pathways involved in tomato fruit ripening as a first step to help mitigate poor quality. It has been established that DNA methylation is important for determining fruit ripening; however, it is unknown how methylation changes in fruit ripened under different postharvest handling methods, therefore, we assessed the methylome, transcriptome, ripening hormones (ethylene and ABA), and quality parameters in tomato fruit stored under chilling and non-chilling temperatures. Ripening was slowed at the low, chilling injury threshold temperature, i.e. 12.5°C, and at this temperature, we found uncoupling of multiple biological clocks that collectively work in tandem to promote ripening. In another aspect of our work, we attempted to engineer fruit to direct the spatial and temporal expression of key genes in cold-stored postharvest fruit. First, using synthetic and regulated promoters we sought to induce focused expression of the cold-regulatory gene CBF1 in fruit stored postharvest to determine if higher CBF1 fruit expression would mitigate the negative cold stress response. Our results suggested mis-regulation of fruit development and the fruit ripening program due to targeted CBF1 expression in the fruit. We also engineered expression of the RIN (RIPENING-INHIBITOR) gene, a master regulator of tomato fruit ripening that is inhibited by cold stress. We utilized a CRISPR/Cas9 multiplex system to induce edits in the RIN promoter. Our aim was to create a population of RIN allelic fruit mutants, which could influence the RIN-induced gene regulatory network in tomato fruit, leading to downstream changes in fruit ripening including under chilling. To date, we have generated over 200 RIN promoter mutants with diverse genetic lesions and RIN transcriptional levels. Preliminary evaluation of the quality of these mutants together with transcriptomic analysis should help to explore the mechanisms underlying fruit quality modifications due to genome editing. Ultimately, this knowledge could help improve the efficiency and sustainability of the tomato industry, while also enhancing consumer satisfaction.

Postharvest chilling injury, tomato fruit, gene editing, regulated gene expression, fruit quality

Auxin signaling mediated by miRNAs in banana fruit ripening

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MicroRNAs (miRNAs) have been documented in the past decades as critical regulators of gene expression, and a group of miRNA families are identified to target genes related to auxin signalling, including TIR/AFBs and ARFs. However, the role of auxin and miRNAs in auxin signalling during the ripening of banana, a typical climacteric fruit with rapid ripening and dramatic physiological and biochemical changes, is still unclear. Here, we reported 15 TIR/AFB, 50 Aux/IAA, and 49 ARF gene families of auxin signalling in banana. In addition, multiple miRNAs including miR393, miR160 and miR167 targeting auxin-related genes were also identified and experimentally validated. Further, expression analysis revealed the responses of these auxin-related miRNAs to ethylene. Finally, we proposed a mode of action of miRNA-mediated auxin signalling in ethylene-induced banana fruit ripening. These findings reveal the miRNA regulation on auxin response in banana and provide a model for studying miRNA-mediated hormone regulation in other climacteric fruits.

Banana, ripening, auxin signalling, MiRNA

High resolution transcriptome for avocado off tree ripening

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Ripening is a crucial stage of fruit development initiating changes to flavour, texture, colour and nutrition, making them more desirable for consumption by seed dispersal organisms. Avocado provides an interesting mechanism, where fruit can hold on to the tree in an unripe state for over a year. It is not until the fruit reach maturity and abscise that they become sensitive to ethylene and the ripening process proceeds. However, the wide flowering window (up to three months in some growing regions) means the fruit are at varying stages of maturity complicating optimal harvest times to ensure high fruit quality. Understanding the physiological and molecular mechanisms underlying avocado ripening is essential for developing strategies to optimise postharvest practices and maintain fruit quality. We have taken a molecular approach, to understand the off tree ripening biology of avocado. 425 fruit were harvested and brought back to the lab where they were held at 20 C for until they had reached an eating ripe (ER) state. All fruit were monitored daily following detachment, for ethylene evolution and ER. Fruit tissue was sampled using a cork borer for 25 randomly selected. Up to 20 individual fruit samples were selected for transcriptome analysis per stage of development, depending on ethylene evolution and ER results, concentrating on the earlier sampling times following harvest in attempt to identify metabolism associated with release of the of the on tree ripening block. Over 180 RNAseq libraries were constructed, and pair-end sequenced resulting in over 3TB of data. This transcriptome provides a resource for the avocado research community, encompassing a high-resolution sample set following detachment. Not surprisingly, ethylene and other hormone related genes change in response to fruit detachment and subsequent ripening. The results of our initial findings from this dataset will be reported and discussed.

RNAseq, ethylene, fruit ripening, avocado

Metabolomic profiling and hormonal assessment of synchronized exocarp-mesocarp tissues throughout ripening stages of ‘Fuerte’ and ‘Hass’ avocado cultivars

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Encarna Aguayo, Postharvest and Refrigeration Group, Institute of Plant Biotechnology, Universidad Politecnica de Cartagena, Cartagena, Spain Avocado (*Persea americana Mill.*) is one of the most economically important subtropical/tropical fruits worldwide and the consumption of avocado has significantly increased in the last ten years mainly due to its high nutritive value. Colour development in avocado fruits is a sophisticated molecular process influenced by several factors, including genetics, environmental conditions, and agricultural practices. To understand this mechanism, metabolomic comparative analyses were conducted using fruits of two exocarp colour contrasting avocado cultivars 'Fuerte' and 'Hass' during ripening. Exocarp colour analysis showed significant differences in CIELAB colour space between both cultivars at ready-to-eat (RTE) stage. Pigment content in the exocarp exhibited an accumulation of anthocyanins in 'Hass' avocado, while chlorophyll content showed no differences. Carbohydrate quantification indicated that 'Hass' exocarp contained an increased abundance of sucrose, mannoheptulose, and perseitol at RTE. On the other hand, 'Fuerte' mesocarp contained higher levels of glucose and fructose at RTE. Higher amounts of fatty acids were observed in both tissues of 'Fuerte', showing a differential distribution of lipids, where palmitate, alpha-linolenate, and oleate presented major differences in the exocarp at RTE. Polar metabolites indicated differences in amino acid and carbohydrate metabolisms between cultivars, being accumulated serine, valine, malate, perseitol, shikimate, and succinate in 'Hass' exocarp at RTE, suggesting an activated carbon metabolism associated with the production of pigments. Hormone analysis suggested that abscisic acid and salicylate could be involved in the orchestration of pigment biosynthesis, displaying a higher amount in 'Hass' exocarp at RTE. These findings indicate that primary metabolites and hormones crosstalk plays a significant role in colour development in the exocarp and in the softening in the mesocarp of avocados, suggesting new perspectives about the relation of the development of this tissue synchronization during postharvest ripening. (This research was financed by ANID-Fondecyt 1220223 and ANID-ICN2021_044.)

Persea americana, exocarp, mesocarp, colour development, abscisic acid, ripening

Hormone and transcriptome profiling during fruit development in apple

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Plant hormones are critical for all aspects of plant development, and their relative importance for each biological process is confounded by their complex interactions with each other. Interestingly, there is one report in the literature showing a peak of jasmonic acid (JA) precedes other well-known hormonal ripening regulatory mechanisms in the climacteric crop plants apple and tomato. In addition, we have observed gene expression peaks of JA biosynthetic genes prior to ripening during tomato fruit development, and a key regulator of ripening, NAC-NOR, shares homology with JA - induced NACs from Arabidopsis. The main aim of this project was to elucidate the role of jasmonic acid metabolism and hormonal crosstalk in setting up ripening acquisition in apples (*Malus domestica*) by integrating transcriptomics and metabolomics data. To better understand the ripening process in apples, we carried out a comprehensive hormone profiling (jasmonates , cytokinins (CKs), auxin (IAA), abscisicates (ABAs), ethylene, gibberellins (GAs) and salicylates (SAs)) for two apple cultivars 'Gala' (normal ripening) and ' Scifresh ' (partial ripening mutant) over a developmental time course from flowering into storage. We found an increase of the JA precursor 4-(3-oxo-2-(pent-2- enyl) cyclopentyl) butanoic acid (OPC-4) prior to ripening, and a transient peak of the JA-catabolite dihydro - JA, also prior to ripening. However, bioactive JA and JA-Ile, the iso leucine conjugate that binds to the JA receptor, were not changed. In addition, we found bioactive GAs and their catabolites were increased in 'Gala' in comparison to ' Scifresh ' during the early stages of fruit development. The content of other hormones such as IAA, ABA and SA were similar for the two cultivars, and did not appear to change during or prior to ripening. A comprehensive transcriptome is currently being analysed from this sample collection, to elucidate potential crosstalk and hormonal regulation of fruit ripening in apple. We will report and discuss our results.

Jasmonates, cytokinins, gibberellins, fruit ripening, hormonomics, multiomics

Closing the gap between fundamental and applied research in fruit biology to improve quality

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Fruit quality directly impacts marketability and consumer acceptance. While it is essential to use postharvest techniques to maintain quality during the supply chain, it is crucial to use varieties with high postharvest potential and optimal crop management strategies in the field to ensure the best product quality for consumers. Breeders have focused on improving fruit texture to extend shelf life, but sometimes, they neglect other attributes such as flavour and nutrition. My research program integrates biotechnology and consumer-based approaches to develop flavourful, nutritious, and long-lasting fruit. We have successfully used gene editing strategies to improve the shelf-life of tomatoes by targeting key pectin-degrading enzymes. We have also studied traditional non-ripening mutations to develop tomato hybrids with long shelf-life and determined their impacts on colour and taste quality attributes. Additionally, we have developed tomato lines with the potential for vitamin C biofortification by knocking-out fruit-specific ascorbic acid peroxidases. These lines are currently being evaluated in field trials for the second year. Moreover, we have studied how fruit quality traits in commercial strawberry have been altered during domestication and breeding. We found that shelf-life was positively correlated with firmness and negatively correlated with the sugar-acid ratio. Despite this observation, heirloom strawberry cultivars are a potentially rich source of favourable alleles for enhancing consumer-focused fruit quality traits in modern long shelf-life cultivars. Our research has also provided extensive knowledge on nut development of pistachios (fruit and kernel) and how spring temperatures at the time of bloom strongly impact quality traits at harvest time. Overall, our research in diverse fruit crops emphasizes the importance of understanding the molecular and biochemical basis of fruit traits to employ effective strategies for breeding, crop management, and accurate phenotyping, all needed to improve quality.

Fruit biology, fruit quality, shelf-life, consumer-based traits, gene editing, conventional breeding, preharvest and postharvest continuum

Apple production systems versus postharvest eating quality: the influence of greenhouse gas production

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The sustainability of agricultural production systems is increasingly recognised as an important driver of consumer food choice. In this study, we presented consumers a disease-resistant apple cultivar, 'PremA34', which is anticipated to have contribution to global warming that is 15% less than a standard apple due to the reduced need for orchard sprays. The 'PremA34' apples (mean firmness; FF=8.3 kgf, mean Soluble solids concentration; SSC=15.3%) were compared to two standard apples with similar external appearance one ('Scilate') was superior in eating quality (FF=8.7 kgf, SSC=15.8%) and the other ('Gala') was inferior in eating quality (FF=6.2 kgf, SSC=12.7%). Consumers were provided information about the lower spray requirement of 'PremA34' compared to other apples, before taking part in an experimental market (silent auction) in which each received either a 'Scilate' (59 consumers) or a 'Gala' apple (57 consumers) for free and then bid to exchange their apple for a 'PremA34' apple. All consumers received $5NZ; successful bidders received a 'PremA34' apple, and any change owed; unsuccessful bidders took the free apple and the $5NZ. The consumers made 10 bids and after the fifth could taste both apples. Consumers were categorised according to their pattern of bids after tasting n those whose bids: (1) did not change from $0, (2) were above $0 but did not change, (3) increased, or (4) decreased. In comparisons of 'PremA34' with 'Scilate' (the higher eating quality apple), 32 consumers decreased their bids after tasting and 15 consumers increased their bids, whereas with 'Gala' (the lower eating quality apple) 18 consumers decreased their bids and 27 increased their bids. The data from bids and associated thought-listing comments made during the auction are interpreted in terms of diversity in consumer responses to sustainability of apple production, concerns regarding green-washing, and the relative importance of sustainability versus apple eating quality.

Sustainability, eating quality, experimental market

Improving fresh produce export supply chain performance by establishing an independent surveyor network

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Australian fresh produce enjoys a good reputation in Asian markets for premium quality, safety and grown under a "clean and green" environment. However, product quality and delivery can sometimes be inconsistent for a range of reasons. Receiving objective feedback from the market is necessary to drive improved production and postharvest practices for delivering consistent quality and building consumer value that command premium prices and preferential purchasing. Measuring changes in product quality from harvest to the consumer together with monitoring temperature and time in the supply chain can identify critical points for reducing the risk of quality loss. Our previous export supply chain analysis activities identified the need to establish a network of fresh produce quality surveyors that provide independent and reliable feedback to producers and exporters. Over the past 2 years, we have identified, engaged with and conducted training with ten businesses in Singapore, Malaysia, Hong Kong, Japan and Thailand that have the skills and resources to assist with in-country fruit quality and shelf-life assessments. Through this process, we established common quality assessment procedures and associated image sets and for avocado, strawberry, mango, banana and summer fruit. A rapid online reporting platform has been developed and is being customised for each commodity. We provided in-country and virtual training to support the surveyors as required or when procedures were updated, or new commodities were added. Assessment training videos are also under development to support the capacity building. We plan to extend the network to India, South Korea, Vietnam and the UAE. The network has also been designed to support research activities that are improving supply chain performance, evaluating new postharvest treatment technologies and packaging and validating shelf-life prediction models. The aim is to make this service a long-term support tool that provides meaningful information flow for commercial businesses to rapidly correct shipment issues, improve product quality and performance and to objectively support any in-country insurance claims.

Fruit, quality assessment, training, capacity building

Consumers' perceptions of apple freshness in controlled atmosphere storage

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Despite controlled atmosphere (CA) storage being used commercially on apples for around a hundred years, the technology is unfamiliar and the outcomes suspicious for many consumers. Occasionally, these concerns are raised in the media and postharvest practitioners are asked for comment. We have an ongoing interest in the cognitive knowledge structures that enable consumers to make sense of foods and food systems. One way we can uncover these cognitive structures is using means-end-chain (MEC) methodology. MEC is a laddering approach that can be used to elicit hierarchical reasoning for an individual's decisions and is usually implemented using a small number of interviews. Here, we implemented a novel online version that allows a more objective analysis of the data. In this online study of 2253 UK consumers, some participants were provided with descriptions of the CA technology and its benefits while others weren't provided with any information. When information on CA was provided, the aggregated individual explanations of reasoning (MEC hierarchy) were ordered from crunchy/juicy/flavourful/fresh/like the taste/safe/inviting will eat/enjoy/nourishing/refreshing money well spent/healthier diet/positive feeling accomplishment/longer life/enjoyment in life/respect myself. However, even when information was provided, some participants portrayed more negative perspectives such as: will not like taste/texture will not enjoy waste of money. In the absence of CA information, the MEC became simpler and shorter and there were higher frequencies of consumers identifying statements and statement linkages that were negatively positioned. Overall, most of the information about CA storage was new to consumers. Furthermore, when information on CA storage was provided to consumers it did influence expected liking and increase willingness to eat CA-stored apples. The societal implications for fresh food storage/supply and its acceptance by consumers is considered.

Consumers, apples, controlled atmosphere storage

The effect of acidity, flesh firmness and total soluble solids of ‘Forelle’ Early Market Access (FEMA) fruit, on consumer experience after storage

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The South African pome industry comprises approximately 3700 ha of 'Forelle' pears. Previously, this cultivar experienced quality issues with mealiness and astringency which were overcome by harvesting at the correct maturity and a mandatory 12-week cold storage period. This resulted in a delay to market, and a break in South African bi-colour pear supply. The 'Forelle Early Market Access (FEMA) program was initiated, whereby fruit were left on the tree for longer to overcome astringency associated with early optimum 'Forelle', and mealiness, which was overcame by 1-methylcyclopropene (1-MCP) application after harvest. This program proved to be a massive success. However, to protect the FEMA brand, orchards were only released when fruit reached a minimum flesh firmness (< 6 kg) and total soluble solids (TSS) above 14 Brix. This posed challenges when TSS content reached adequate levels, but firmness did not drop, or, when flesh firmness dropped sufficiently, but TSS did not accumulate sufficiently. Another concern, unrelated to release criteria, was a low titratable acidity which raised concerns regarding storability and a poor consumer experience. A study to address this problem was initiated. Orchards used in this project were selected based on flesh firmness, and TSS and acidity levels. 1-MCP was applied to fruit immediately after harvest and fruit stored for 6 weeks at -0.5°C in regular air. After storage, maturity analysis was conducted on the fruit and a consumer and descriptive sensory analysis (DSA) performed. It was found that flesh firmness had a significant impact on consumer experience after storage. Flesh firmness above 6.3 kg or higher acidity resulted in lower consumer experience. TSS did not impact the overall liking, although very low TSS levels resulted in a poor overall rating. None of these parameters under investigation had any effect on the storability of the fruit.

Pears, malic acid equivalents, consumer analysis, descriptive sensory analysis, taste, storability

Consumer-oriented postharvest improvement opportunities in the pineapple (*Ananas comosus* L.) value chain in Camarines Norte, Philippines

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Pineapple is one of the economically important fruits grown and consumed in the Philippines. In Camarines Norte, the third-ranking province in terms of production and hectarage, next only to Bukidnon and South Cotabato where the big multinational companies exporting the commodity are situated, pineapple continues to be a priority crop and major source of livelihood especially for smallholder growers (PRDP, 2022). With its huge potential for market growth and income generation, there is a need to take a closer examination of the entire supply chain performance, which specifically focuses on understanding consumers' demand and preferences for industry improvement. This study was conducted to assess the status of pineapple supply chain and determine what consumers value in the fruit using survey interviews in the major production and market centres. This was complemented by focused group discussions, key informant interviews and ocular visits in the production areas. Initial interviews with farmers and traders indicated the problem of forced fruit ripening (not observing proper maturity) with the application of ethrel to make the peel turn yellow which resulted in inferior quality and sour fruit taste. In a consumer survey undertaken, sweet taste is the number one attribute preferred, but it is interesting to note that consumers equally desire quality and safety assurance, e.g. cleanliness, and freedom from defect and damage. Their major disappointment in the fruits bought is the inferior internal quality of the fruit (either damaged, diseased, overripe, sour, with off taste, or with short shelf-life) even if the external quality is deemed excellent. These together with related information from the survey can be used as basis in identifying improvement opportunities along the value chain which are aimed to enhance produce quality and safety and reduce postharvest losses. Eventually the improvements will translate to increased incomes of different chain actors and stakeholders.

Consumer preference, pineapple, quality attributes, value chain

Sensory quality of cultivar ‘Red Aroma’ in relation to harvest time and 1-MCP treatment

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In Norway, the apple cultivar ' Red Aroma ' accounts for approximately one third of the Norwegian production. Treatment with 1-MCP has been tested on fruit of different ripening degrees to improve shelf - life and sensory properties. Fruit was harvested and treated with 1-MCP at one-week intervals starting two weeks before optimal harvest time (OHT) and ending two weeks after OHT. Fruit was stored until the end of November in regular atmosphere at 4°C. A semi - trained sensory panel evaluated selected sensory parameters. The panel evaluated 1-MCP treated fruit from all harvest times as firmer, less mealy, crisper, and juicier than the untreated fruit. The untreated fruit harvest ed one or two weeks after OHT were more aromatic (floral and fruity), sweeter, and riper. The 1 - MCP treated fruit was more acidic than the untreated fruit. Intensity of grassy flavour was lowest for the untreated fruit after optimal harvest time. Evaluated sensor y properties correlated with measured physiochemical parameters. Optimal sensory quality in relation to harvest time and 1-MCP treatment will be discussed.

1-MCP, Red Aroma, sensory quality, harvest time

Assessing kiwiberry selections for susceptibility to skin damage

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Apart from size, a key characteristic of kiwiberry fruit that differentiates them from current commercial kiwifruit is their thin, living skins. Significant amounts of skin damage have been observed on some kiwiberry selections but not others. After trialling a range of techniques for their ability to induce skin damage, a bespoke automated device able to replicate observed skin damage was developed. Using the device, we were able to differentiate selections for their susceptibility to skin damage. The incidence of skin damage generated was not affected by fruit size within a selection and did not affect softening of fruit, even for selections that developed significant levels of skin damage. Microstructural observations of the skin layers of representative selections indicated that resilience or susceptibility to skin damage is likely to be related to the nature of the fruit epidermis rather than tissues below the epidermis. These findings will be important for fruit trait phenotyping of new kiwiberry selections.

Actinidia arguta, softening, automation, phenotyping, skin structure, epidermis

Characteristics associated with kiwifruit skin sensitivity

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A major function of fruit skins is to provide protection for the internal flesh and seeds. The robustness of the skin at harvest has important implications for handling and storage of fruit within the supply chain. Delicate skins are more likely to become damaged, and therefore be more susceptible to opportunistic rot infections, and may be more susceptible to pathogenic infections when sound, all of which may lead to fruit loss. Several factors contribute to the degree of protection provided by the skin, including its overall thickness, the nature of the cells comprising the skin layers (for example, whether the skin is comprised of living or dead cells), and the nature of the surface that faces the environment (for example, roughness, waxiness, and the presence of hairs and glands). Characteristics of the skin and underlying fruit flesh of two Actinidia chinensis var. chinensis kiwifruit genotypes that exhibit noticeably different skin sensitivities were investigated by microscopy. Tissue structure was characterised through histology, while immunolabelling was used to investigate cell wall composition at four key developmental stages during maturation and ripening: i) immature fruit with few black seeds, ii) fruit with black seeds, iii) mature fruit that had completed growth but not started to ripen, and iv) fruit which had softened markedly. Differences between the two genotypes will be discussed with reference to postharvest performance.

Actinidia chinensis, microscopy, epidermis, structure, maturation, ripening

Orange peel disorder in sweet cherries is developed during preharvest and affected during postharvest by relative humidity

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The quality of the sweet cherry is an essential factor when exporting this fruit, considering the long distances it must travel from Chile to China. It has been observed that storage longer than 40 days under modified atmosphere (MA) conditions and cold transport would lead to the appearance of a physiological disorder known as orange peel. This work aimed to determine the preharvest factors, phenological stages and storage conditions, that favour the appearance of this disorder in sweet cherry fruit. Sweet cherries were collected from commercial orchards in Lago Ranco (2021/2022 season) and Tralcao (2022/2023 season) from Los Rios Region, Chile. Regina, Kordia, and Lapins cultivars were sampled at green, veraison, red, and mahogany red fruit. Before harvest, air temperature, relative humidity, radiation, and plant water status were measured in each of the cultivars for both seasons. Additionally, during the 2022/2023 season, a heat treatment was applied during fruit development and with different relative humidity (RH) treatments (45, 65 and 100%) during postharvest storage. The quality evaluation was conducted in the four sampling stages and after storage, where soluble solids, titratable acidity, firmness, size, colour, incidence, and severity of orange peel disorder were assessed. In addition, pitting, internal browning, and rotting during postharvest were measured. The results indicated that Regina and Lapins showed a higher disorder incidence during harvest than Kordia (2021/2022), regardless that all cultivars exhibited optimum plant water status during fruit development. Lapins was the most susceptible cultivar as it showed the disorder from preharvest in both seasons. In addition, significant differences were found in the severity of orange peel in the HR treatments (2022/2023), that is, the lower the RH, the higher the disorder severity. Therefore, orange peel is a disorder that develops during preharvest, and influenced by relative humidity conditions during storage.

Prunus avium, orange peel disorder, postharvest

Antioxidant response of sweet cherry cultivars with contrastive surface pitting susceptibility during cold storage

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Surface pitting is a physiological disorder characterised by one or more depressions on the fruit surface, resulting from cell collapse beneath the skin, typically developing in cold storage several days or weeks after bruising. This study aimed to assess the antioxidant response and cell wall disassembly in sweet cherry cultivars with varying susceptibilities to surface pitting during cold storage. Three cultivars (Sweetheart, Lapins, and Regina) were subjected to mechanical stress at harvest and stored under passive controlled atmosphere and cold conditions (0°C, 95% RH). Firmness, cell wall degradative enzymatic activities (PME, PG, PL), antioxidant defence system (CAT, SOD, POD, PPO, PAL), phenolic compounds, and antioxidant capacity (DPPH inhibition) were evaluated. Sweetheart and Lapins exhibited higher pitting severity after 15 days of cold storage compared to Regina. However, after 30 days, no significant differences were observed. Regarding firmness, Regina had the highest firmness at harvest, followed by Lapins and Sweetheart. Sweetheart fruit with induced pitting displayed increased firmness compared to control samples, a trend not observed in the other cultivars. Sweetheart also showed increased alcohol-insoluble residue (AIR) yield after mechanical stress, while the cell wall degradative enzymes did not show differences, except for PME activity, which was higher in Lapins and Sweetheart pitted samples. Anthocyanin content increased in pitted cherries during storage, mainly in Sweetheart. However, no significant differences were observed in phenolic acids. Positive correlations were observed between antioxidant enzyme activities and pitting severity. Moreover, Regina showed lower activities in the control samples compared to the other cultivars. The sweet cherry cultivar resistant to surface pitting (Regina) exhibited higher antioxidant activity compared to susceptible cultivars, highlighting the importance of these factors in understanding pitting susceptibility. Surface pitting is a symptom of chilling injury; therefore, the varietal response to cold stress could be directly related to pitting susceptibility.

Prunus avium, mechanical stress, chilling injury, antioxidant

Modelling shrivel development in ‘PremA96’ apples during storage

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'PremA96', marketed as Rockit & trade, apples are sensitive to the development of shrivel symptoms during storage because of their small size. We determined how fruit maturity, storage environment and delays in initial cooling can affect shrivel development during subsequent storage of these fruit. Fruit was stored in different relative humidity environments (> 90% RH and 100%) at 0.5°C in regular air atmosphere for up to 6 months, with monthly or three-monthly assessments to provide knowledge on fruit quality and shrivel symptom development. Shrivel, weight loss and rot development were monitored, and acoustic firmness, permeance, internal ethylene and fruit flesh firmness were monitored throughout the trial. Less mature fruit performed better during longer storage, while a 24-hour delay in cooling did not increase symptom incidences. Orchard-based differences could not predict shrivel development. Methods were developed that could help identify individual fruit at risk of shrivel, and a prediction model was developed that could allow selected fruit to be stored for up to 5 months in regular air with less than 10% of the fruit showing shrivel symptoms.

Rockit, humidity, acoustic firmness, weight loss

The relationship between the mechanical properties of kiwifruit skin and shrivel disorder

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Shrivel is a common postharvest storage quality issue in kiwifruit. It is characterised by wrinkled skin and deformation of the fruit surface. This creates an undesirable appearance and causes fruit to become unacceptable for consumer purchase in most markets resulting in industry losses and fruit wastage. Shrivel development is often affected by water loss, flesh softening, and skin properties which affect the mechanical properties of the fruit. This work aims to provide information on the relationship between the mechanical properties of the skin, the outer pericarp flesh and shrivel severity in kiwifruit using a texture analyzer (TA-XT2, Stable Micro Systems, UK). Gold kiwifruit (Zespri 'SunGold') was stored for up to 8 weeks at high and low water loss conditions to induce a wide range of shrivel symptoms. The mechanical properties were assessed weekly during storage using tension and compression tests. Tension measurements were done on axial and radial samples of kiwifruit skin using vice clamps until rupture and compression assessments were carried out on flesh samples of pericarp tissue. Changes in mechanical properties such as tensile strength and elastic modulus of kiwifruit skin and flesh in relation to shrivel severity will be discussed.

Water loss, Actinidia, postharvest, tensile strength, elastic modulus, turgor loss, failure stress

Early signatures of *Botrytis cinerea*-strawberry fruit interaction reveal the presence of grey mould disease before symptom development

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Strawberries are a high-value soft fruit crop grown worldwide that suffers significant losses in postharvest due to grey mould disease caused by *Botrytis cinerea*. Rapid development of fungicide resistance in *B. cinerea* and high susceptibility of strawberries call for fast and non-destructive methods to detect grey mould disease for decision making and integrated pest management (IPM) strategies. We hypothesised that *B. cinerea* infections on strawberries cause changes in host defences and metabolic pathways that can be detected by profiling changes in fruit surface characteristics and emission of volatile organic compounds (VOCs). We used multispectral imaging (MSI) and gas chromatography-mass spectrometry (GC-MS) to compare the spectral profiles of *B. cinerea* -inoculated versus mock-inoculated fruit from 0 to 48 hours post inoculation (hpi) and sampled VOCs non-destructively at similar time points (9-24 hpi) using Twisters TM. The reflectance profiles of *B. cinerea*-inoculated fruit differed from mock-inoculated ones as early as 12 hpi, with a set of seven wavelengths in the visible and infrared spectrum allowing for a significant separation of fungal infection. Partial least squares discriminant analyses showed that infected samples clustered together as early as 9 hpi and emitted VOCs with antifungal activity, such as linalool, estragole, and limonene, pointing to an early coordinated host response to *B. cinerea*. A dual RNAseq study of strawberries mock-inoculated and *B. cinerea*-inoculated at early time points (3-24 hpi) revealed a high number of differentially expressed genes, particularly at 12 hpi, in *B. cinerea*-inoculated strawberries that could explain the features revealed by the MSI and VOC analyses. We also observed higher expression in the *B. cinerea*-inoculated samples of strawberry genes involved in redox activity and secondary metabolic pathways, such as the mevalonic acid pathway, which is the precursor for several VOCs detected in our analyses. Overall, this research highlights the potential of complementary approaches for early detection of grey mould in postharvest and the study of fruit-pathogen interactions.

Necrotroph, volatile organic compounds, multispectral imaging, postharvest disease, pathogenicity

Species-specific real-time PCR assays for nine *Colletotrichum* species causing apple bitter rot in Mid-Atlantic

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Apple bitter rot is an important disease worldwide causing pre-harvest fruit losses ranging from 2-100%. In addition to expressing in the orchard, apple bitter rot is a postharvest problem in cold storages ranging from 2-15% in incidence. Economic impacts of bitter rot in the U.S.A. are estimated between $300 to $400 million annually. In Mid-Atlantic U.S.A. this disease is caused by nine different *Colletotrichum* species which vary in distribution depending on many factors such as latitude, climate, relief, other hosts, and crop management practices. There are three main species complexes in *Colletotrichum* genus with pathogens infecting apple and pear fruit: (1) *acutatum* species complex (CASC), (2) *gloeosporioides* species com-plex (CGSC), and (3) *boninense* species complex. Over the last 8 years, efforts in the Mid-Atlantic U.S.A. have led to identifying nine species as causal agents of apple bitter rot: *C. fructicola*, *C. chrysophilum*, *C. noveboracense*, *C. siamense, C. theobromicola*, *C. henanense* and *C. gloeosporioides* sensu stricto (s.s.) from CGSC, and *C. fioriniae* and *C. nymphaeae* from CASC. Using culture-, morphology-, and single locus sequencing-based methods to identify the *Colletotrichum* species is severely limited in accuracy and effectiveness while multilocus sequence typing for delineating species is costly, time-intensive, and requires higher expertise. In this work, we developed species-specific hydrolysis probe real-time (RT)-PCR assays for the nine *Colletotrichum* species causing bitter rot in the Mid-Atlantic U.S.A.: *C. fructicola*, *C. chrysophilum*, *C. noveboracense*, *C. gloeosporioides* s.s. , *C. henanense*, *C. siamense* and *C. theobromicola* from *C. gloeosporioides* species complex, and *C. fioriniae* and *C. nymphaeae* from *C. acutatum* species complex. After meticulous searching for polymorphisms in 14 gene regions, we designed primers and probes in 5 of them for the 9 target species: *ladA*, *GAPDH*, *ApMat*, βtubulin and calmodulin. Four out of nine primer-probe set pairs were able to be duplexed. The sensitivity tests showed that as little as 0.5 pg DNA was detectable. These RT-PCR assays will provide rapid and reliable identification of these key *Colletotrichum* species infecting apples and will be critically important to conduct studies that will elucidate their biology, epidemiology, fungicide resistance and management on apple as the number one produced tree fruit in the U.S.A.

Diagnostic assays, Colletotrichum species, anthracnose, bitter rot, apple, plant pathogenic fungi

From seed to storage: disease management in organic beetroot production to reduce food waste

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The market for organic agriculture is rapidly growing. In Switzerland, the production of organic beetroot is particularly renowned. However, their storage until spring has become increasingly difficult in recent years, and losses due to post-harvest rots can lead to over 50% by March. Consequently, most organic beetroots sold in spring need to be imported if the previous season was poor. The causes of the various storage rots in beetroot are currently unclear, and therefore there are few measures to prevent them in organic production. Pathogen infections causing storage rots in beetroot, but also in other long-stored vegetables, can occur via the seed, in the field, or post-harvest. Understanding the process of infection is, therefore, critical to find preventive solutions. Here, we present the results of a three-year project aiming at reducing post-harvest losses in organic beetroot production. In a combination of on-farm field experiments and laboratory analyses, we aimed to elucidate the causes of storage rots in organic beetroot and develop measures to improve storability. Analysis of stored beetroot in 2021 and 2022 revealed *Phoma betae*, *Fusarium* sp. and *Plectosphaerella* sp. as predominant pathogens in Switzerland (season 2023 ongoing). *Plectosphaerella* sp. was never identified before on beetroot. *Mortierella*, *Mucor* and *Alternaria* were found to be additional causative agents of storage rots. Seeds analysis highlighted the same pathogen identified on the rotting tuber (*Alternaria* sp. *Phoma betae* and *Fusarium* sp.), suggesting that the possible cause may come directly from the seeds. Different measures, such as steam sterilization of the seed, the use of biocontrol products in the field and before storage, or processing and cooling methods after harvest, as well as cultivar differences were investigated. Various measures were found to affect seed health, seedling emergence, leaf health, and the quality of beetroot after storage.

Beetroot production, biocontrol products, post-harvest losses, pathogen infection and on-farm field experiments

Identifying and characterizing postharvest *Fusarium* fruit rot in *Cucurbita moschata* D. pumpkin

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Pumpkin is esteemed globally for its efficiency in producing nutritious food per unit of area and labour. Widely cultivated in Israel for decades, the tropical cultivar *C. moschata* D. produces large pumpkin fruits, often weighing 15-25 kg or more, with a shelf life of 6-10 months and commonly sold as freshly cut slices. However, in recent years, farmers are facing significant losses, up to 50%, attributed to postharvest fruit decay. A comprehensive five-year survey across five sites in Israel unveiled that most instances of fruit decay originate at the stem end, with *Fusarium* spp. identified as the primary pathogen. Notably, various pathogenic *Fusarium* isolates were also isolated from seemingly healthy seeds and plant parts, hinting at seeds as a potential source of contamination. Greenhouse cultivation under insect-proof netting has emerged as a potent preventive measure, ensuring fruit rot-free storage for up to 8 months. Moreover, storing pumpkins at 20-25°C with RH 70% has exhibited a 50% reduction in rot incidence, particularly beneficial for small organic farms. Ongoing investigations delve into seed disinfection and fungicide treatments during cultivation to further mitigate postharvest fruit rot. Integrating these pre and postharvest strategies holds promise in effectively combating *Fusarium* stem-end rot, thus curbing losses in 'Tripolitani' pumpkin storage. The effect of insects' activity during cultivation along with heat waves during storage on fruit resistance to *Fusarium* fruit rot will be discussed.

Cucurbita, fungi, soilborne, storage

PCR primers and LAMP for detection of three postharvest apple diseases

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The detection of three fungi that cause postharvest storage diseases of apples was examined. Bull's eye rot (BER) is commonly caused by the fungus *Phlyctema vagabunda* syn. *Neofabraea alba* in New Zealand. Several polymerase chain reaction (PCR) primers were compared in quantitative PCR (qPCR) reactions to detect field inoculum of *P. vagabunda* from leaves collected at harvest in 2017 and 2018 from eight orchards in the Hawke's Bay and Central Hawke's Bay regions of New Zealand. Primers based on the beta-tubulin gene region were more specific but less sensitive than those based on an 18S ribosomal gene region. The amount of inoculum in DNA extracted from leaves was too low to be detected reliably by the beta-tubulin primers used in qPCR. Taqman qPCR using 18S primers and DNA extracted from leaves reliably detected *P. vagabunda* inoculum. The sensitivity of the 18S primers indicates that they are more suitable for elucidating the disease cycle and inoculum sources of *P. vagabunda* in the field than the beta-tubulin primers. Loop-mediated isothermal amplification (LAMP) was compared with qPCR for detecting inoculum of *Botrytis cinerea* (causing a firm postharvest fruit rot) and *Venturia inaequalis* (causing pepper spot disease postharvest) in the orchard. Results will be presented, and their implications for using these tests to elucidate the disease cycle.

Phlyctema vagabunda, Neofabraea alba, Venturia inaequalis, Botrytis cinerea, lenticel rot, pepper spot, grey mould, postharvest, beta-tubulin, ribosomal DNA, qPCR, Taqman qPCR, LAMP

Detection of *Phlyctema vagabunda* using LAMP/CRISPR-Cas

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Significant postharvest fruit losses are attributed to pathogens causing rots, leading to an unsellable product. One of these pathogens, *Phlyctema vagabunda* , causes Bull's Eye Rot (BER) in susceptible apple cultivars grown in Aotearoa- New Zealand. Early detection of this pathogen is important, to inform if mitigation is required or if there is risk in storing susceptible batches of fruit for long periods. Traditional plant disease identification methods lack the sensitivity required for early detection, so molecular approaches are being developed to replace traditional methods such as visual examination. The preferred, or gold standard molecular method, polymerase chain reaction (PCR), is laboratory based, requires sophisticated equipment and highly trained personnel, which results in high cost per sample. Several isothermal DNA amplification methods are now available that can be used as point - of - care, or in-field solutions. Isothermal reactions run at a constant temperature, eliminating the need for thermal cyclers, resulting in a relatively cheap, quick, and user-friendly assay. One of these technologies, loop-mediated isothermal amplifcation (LAMP), can often result in unwanted amplification of non-target artifacts and is frequently so effective that contamination from positive controls can lead to false positives. To overcome these problems, we combined LAMP with CRISPR/Cas technology, to add specificity. We have used a divergent region of the beta-tubulin gene from *P. vagabunda* , to design a LAMP/CRISPR-Cas assay. We screened a collection of 43 saprophytes and plant pathogens often co-localised with *P. vagabunda* in apple orchard samples, and observed the assay to be specific to *P. vagabunda* . We tested the sensitivity of the assay and have determined that we can detect down to two DNA copies per reaction. Lastly, we have conducted experiments using existing genomic DNA extracted from field trials, to compare with previous PCR - based detection systems. We will report and discuss the results of these trials.

Phlyctema vagabunda, CRISPR/Cas, diagnostic, isothermal amplification, Bull's Eye Rot, apple

Identification of sarmentosin as a key bioactive from blackcurrant for inhibiting monoamine oxidase activity in humans

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Monoamine oxidase (MAO) enzymes metabolise catecholamine neurotransmitters such as dopamine, norepinephrine and serotonin and therefore have a crucial role in modulating mood and cognitive function. Consuming blackcurrant (*Ribes nigrum*) juice, but not anthocyanin-enriched blackcurrant powder, is known to inhibit platelet MAO-B enzyme activity, suggesting that anthocyanins are not the principal bioactives responsible for MAO-B inhibition. To therefore identify the primary MAO-bioactives, MAO-A/B-inhibitory phytochemicals were isolated from blackcurrants using bioactivity-driven fractionation combined with liquid chromatography-mass spectrometry (LCMS). Subsequent analyses identified sarmentosin, a γ-nitrile glycoside, and its hydroxycinnamoyl esters as the predominant compounds responsible for this effect in vitro. In vivo MAO-A/B efficacy was subsequently confirmed via a small pilot clinical study in healthy humans where consumption of blackcurrant-derived, purified sarmentosin temporarily inhibited platelet MAO-B activity comparably to in vitro findings. In a follow-up double-blind crossover clinical study, the efficacy of freeze-dried whole-fruit blackcurrant powder in inhibiting MAO-B was compared with blackcurrant juice and found to be indistinguishable from each other, showing 90% platelet MAO-B inhibition 2-hours post consumption. Further investigation of the effects on catecholamine neurotransmitters and mood demonstrated that platelet MAO-B inhibition negatively correlated with some plasma catecholamine metabolites and mental fatigue, but positively correlated with descriptors of alertness. These findings highlight that consumption of a single dose of blackcurrant product via either a juice or a freeze-dried whole fruit powder format may positively affect mood in healthy adults.

Phytonutrients, functional foods, beverages, neurotransmitters, cognition, mood

An in vitro analysis of bioactive compounds and antioxidant activity in Brassica microgreen radish (*Raphanus sativus*)

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Plants from the Brassicaceae family have natural compounds like phenols and glucosinolates that are known to offer many health benefits, such as anti-inflammatory, anti-diabetic, neuroprotective, and anti-cancer properties. Microgreens are young leaves of plants that are harvested early on in their growth. They are popularly known for their vibrant colours, unique Flavors, and soft textures, making them a popular choice in fine-dining restaurants. However, microgreens have a short shelf life and must be consumed soon after harvesting. LED lights are a better alternative than fluorescent lights for cultivating microgreens, as they provide high levels of illumination while emitting less radiant heat, which is beneficial for plant growth. Additionally, LEDs can enhance the nutritional value of microgreens and extend their shelf life by delaying senescence. It is important to understand how post-harvest storage, LED light exposure, and simulated gastrointestinal digestion can affect the health benefits of Brassica microgreens. Thus, the aim of this study is to determine the impact of different LED light exposures and in vitro digestion on the major polyphenols, glucosinolates, and antioxidants present in raw and digested radish (*Raphanus sativus*) microgreens. To determine whether LEDs can induce an increase in bioactive compounds (glucosinolates and phenolics) in brassica microgreens, we tested red, blue, and far-red LED lights. We also measured bioavailable bioactive compounds during the intestinal phase after in vitro digestion. Red, blue, and far-red LED lights were applied to radish, during storage for five days at 5°C and 85% relative humidity. The levels of ascorbic acid, total phenols, kaempferol, and quercetin glycosides, as well as antioxidant activities of all three Brassica microgreens, were greatly increased by red light. Red LED light also increased glucoraphenin. Potentially, the red-light stress resulted in the production of secondary metabolites in immature plants. During the intestinal phase of in vitro digestion, a higher concentration of phenolic compounds, glucosinolate components, and antioxidants was observed. Therefore, we recommend the use of red LED light as a postharvest treatment for enhancing the bioactive compounds of radish microgreens.

Phytochemicals, Brassicaceae vegetables, antioxidant properties, light quality, phenols, glucosinolates

Phenolic composition, antimicrobial activity and antioxidant capacity of Burdekin plum during maturation

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Burdekin plums are fruits of *Pleiogynium timoriense* (DC.) *Leenh*, which is native to Australia. The fruits have been traditionally consumed by Indigenous Australians but are still underutilised to this day. Recent research shows that the mature fruit is nutritious and has strong antioxidant capacity. To the best of our knowledge, no study has investigated the phytochemical composition and functionality of Burdekin plums during maturation. To fill this knowledge gap, the main phenolic compounds, antimicrobial activity and antioxidant capacity were determined in Burdekin plums harvested at three maturity stages. Results obtained from the water extracts of Burdekin plums revealed that the phenolic composition, antimicrobial activity and antioxidant capacity changed during maturation ($p < 0.05$). The green fruits had a higher content of quinic acid (3000 mg/100 g DW), gallic acid (30 mg/100 g DW), and galloylquinic acid (100 mg/100 g DW), whereas the fully mature fruits had a higher content of cyanidin 3-galactoside (40 mg/100 g DW). Regarding antimicrobial activity, half red fruits and fully mature fruits exhibited a stronger inhibition against the Gram-positive bacterium *Staphylococcus aureus* (inhibition zone > 8mm) compared to green fruits (inhibition zone <2 mm from). However, the antioxidant capacity decreased during fruit maturation. In conclusion, maturation has a significant effect on phenolic compounds, antibacterial activity and antioxidant capacity of Burdekin plums, which should be considered when utilising the fruits as a functional food source.

Maturation, phenolic, antimicrobial, antioxidant, functional

The attributes of fruit for blood glucose control

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As the world faces a "tsunami" of glucose intolerance associated with the metabolic syndrome, diabetes, and ageing, there is growing aversion to foods high in sugars, which include fruit. However, fruit combines several attributes making it an excellent carbohydrate source in prudent diets for blood glucose control, especially when consumption patterns take advantage of fruit properties. Fruit attributes include fructose-rich available carbohydrate, which is much less glycaemic than glucose or starch, so equal carbohydrate exchange of fruit for starchy food may alone substantially lower glycaemic response. The dietary fibre complement of fruit consists of parenchyma cell walls that disperse during digestion, forming a slurry that impairs bulk transfer of sugars to the gut wall, by retarding mixing and diffusion within the intestinal chyme. Fruit organic acids lower gastric pH and have a strong buffering capacity, with two anti-glycaemic effects n stopping gastric starch hydrolysis by salivary amylase and delaying duodenal neutralisation of gastric contents which activates an enterogastric reflex, slowing gastric emptying, thus lowering glycaemic response. Added to the above effects is the direct influence of fruit phenolic compounds on glucose uptake receptors. All the foregoing influences of fruit on sugar uptake apply not only to fruit sugars, but additionally to the digestion of starchy food consumed with fruit. But because fruit sugar has some glycaemic effect the optimum strategy for minimising blood glucose response is to consume fruit close enough to a starchy food to impair its digestion but separated enough for the fruit and starch glycaemic responses to not overlap, and with fruit preceding starch, so that the fruit components are present when the starch enters the gut. Strategically applying the multiple anti-glycaemic attributes of fruit, we have achieved substantial reductions in blood glucose response of nearly 50%, making fruit as effective as drugs in the management of postprandial glycaemia.

Fruit, glycaemic response, dietary fibre, organic acids, diet

Effects of pea and meat as protein sources on risk factors for colorectal cancer in a rat model

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The EAT-Lancet Commission has recommended replacing meat with plant-based protein sources, for human and planetary health. One of the principal benefits of using plant-based protein sources in the diet is that plant protein is often associated with dietary fibre, in the form of cell wall material. Yellow split pea is a plant protein source with a substantial dietary fibre component, but exactly how much of an advantage split pea has over meat as a protein source, in terms of beneficial effects in the large bowel is of interest, in view of the association of colorectal cancer with diets high in meat and low in fibre. We therefore used a valid rat model of faecal bulking to quantify the hind gut effects of pea and meat. The rats were fed diets containing the same quantity of protein, as yellow split pea or minced beef in powder form, and during a four-day balance period feed intake and faecal dry matter output, faecal water holding capacity and hydrated faecal mass per 100 g feed intake (as an estimate of human faecal output) were accurately measured. Products of protein putrefaction were also determined. Changes in microbiota composition and residual fermentable carbohydrate will also be measured. The mass of caecal contents was also determined. Pea cotyledon, compared with meat significantly increased caecal content, faecal dry matter, water holding capacity resulting in a significant ($p < 0.001$) 3.5 X increase in fully hydrated faecal mass from 19.7 ± 0.8 g /100 g diet for meat to 71.4 ± 13 g/100 g diet, resulting in a reduced concentration of protein putrefaction products in gut contents. Substitution of meat by pea cotyledon leads to substantial changes in the physical properties of hind gut contents that will lead to a reduced risk of colorectal cancer.

Colorectal cancer, meat, pea cotyledon, faecal bulk, fermentation

Unravelling the ecological mechanisms involved in the effect of *Aureobasidium* sp. on apple fruit surface microbiome in relation to postharvest rot development

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Apple fruit encounter losses at all stages of the supply chain due to development of decay caused by a variety of pathogens. In this regard, the fruit serve as a habitat for diverse epiphytic and endophytic microbial communities consisting of the fruit microbiome. It is believed that a dynamic interaction exists between microorganisms including pathogens. In the last decade, the availability of sequencing technologies and bioinformatic tools, have enhanced our ability to investigate complex plant-microbial interactions and their impact on plant health and disease. Current knowledge of the microbiome of apples includes their taxonomical and functional characterization, and factors influencing their assembly like fruit genotype, cultivation practices, fruit development stages and storage conditions. Studies have also identified a set of core taxa members that exist in the apple fruit microbiome. Building on this knowledge, we hypothesized that manipulating the abundance of *Aureobasidium* sp. a core taxon on the apple fruit surface and an effective biocontrol agent, would impact the fruit microbiome assembly and composition and possibly steer the microbiome towards a 'healthier state' that subsequently protects the fruit from postharvest decay. We introduced the yeast by spraying in high volumes at different developmental stages starting from flowering until harvest. Results revealed that *Aureobasidium* colonize the fruit in varying proportions at different periods of storage, with the most prominent effect observed in those samples treated immediately after harvest. We also explored the differences in the bacterial and fungal community assembly composition as a result of its colonization, and unraveled different ecological drivers controlling the fruit community assembly in response to the introduction of *Aureobasidium*. Treated fruits showed a decrease in decay incidence as compared to the untreated fruits, with the least decay incidence observed in fruit treated both preharvest and postharvest, followed by those treated only during postharvest and higher incidence in fruits treated only preharvest.

Apple, microbiome, Aureobasidium, biological control

Volatile organic compounds of *Wickerhamomyces anomalus* prevent postharvest black spot disease in tomato

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Postharvest diseases like black spot, caused by *Alternaria alternata* lead to substantial economic losses for the tomato industry, significantly impeding its progress and development. Biological control has emerged as a promising approach for managing postharvest diseases in fruits and vegetables, offering advantages in safety, environmental sustainability, and often good efficacy. Our research group identified *Wickerhamomyces anomalus* as a promising biocontrol agent against postharvest tomato black spot. While the physiological mechanism of black spot prevention and control of the yeast was explored, the role of its metabolites in disease control remains unexplored. Therefore, this research aimed to investigate the potential of *W. anomalus* metabolites in preventing and controlling tomato black spot disease caused by *A. alternata*. Additionally, our study explored the inhibitory effect of the yeast's key components on *A. alternate*. Through GC-MS analysis, isoamyl acetate was identified as the major metabolite from *W. anomalus* with potential inhibitory efficiency. Our results demonstrated that isoamyl acetate could inhibit *A. alternata* both *in vitro* and *in vivo* and effectively control postharvest tomato black spot. These findings suggest that isoamyl acetate has the potential to be a viable alternative to fungicides for controlling postharvest black spot of tomatoes.

Tomato; Alternaria alternata; Wickerhamomyces anomalus; Isoamyl acetate; Black spot

After harvest ethanol vapor treatment reduces fungal load in Medjool dates

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'Medjool' dates are in high demand, but the level of microbial load can exceed thresholds set by some countries. The objective was therefore to identify methods to reduce the microbial load of Medjool dates after harvest without compromising its quality. 'Medjool' dates were obtained after harvest from the same orchard over 2 seasons or from a packing house after 6 months of storage. The dates were treated with ethanol vapor, cold-plasma application of hydrogen peroxide or a commercial formulation of peracetic acid. In all experiments, treatment with ethanol vapor for 20 hours reduced fungal load by at least 2 orders of magnitude but had minor effects on bacterial load. The ethanol vapor treatment was also effective when carried out after 6 months of storage at -18°C. Treatment with hydrogen peroxide reduced bacterial load but showed skin damage that recovered after shelf life in one experiment but not in another. Similar levels of external and internal of microbial load were measured suggesting that external contamination was dominant in asymptomatic fruit. Sequencing of microbial DNA in the dates showed that *Aspergillus* was the predominant fungal genus while *Bacillus* was the dominant genus after shelf life. The treatment with ethanol vapor changed the volatile profile of the dates but did not have an apparent influence of their flavour. The ethanol vapor treatment can be a useful tool to reduce microbial load in relevant postharvest systems.

Palm dates; postharvest; ethanol vapor, Aspergillus

Postharvest shelf-life extension of raspberries using single and dual release sulphur-dioxide emitting sheets

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Fresh fruits like raspberries are a good source of essential vitamins and minerals. However, they are very perishable products with a short shelf-life, generating large postharvest losses. Fruit quality for the market is largely determined by physicochemical parameters like size, colour, firm texture, absence of decay, injuries and bruises and a balance between sweetness and acidity. It's quite essential to maintain fruit quality during transport and commercialization until the fruit is consumed. Sulphur dioxide (SO_2) is extensively used for table grapes as a postharvest treatment to lessen the level of decay throughout the storage and transportation periods. We investigated the effect of single and dual release SO_2 emitting sheets on various ventilated punnets for decay development during storage without affecting other quality parameters. The berries were evaluated after 3 days cold storage (6°C) and again after 3- and 7 days retail shelf-life (15°C). After 3 days at 6°C), SO_2 sheets with the different punnets significantly reduce postharvest decay compared to the untreated berries. Treated berries were also significantly firmer. Raspberries stored with the SO_2 sheets were also visually, lighter red in colour than the controls. The efficacy of SO_2 sheets on postharvest decay of raspberries in these trials clearly demonstrates its potential to reduce losses during storage and transport.

Postharvest decay, raspberry, SO_2

A study on construction of complex biocontrol microbial communities based on the microbiome to control postharvest diseases of red grapes

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Red grapes are one of the most important varieties for fresh grape cultivation, with a series of characteristics such as large fruit grains, crispy flesh, bright colour, moderate taste, and high yield, as well as high nutritional value. They are widely cultivated in China. To understand the overall microbial community of red grapes during storage, which can provide guidance for the control of postharvest diseases, this study analysed the bacterial and fungal community structure during different storage periods of red grapes using high-throughput sequencing. At the same time, beneficial antagonistic strains belonging to the "core" microorganisms were screened from the surface of red grapes and the antagonistic strains were compounded. This study found that the diversity of microbial communities of red grapes during the early stage of storage was high, and bacteria were significantly higher than fungi. The postharvest decay of red grapes was related to pathogenic fungi *Cladosporium*, *Penicillium*, *Alternaria* and *Aspergillus*. Two strains of biocontrol bacteria B2 (identified as *Bacillus lincheniformes*) and B4 (identified as B*acillus velezensis*), as well as two strains of biocontrol yeast A5 (identified as *Rhodotorula graminis*) and A6 (identified as *Rhodotorula babjevae*), were screened from the top 15 "core" microorganisms in terms of total abundance to control post-harvest blue mould and powdery mildew caused by the pathogens *Penicillium expansum* and *Aspergillus niger*. Respectively, these strains were then combined to obtain the optimal ratio of biocontrol bacteria for controlling blue mould disease. For W3 (A5: B2: A6: B4=1:1:8:10), the optimal proportion for preventing and treating powdery mildew is Q3 (A5: B2: A6: B4=5:1:6:12). The antibacterial rate of the composite strain W3 obtained above is 63%, and the antibacterial rate of Q3 is 35%, which can provide candidate strains or composite agents for solving post-harvest *Penicillium* and powdery mildew in red extraction.

Red grapes, microbiomics, antimicrobial activity, composite bacteria, biological control effect

Sustainability challenges and future opportunities for food production in a changing world

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Nature's assets: our soils, our vegetation, our biodiversity, our waters, plus our weather, underpin our well-being. An outline is provided of the natural-capital concept which integrates economic thinking with ecological principles, by considering nature's assets as capital. In the economic world, interest and rents flow from capital. By analogy, in the ecological world ecosystem services flow from our natural capital stocks, and these are massively valuable. We need to sustain nature's assets. Before looking forward to opportunities, I look back-to-the-future, and discuss the 1911 book by Franklin Hiriam King on "Farmers of Forty Centuries" in East Asia. King visited Japan, Korea and China in 1909 to ". . . consider the practices of some five hundred millions of people who have an unimpaired inheritance acquired through four thousand years." His prescience was a forerunner of modern ecosystem-services thinking. King highlighted how the utilisation of organic wastes, including those resulting from a failure of (the then) post-harvest management of food products, was critical for sustaining stocks of organic matter in soil. Only through this investment of organic-waste back into nature had it been possible, King concludes, to farm these lands continuously for 4,000 years. Soil without carbon, he noted, is inert. The continuous application of organic waste onto land, King asserts, also had a quirky consequence, which I will discuss. Looking forward, through the lenses provided by ecosystem-services analyses and life cycle-assessments, I consider that it is possible to discern plentiful opportunities to sustain new food-production practices and healthy food consumption patterns in a rapidly changing world.

Food-waste metrics, waste-as-a-resource, soil organic-matter, ecosystem services, carbon footprinting

Controlled atmosphere storage: research and commercial

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Controlled atmosphere (CA) storage is an established feature of postharvest systems, prolonging the life of numerous horticultural crops. CA usually refers to the manipulation of oxygen and carbon dioxide concentrations within tightly defined limits and may also include ethylene removal. Systems have been developed for land-based storage and during shipping. Both low oxygen and high carbon dioxide can individually or together retard produce deterioration under CA. Academic research has largely addressed land-based systems, with a shift from the static empirical approach using a fixed atmosphere to setting the oxygen concentration based on the behaviour of the produce (dynamic CA). These systems are being optimised to maximise the CA response to low oxygen. Systems operate by setting the oxygen concentration after determining the lowest safe oxygen concentration using chlorophyll fluorescence, or by monitoring the production of ethanol or respiratory activity/respiratory quotient. The most researched crop is apples. A wider range of crops are shipped under CA by sea than are stored on land. Sea freight CA systems have developed differently from land-based systems. Often the atmosphere is less tightly controlled; rather it is ventilated on demand when oxygen or carbon dioxide thresholds are exceeded. These systems typically utilise a higher oxygen concentration in conjunction with a higher carbon dioxide concentration than the systems developed for land-based storage. These differences in approach to CA are discussed with respect to produce biology and quality.

Static, dynamic, apple, avocado, kiwifruit, quality, shipping

Two-factorial dynamic storage systems for pome fruit: Oxygen and temperature control based on CO_2 release rates

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DCA-CD Plus is a novel two-factorial storage concept that aims to simultaneously define an optimum and transient oxygen partial pressure (pO_2) and temperature range for apples, based on their CO_2 release rate. It is assumed that by establishing an extremely low pO_2 in the room atmosphere, fruit metabolism is suppressed to a minimum, thereby allowing for higher storage temperatures without promoting ripening and associated quality decline. This concept is primarily suggested to contribute to lower energy usage of the cooling system while maintaining optimal fruit quality. The DCA-CD Plus system was tested over four seasons with the apple variety 'Braeburn' in commercial storage rooms of 11-ton capacity at a research facility in Southern Germany. The reliability of the CO_2 release rate as the input value for dynamic pO_2 and temperature control was evaluated through extensive analysis of fruit quality parameters, occurrence of disorder symptoms, and studies of anaerobic metabolite levels. Energy usage and running times of individual components of the cooling systems (compressors, evaporators, defrosting, ventilators) were recorded to determine the potential for energy savings. Evidence from multiple seasons indicates that 'Braeburn' apples can be safely stored under DCA-CD Plus conditions at $pO_2 < 1.0$ kPa without developing disorder symptoms related to low oxygen stress or exceeding critical thresholds of acetaldehyde, ethanol, or ethyl acetate. Dynamically increased temperatures reduced the energy usage of ventilators, defrosting, and compressors, without affecting the fruit softening rate, peel yellowing, and titratable acidity levels.

DCA, energy efficiency, storage technology, Low oxygen

Expression changes of ripening genes in kiwifruit under regular cool storage after controlled atmosphere

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Controlled atmosphere (CA) technology extends the storage life of kiwifruit (*Actinidia spp.*) by delaying and slowing ripening, reducing ethylene production, and reducing sensitivity to ethylene. However, due to the equipment requirements, it is difficult to apply CA during the transport, distribution, and retail phases of the supply chain. One common practice in New Zealand is to store kiwifruit in CA after harvest. Subsequently, transportation to the global market is conducted in the regular refrigerated air environment. The physiology of kiwifruit ripening in cool storage after removal from CA is unknown. The objective of this study was to identify the ripening pathways that are impacted during post-CA period. Kiwifruit (*A. chinensis cv.* 'Zes008') were harvested from three orchards at commercial maturity, and stored in CA for 2, 4, 6, or 8 weeks before being transferred into regular cool storage for a subsequent 6 weeks. Fruits were sampled fortnightly and assessed within 24 h after removal from storage and after exposure to three days of retail shelf-life conditions (20°C). The relative expression of genes involved in ethylene biosynthesis, cell wall modification, and starch degradation pathways were quantified using quantitative polymerase chain reaction (qPCR). The results suggest that the ethylene biosynthesis pathway was suppressed during CA storage but subsequently reactivated during the post-CA shelf-life period. On the other hand, the storage atmosphere had less impact on the starch degradation and cell wall modification pathways, however, these pathways were activated by the change in post-storage temperature.

Actinidia chinensis, ripening, qPCR, ethylene production, cell wall, carbohydrate, postharvest

Chlorophyll fluorescence as a tool for non-destructive assessment of greening in potato tubers

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Potato tubers (*Solanum tuberosum L.*) are an essential basic commodity worldwide, and the total world production is nearly 375 million tonnes (FAOSTAT, 2022). Light exposure to potatoes may induce the formation of both chlorophyll (Chl) and toxic, colourless glycoalkaloids. Even though Chl itself is harmless, the risk of simultaneous formation of glycoalkaloids leads to rejection of green potatoes. Hence, greening of potatoes is a major cause for food waste and economic loss. The aim of this study was to evaluate chlorophyll fluorescence (ChlF) as a tool for non-destructive assessment of greening in potato tubers. A series of potatoes (cv. Folva) with different grades of greening was created by exposing the potatoes to light from 0 to 72 h. ChlF was measured within a marked circle on the potatoes using a portable pulse-amplitude-modulated Chl fluorometer, and the simple fluorescence ratio (SFR R), i.e. far-red emission over red emission upon red excitation, was calculated. For reference, colour measurements were performed within the same area of the potatoes, and the peel was extracted in methanol and analysed for Chl content by spectrophotometry. SFR R and Chl content was tightly correlated in a linear relationship (R^2 = 0.960, P = 0.000). Colour values were less related to Chl content, with the highest correlation found for hue in a curvilinear relationship (R^2 = 0.846, P = 0.000), which may be explained by interference of other colours in the potato peel. We conclude that ChlF can be a useful tool for assessment of Chl content in the peel of potatoes. The method can be applied to monitor greening of potatoes both in research and for commercial purposes.

Solanum tuberosum, chlorophyll, glycoalkaloids, multiplex, simple chlorophyll fluorescence ratio, colorimetry, spectrophotometry

Feasibility study to utilise near-infrared spectroscopy as a decision support tool to reduce asparagus tip breakdown

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Due to a short season of UK asparagus, large quantities of spears are being imported to provide this high value vegetable throughout the year. Cold storage can maintain the quality of asparagus for one week and a further week during shelf-life. During these periods the postharvest physiological disorder tip breakdown may develop, which can lead to significant commercial losses. In its latter stages the disorder is characterised by the presence of watery bracts at the tip of the spear and a foul odour, which makes not only the affected spears unmarketable, but also other spears in the batch. The hypotheses of this study were that fast growth, changes in sugar translocation and cell death may be key components of the mechanism and that the effects of these can be measured by spectrometry at a stage, where they cannot be detected visually. In order to obtain spears with tip breakdown, asparagus with susceptibility to the disorder ('Aspalim') was grown under warm (28/14°C) day/night temperatures (with controlled relative humidity and light cycle). Harvested spears were directly moved to shelf-life storage at 7°C in film covered trays (for 14 d), then assessed. After harvest (18 harvests) and after shelf-life, reflectance spectra of different spears (n=514) were measured by means of a Labspec spectrometer (ASD Inc.) in the range of 780 nm to 2500 nm with a fibre optic probe with illuminator. 'Aspalim' spears examined after shelf-life (n=274) had an incidence of 8.6% of tip breakdown. While the accuracy of linear discriminant analysis (PCA FCV validation) was high overall (e.g. 86%), the number of correctly predicted tip rot spears was low (e.g. 46%). Therefore, complementary non-destructively collected data is needed for prediction of tip breakdown. In the future, machine vision to identify asparagus spears pre-symptomatically will be investigated.

NIR, Asparagus officinalis, tip rot, spectrophotometry

Assessing vanilla bean dry matter and quality aspects non-destructively with NIR model development for Vava'u, Tonga

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Vanilla planifolia H.C Andrews (vanilla) is an important crop in Pacific Island countries. Cured vanilla is a low-volume, high-value, and stable long-shelf-life product, making it ideal for export on long shipping routes. This study focuses on *V. plantifolia* grown in Vava'u, Kingdom of Tonga. Tongan legislation requires farmers to sell ripe beans with a yellow tip. Only fully mature and ripe beans will produce good-quality cured beans with the required vanillin content and typical vanilla aroma. The 'Tonga Vanilla Activity' funded by MFAT (2019-2024) used a handheld NIR device (Texas Instrument DP Nano) to test and assess vanilla beans on the vine during the final ripening stages and during curing. The data collected during the traditional curing, sun and shed drying, and during simulated container drying from beans cured in the lab oven have been pivotal in constructing a robust model. This model accurately predicts the percentage of dry matter (%DM), glucovanillin and vanillin concentrations in the bean, which are key determinants of its final quality. The high confidence factors for %DM at harvest 20% DM, with a solid level of specificity and sensitivity, both 90%, further underscore the practicality of our predictions, ensuring the production of high-quality beans. Developing a non-destructive method for assessing vanilla bean quality is a significant development. It addresses the challenge of being able to distinguish immature beans from those conforming to the regulation harvest criteria once the beans have been cured. This device and fitted models not only aid in assessing the quality at harvest and after curing but also play a pivotal role in ensuring Tongan vanilla is seen by the market as a high-quality product.

Vanilla, curing, NIR, non-destructive quality assessment, international development

SmartFresh™ in the preservation of mangoes postharvest quality after long periods of cold storage

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Mango is a very important crop for the Brazilian fruit industry, and was, in terms of volume, the most exported fruit from Brazil in 2023. Destinations are generally European or North American countries. However, with the growing interest in Brazilian mangoes from more distant markets, it is necessary to use new technologies that allow the fruits to reach these countries with high quality. Being a climacteric fruit, whose maturation and senescence are related to ethylene, one of the technologies that helps the extension of post-harvest life by maintaining the quality of the mango is SmartFresh (1-Methylcylopropene) which is a post-harvest growth regulator that blocks the action of ethylene by binding to its receptors. The objective of this trial was to evaluate the effect of SmartFresh on the conservation of mangoes' post-harvest quality, Keitt variety, in long cold storage scenarios. The mangoes were harvested at ripening stage 2 (scale 1 to 5), processed, packaged, and then applied with SmartFresh at a dose of 600 nL/L for 12 hours. Cold storage was carried out at 10°C and evaluations of pulp firmness, maturation index, internal browning and soluble solids were carried out after 35, 45 and 55 days under refrigeration. In each of the evaluations, it was possible to observe significant effects of the treatment in relation to the maintenance of a higher pulp firmness, a lower maturation index and the reduction of internal browning. In the evaluation carried out after 45 days in cold storage, mangoes treated with SmartFresh TM had pulp firmness 2.4 times higher and did not present internal browning, while 70% of untreated fruits presented this disorder. Therefore, SmartFresh proved to be an efficient technology for maintaining the quality and extending the post-harvest life of mangoes stored for long periods under refrigeration, being effective at the dose of 600 nL/L.

1-MCP, Mangifera indica, maturation, firmness, quality conservation

A new 1-MCP delivery system opening up opportunities for small packaging

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Postharvest storage losses are one of the main sources of food spoilage worldwide threatening food security and economic sustainability. For the last few decades 1-methylcyclopropene (1-MCP) has proven to be a game changer in preserving apple fruit of the highest quality year-round and has since also founds its' uses for storage of other fruits like pear and kiwifruit. The benefits of 1-MCP on postharvest quality maintenance are well known and range from decreased ethylene production over colour retention, decreased dehydration to maintenance of firmness. However, up till now only fruit stored in large volumes has been able to commercially benefit from these benefits. Nevertheless, the benefits of 1-MCP for other fruits and vegetables are also becoming more and more apparent but they cannot be exploited commercially due to the volumes they are stored of packed in. Some examples are the delay of rachis browning in grapes, delay of dehydration, weight loss and degreening of broccoli, delay of senescence in strawberries. More recently, technological progress is bringing the benefits of 1-MCP closer for small packaging like individual pallets, single boxes or even clam shells. This opens the potential for those fruits that are packed in small packaging at harvest, or closely harvest and shipped to far away markets immediately. We will present an award-winning patented technology that enables the release of highly pure 1-MCP from any material from simple stickers to the actual packaging. The presentation will show an overview of the unique properties of this technology, as well as the potential importance for several crops that are currently not reaping the benefits of the senescence delaying effects of 1-MCP. The presentation will also show results of extensive testing of the technology on several fruits and vegetables in a lab environment as well as on a semi-commercial and commercial scale.

1-MCP, small packaging, grapes, berries, broccoli

Physiological and biochemical changes associated with the ripening of Banganapalli and Neelam mangoes, induced by 1-methylcyclopropene (1-MCP)

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Mangoes, the fruit of the tropics and subtropics, are perishable due to their climacteric nature, which decreases their shelf life and quality. Fruit ripening is characterized by a series of biochemical changes initiated by the autocatalytic production of ethylene and an increase in respiration. Chemical and non-chemical treatments are used to maintain fruit quality during storage. The 1-Methylcyclopropene (1-MCP), an ethylene antagonist, is used in various fresh fruits and vegetables for extended shelf life and quality. It blocks the ethylene receptors, preventing normal fruit responses to ethylene. Studies were conducted to assess the impact of 1-MCP on the quality and shelf life of two mango cultivars, viz. V 1, Banganapalli, and V 2, Neelam. The fruits at ripening stage 2 (25% ripening) were exposed to 1-MCP vaporization at three different levels under cold (CS, 16°C) and ambient storage (AS, 27 ± 2°C) conditions. The 1-MCP at 900 ppb was found effective in retaining higher fruit firmness (V 1 = 7.22, V 2 = 7.68 Newton), irrespective of the storage conditions. Under CS, the 1-MCP at 900 ppb recorded the lowest sugar content in both V 1 (8.59) and V 2 (8.72), while the control recorded the highest (V 1 - 10.88, V 2 - 9.81). The Pectin Methyl Esterase (PME) activity was strongly inhibited by 1-MCP treatments. Under CS, the variety V 2 had higher anthocyanin accumulation (412.15) than any other treatments. The climacteric peak of 1-MCP-treated fruits was significantly delayed by three days. 1-MCP at 900 ppb recorded a very low CO_2 evolution (V 1 - 27.7, V 2 - 34.0), while the control fruits had the highest respiration rate (V 1 - 43.0, V 2 - 44.1). The shelf life of mango fruits at the 25% ripening stage has been significantly enhanced by 1-MCP under CS (16°C). The variety V1-Banganapalli recorded a shelf life of 11 days due to 1-MCP at 900 ppb, while the untreated fruits registered only seven days. The other variety, V2-Neelam, had a shelf life of 15 days with the same 1-MCP treatment, while the control recorded ten days.

Mangoes, 1-MCP, physiology, shelf-life, fruit quality

Rapid wound healing - a new strategy to reduce postharvest losses in fruit and vegetables

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Fruit and vegetables are susceptible to various types of mechanical damage during harvest and post-harvest handling, which destroy the protective epidermal tissues and not only open avenues for pathogen infection, but also exacerbate water transpiration. Fortunately, fruits and vegetables have the ability to respond to wound stress by forming a closing layer at the wounds, which can effectively inhibit the infection of pathogens and reduce water transpiration. However, natural healing takes a long time, and measures need to be taken to accelerate healing. A variety of chemicals can accelerate wound healing of fruits and vegetables, including salicylic acid and its analogue BTH, melatonin, sodium nitroprusside, chitosan, chito-oligosaccharides, phenylalanine and sodium silicate. In addition, physical and biological measures such as hot water immersion, UV-C irradiation and biocontrol yeasts can also accelerate the wound healing. The mechanism of rapid healing involves a variety of metabolisms such as phytohormone signalling, reactive oxygen homeostasis, transcription factors, sucrose metabolism, respiration and energy metabolism, fatty acid metabolism and phenylpropanoid metabolism. At present, research on rapid wound healing focuses mainly on a few fruit and vegetables, such as potato, sweet potato, muskmelon, kiwifruit, apple and pear. The methods and conditions of healing still need to be optimized and the mechanism of healing needs to be studied in depth.

Fruit and vegetables; rapid wound healing; methods; mechanisms; perspectives

Curing temperatures affect the wound healing metabolism of ‘Clearwater Russet’ potato tubers

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Potatoes are usually cured at 10 to 12.7°C and 95% relative humidity (RH) for 14 days. However, the industry has recently questioned the impact on the wound healing within this temperature range and if product application can affect the response. The objective of this study was to investigate the effect of calcium chloride ($CaCl_2$) and nitric oxide (NO) on wound healing metabolism of potato tubers at two curing temperatures (10 or 12.7°C, 95% RH). In 2023-2024 storage season, 'Clearwater Russet' potatoes were harvested and immediately treated with i. control (without any treatment), ii. nitric oxide treatment (0.022 g L^{-1}) for 5 hours, or iii. $CaCl_2$ spray application (2%, w/v). Potatoes were then cured at 10 or 12.7°C and 95% RH for 14 days. Samples were collected every two days (0, 2, 4, 6, 8, 10, 12, and 14 days) to determine weight loss, respiratory activity, phenylalanine ammonia-lyase (PAL) activity, and total phenolic contents. Low curing temperature (10°C) resulted in less weight loss compared to 12.7°C. Nitric oxide (NO) and $CaCl_2$ resulted in higher weight loss than control, which increased and reached 0.62% on day 14. The respiration rate remained unaffected over the 14-day curing period. Significant interactions were observed between treatments and temperatures, as well as between treatments and curing periods for PAL and total phenolics. PAL activity increased at a faster rate at 12.7°C and peaked on day 2. At 10°C the initial PAL peak was observed on day 4. Interestingly, a second peak of PAL activity was observed on day 10. Total phenolic content mirrored the PAL activity, but potatoes cured at 10°C had higher total phenolic content than at 12.7°C. Overall, the wound healing metabolism responded faster at 12.7°C compared to 10°C, while the respiration rate remained unaffected. While this study offers valuable insights into wound healing metabolism, further investigations are needed to validate these findings beyond the one-year evaluation period.

Phenylalanine ammonia-lyase (PAL), total phenolics, respiration rate

Integrated management of superficial mould on stored pome fruit

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The development of superficial mould on stems and calyx sepals of stored apples and pears has considerable economic implications for the South African pome fruit industry. Postharvest management, particularly employing synthetic fungicides like fludioxonil (Flu) and pyrimethanil (Pyr), is crucial in controlling fungal diseases on pome fruit in South Africa's commercial packhouses. Typically applied via drench methods, Flu has proven more effective than Pyr, while packaging types such as clear non-perforated polyethylene bags exacerbate mould development. A study evaluating Flu (299 mg/L) and Pyr (500 mg/L) drench applications on three apple cultivars stored for six months at -0.5°C found that combining chemical drench with alternative packaging like perforated bags mitigated calyx and stem mould symptoms, with MAM sheeting resulting in low mould incidence across cultivars. Additionally, thermofogging with Flu or Pyr on the 'Fuji' cultivar under controlled conditions showed Pyr to be least effective in reducing mould. Sanitiser dip application, particularly with Hypercide® and Steri-harvest®, resulted in 0% mould incidence when paired with perforated bags or MAM sheets. Fungicide sensitivity tests conducted on *Alternaria arborescens*, *Cladosporium* spp. and *Epicoccum* spp. isolates revealed varying sensitivity to Flu, Pyr, thiabendazole, fluopyram, and difenoconazole. In summary, effective postharvest management involves judicious fungicide application, appropriate packaging, and sanitation practices, with an understanding of fungicide sensitivity and employing suitable treatments to enhance fruit quality and reduce postharvest losses.

Management strategies, fungicides, packaging, sanitizers

Pre- and post-harvest management to reduce losses during storage of pome fruits

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The demand for high-quality, residue-free food is exerting increasing pressure on the pome fruits sector, which accounts for 65% of fruit-growing areas in Switzerland. However, reducing synthetic products in orchards increases the risks of fungal diseases during storage, thus significantly impacting the industry's revenues and ecological footprint. Therefore, there is a need to test and validate new approaches and biological products to limit these losses across all production systems, meeting the public's expectations and aligning with the new direction of Swiss agricultural policy. In a holistic approach, combining pre-harvest biological and sustainable control strategies, effective post-harvest innovations and laboratory screening analysis for promising products, we sought solutions to reduce losses due to fungal rot during the storage of pome fruits. At the end of season 2022, the main quality deficiencies were assessed before storage, with apple scab identified as the predominant issue. The assessment revealed that 69.9% of apples exhibited scab infestation, highlighting the need for effective pre-storage interventions. Following storage, the assessment focused on prevalent post-harvest diseases such as *Monilia* sp. and *Neofabraea* sp. The results indicated that over 70% of apples were infested with *Neofabraea* sp. Despite the high level of infestation, Mini CA boxes (Janny boxes) significantly decrease the number of apples infected with *Neofabraea* sp. suggesting that low oxygen levels decrease the growth of fungal pathogens and preserve the fruit. Overall, this study provides valuable insights into the prevalence and severity of pre- and post-harvest diseases in apples, underscoring the importance of effective storage management practices. Further research is warranted to explore the efficacy of different treatments and interventions in mitigating post-harvest diseases and optimizing apple storage conditions.

Pre- and post-harvest interventions, storage management practices, pome fruits sector, Neofabraea alba, sustainable control strategies, fungal diseases

Innovative approaches to disinfect biowastes contaminated by plant pathogens: steaming and composting of onion waste contaminated with *Sclerotinia cepivorum*

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Sclerotinia cepivorum (teleomorph: *Stromatinia cepivora*) is an economically important pathogen of Allium species worldwide. The sclerotia can survive in the soil and in onion waste for 20 years. In Norway, onion white rot is a quarantine disease for onion set producers, making the disposal of onion waste from packing facilities a major concern due to its persistent nature and potential risk of spreading the pathogen with compost. Moreover, the disposal of onion waste is costly in Norway. The effective management of postharvest waste contaminated with plant pathogens present a significant challenge in agricultural sustainability and circular economy initiatives. This study explores the utilization of steaming technology in combination with composting as a novel approach to disinfect, reuse, and recycle biowaste. A stationary soil steaming machine was used to determine the lethal dose (temperature and duration) of *S. cepivorum*. In addition, the onion waste was composted to evaluate the combined effect of steaming and composting on the survival of *S. cepivorum*. Steaming onion waste at temperature exceeding 60°C for 3 minutes was found to be effective in degrading the sclerotia and killing the *S. cepivorum*. The temperature in the composting process reached 60°C, also sufficient to damage the sclerotia and expose it for microbial infestation. By combining steaming and composting technologies, contaminated onion waste can be disinfected, reused, recycled, and returned into soil. The integration of steaming and composting technologies shows promise in disinfecting biowaste and reducing the risk of pathogen spread. This approach not only addresses postharvest waste management challenges associated with plant pathogens but also contributes to sustainable agricultural practices and circular economy strategies.

Onion, postharvest waste, white rot, Sclerotinia cepivorum, sclerotia, steam, compost, bio-waste and circular economy

Non-destructive assessments of near-surface structures of horticultural products

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The growing environment has a profound influence on fruit development. The epidermis of the plant is the interface with its surrounding environment. As such features of the surface and the near-surface layers of cellular structures have the potential to provide information on intrinsic properties of the product, as influenced by the environment. Extending on well-established spectroscopic methods such as near infrared spectroscopy and hyperspectral imaging, in recent years, several novel optical and image-based sensors have been utilised to assess the near-surface properties of the fruit, which may be related to important attributes of quality and storability. For instance, skin topographical information such as surface roughness and lenticel morphology can be quantified using fringe projection and used as a proxy to infer fruit growing conditions. Laser induced light backscattering imaging can be used to assess textural properties in the near-surface tissue of the fruit, providing opportunities for storability prediction and disorder detection. Using optical coherence tomography, near-surface internal structures of tissue can be characterised based on 3D volumes of image data and associated with changes in quality. From all these methods the resulting data comes in forms that usually requires advanced analytical methods for data interpretation. Due to the wide range of inherent biological variability at both individual fruit and batch levels, large amounts of samples are often required to calibrate the sensor data with useful quality parameters usually measured destructively. This talk will provide a review of the current state-of-the-art of these non-destructive methods, provide case studies to demonstrate their capability in skin assessment and quality estimation, and identify existing challenges and potential opportunities for applications in the postharvest supply chain of fresh produce.

Imaging, skin topography, cellular structure, optical property, quality prediction

Analysing changes in biochemical attributes of strawberry during postharvest storage by means of multidimensional point clouds

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One of the major challenges in the postharvest handling of strawberry is their high perishability and textural failures due to compression along the supply chain. Thereof, changes in strawberry quality are marked by its biochemical profiles during fresh keeping periods, affecting fruit senescence and shelf-life expectancy. Close range remote sensing by means of LiDAR scanning had become a source of information as a relative low-cost optical method to investigate geometrical and radiometrical properties of horticultural produce in pre- and postharvest processes. In the present study, optical and geometric characteristics of strawberry samples at different storage conditions were measured by means of two LiDAR sensors with emitting wavelengths at 905 and 660 nm. Multidimensional point cloud fusion from both LiDARs were performed using Fourier series expansion approach for surface reconstruction. Additionally, at each storage condition, pectin and pigment contents were measured after chemical extraction and separation by means of photometric readings. Pectin in strawberry samples were measured using spectrophotometry at 525 nm as galacturonic acid content. Chlorophyll, carotenoids, and anthocyanin contents were analysed by spectrophotometry after wet-chemical hexane-acetone extraction. Correlations between measured content of biochemical profile and LiDAR optical information of strawberries were performed using statistical approaches. Additionally, relations between single and multidimensional LiDAR radiometric information were contrasted to biochemical fruit properties.

Multidimensional point clouds, LiDAR, strawberry, storage, biochemical profile

Identify chilling tolerance-related traits of wax apple (*Syzygium samarangense*) to develop non-destructive selecting technologies by hyperspectral analysis

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Wax apple (*Syzygium samarangense*) is a tropical fruit popular among Asian markets and is also traded globally. However, wax apples are susceptible to chilling injury when stored at below 12°C but develop diseases when stored at above 10°C, making long-term transport of the fruit extremely challenging. The aim of this study is to identify specific traits related to chilling tolerance of wax apple and develop the selection methods. The morphology, physiology, and the development of chilling injury of the fruits of 'Red Jewel (RJ)' and 'Sugar Barbie (SB)' wax apple cultivars during cold storage and shelf display were examined. The 'SB' fruit exhibited superior chilling tolerance than 'RJ' fruit, with chilling injury scores (CIS) of 0.8 and 3. respectively after being stored at 8°C for 14 days plus 3 days at 20°C. The summer fruit was more susceptible to chilling injury, where the CIS of 'SB' summer fruit was 1.7 under the same experimental setting. Correlation analysis revealed that total soluble solids (TSS) and the length-to-diameter ratio (L/D) of the fruit were negatively corelated to CIS, while the fruit skin brightness (L*) was positively correlated to CIS. The Pearson correlation coefficient to CIS was -0.88, -0.84, and 0.90 for TSS, L/D, and L*, respectively. TSS was selected for further study since it was the most consistent chilling-tolerant trait among cultivars and harvest seasons. Non-destructive methods were developed to predict TSS using a portable NIR spectrometer and a hyperspectral camera. 'SB' wax apple fruits of low (< 8 Brix), medium (8-11 Brix), and high-TSS (> 11 Brix) were stored at 8°C for 21 days plus 3 days at 20°C, and the CIS was 0.5, 1.2, and 2.1, respectively. In conclusion, we established TSS as a marker for chilling-tolerant wax apple fruit and showed that fruit with above 11 Brix TSS exhibited strong potential for long-term cold transport.

Chilling injury, hyperspectral analysis, sorting technology, Syzygium samarangense, wax apple

Towards a uniform pear postharvest outcome: adapting a chlorophyll-carotenoid index based on hyperspectral images

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Pears in Washington state is usually grown on trees with large canopies, leading to a greater range of fruit sun exposure. Previous reports have shown the relationship between fruit sun exposure and large and maturity, influencing postharvest outcomes. Additionally, excessive sun exposure can trigger sunscald. As hyperspectral reflectance analysis can be used to identify relative sun exposure and assess sunscald risk in apples based on a chlorophyll-carotenoid index (Cri), it is feasible to tailor this same protocol to determine relative sun exposure of pears and, therefore, establish sorting protocols based on sun exposure to homogenize postharvest outcomes for pear. To investigate this, d'Anjou pears were harvested near Wenatchee, WA, USA, from different tree positions (internal, external, and random) in a commercial orchard. Hyperspectral images (640 x 840 px; 400-1100 nm) were taken from both fruit sides (exposed and non-exposed), and reflectance spectral information for each fruit was extracted and pre-processed using Savizky-Golay and Standard Normal Variate filters. iPLS wavelength selection indicated the most relevant range to determine relative sun exposure and estimate tree position were 400- 450 nm, 500-550 nm, 600-700 nm, and 500 -550 nm, 650-750 nm, and 800- 850 nm. On average, spectral curves from exposed sides were of low intensity, between 450-500 nm and 550-600 nm, compared with less exposed aspects, regardless of tree position. Cri values ranged between 0.9 to 3.6 and 1.1 to 3.8 in fruit exposed sides from external and internal tree positions, respectively. Analysis of variance from Cri values revealed differences between sides and tree positions ($p.value < 0.01$). This result supports the feasibility of using a chlorophyll-carotenoid index to sort pears at harvest according to relative sun exposure and, therefore, more uniform batches and, potentially, postharvest outcomes.

Hyperspectral images, postharvest quality, sun exposure, pigment-related wavelengths, reflectance indexes, climate impact on fruit quality

Using a semipermeable fruit coating as an alternative to CA/MA for international marketing of tree-ripe mango internal atmospheres

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This research was conducted as a part of a project focused on the use of modified atmosphere packaging (MAP) +/- ethylene scrubbing as a way to allow international transport of advanced ripeness stage mangos (Stage 3 to 3.5 on a 1 to 5 scale) for up to 5 weeks at 7°C plus 6 days at 20°C, both with 95% relative humidity. Initial controlled atmosphere (CA) tests established target atmospheres of 4 kPa O_2 + 5-10 kPa CO_2 ('Keitt') or 6 kPa O_2 + 5-10 kPa CO_2 ('Tommy Atkins'). Use of BreatheWay® MAP resulted in average values of 6 kPa O_2 + 9 kPa CO_2 for both cultivars. Semipermeable fruit coatings were tested for comparison with MAP, including coconut oil and three formulations from Akorn Technology (zein +/- coconut oil). Fruit internal atmospheres (O_2, CO_2, and C_2H_4) were measured in coated and MAP fruit during storage at 7°C and shelf life at 20°C. All coatings and MAP resulted in lower O_2 and higher CO_2 internally during storage compared to uncoated control fruit, with coconut oil resulting in gas modification closest to MAP (2 kPa O_2 + 5 kPa CO_2). Internal ethylene content in all treatments varied in accordance with inhibition or onset of ripening; the same was true for CO_2 during shelf life. Coated fruit were similar to MAP fruit in terms of reduced chilling injury, lenticel discoloration, and decay; the same for ripening attenuation in terms of hue and L* values (peel, subepidermal, and near the stone), firmness (compression and puncture resistance forces), acid content, and sensory scores. This research highlights both the potential use of semipermeable coatings to create beneficial internal atmospheres in mango, and the need to consider all potential gas transmission barriers, including coatings and packaging, when applying CA and MA.

Mangifera indica, chilling injury, optimum atmosphere, quality, shelf life, tree ripe

Optimization of *Opuntia ficus-indica* bioactive composite coating to increase bananas shelf life without refrigeration

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The extensive reliance on plastic materials for food packaging within the industry has led to significant environmental and economic challenges. Therefore, the use of edible packaging with diverse capabilities can be considered a favourable alternative. The objective of this study was to optimize the concentration of glycerol and cellulose nanofiber (CNF) in *Opuntia ficus-indica* mucilage (3% OFIM) functionalised with pomegranate peel extract (1% PPE) to enhance the preservation efficacy of banana fruit using central composite design (CCD) approach-based response surface methodology (RSM). The experimental design yielded concentration ranges for glycerol (0.034-1.17%) and CNF (0.0034-0.17%), which were subsequently used in formulating composite edible films aimed at improving their barrier and mechanical properties. Through numerical optimization, concentrations of 0.252% glycerol and 0.02% CNF were determined, resulting in estimated WVP, Botrytis sp. inhibition, and puncture force values of 9.73 g m -2 24 -1 hours, 27.27 mm, and 13.41 N, respectively. Following this, the optimized and validated concentrations of glycerol and CNF were employed in the formulation of OFIM and PPE-based film, which were then applied to banana fruit. The bananas were stored at 25 ± 2°C for 10 days, and parameters including fruit weight loss, decay incidence, firmness, and peel water vapour permeability were assessed. Scanning electron microscopy (SEM) images aligned with the results observed regarding weight loss and peel-WVP. These findings suggest that the optimal formulation developed in this study improved the overall quality of bananas during storage. Optimizing active ingredients in edible packaging formulations represents a promising strategy for enhancing food quality and shelf life, promoting sustainability, and meeting consumer demand for healthier food.

Response surface methodology (RSM); central composite design (CCD); glycerol; cellulose nanofiber (CNF); antifungal properties

Enhancing shelf-life quality of ‘Carmen’ pears with self-assembled Montmorillonite clay-polyvinyl alcohol nanocomposite edible coating

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European pear fruit is known worldwide for its flavour and crispness but is very susceptible to spoilage and physiological disorder after cold storage. In this regards, edible coatings offer an eco-friendly technology to preserve fruit quality along the postharvest value chain. Such films act as physical barriers that decrease permeability of the fruit surface to oxygen and water vapor, leading to low rates of respiration and evapotranspiration, and to offer protection against mechanical damage. Accordingly, this trial aimed to evaluate the potential of the edible coating based on self-assembled montmorillonite clay-poly vinyl alcohol nanocomposite to improve shipping quality in Italian summer pear cultivars, characterised by a complex postharvest management cause its short cold storage and shelf-life. 'Carmen' pears were picked in summer 2023 from a commercial orchard in the Emilia-Romagna region (Italy). Initial fruit maturity was evaluated. The powdery solution was prepared one day before and mixed in water. Afterwards, the liquid coating was applied using a dipping tank and pears were let drying for few minutes. Shelf-life evaluation up to 14 days at ambient temperature at five sampling points was performed. The biopolymer-based gas barrier showed a significant effect on 'Carmen' pear ripening in terms of better green colour retention, higher pulp pressure, less weight loss, and superficial scald prevention during shelf-life. At the same time, it allowed fruit pulp softening and starch conversion into soluble sugars, which is one the most important parameters for consumer acceptance. Therefore, the polymer-clay nanocomposite natural edible coatings might be an alternative solution for packaging houses, which can apply the solution with sprayer bars while running sorting lines after storage or with drenchers, or for retailers to extend the shelf-life of pear without blocking the maturation process, as in the case of 1-MCP or other ethylene chemical inhibitors.

Pyrus communis L. fruit ripening, superficial scald, edible coatings, gas barrier, biopolymer, nanocomposite, food packaging

Edible composite films based on chitosan-cellulose nanofiber incorporated with microencapsulated passion fruit peel powder enhanced shelf-life of organic pomegranate arils

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This study aimed to examine the efficacy of chitosan (CS) reinforced with cellulose-nanofiber (CNF) nanocomposite edible coating incorporated with microencapsulated passion fruit peel powder (PFPP) at 1%, 3%, and 5% (CS-CNF-PFPP) on the shelf-life and quality of organic pomegranate arils stored at 5°C and 95 ± 2% relative humidity for 15 days. The physiological, physicochemical, microbial, and phytochemical contents and antioxidant capacity of the arils were evaluated during storage. CS-CNF-PFPP nanocomposite edible coating significantly reduced weight loss, with arils treated with CS-CNF-5%PFPP showing the least weight loss of 0.95% by 15 days, compared to 1.83% in the control (uncoated). Similarly, respiration rates (RR) were considerably lowered across all CS-CNF-PFPP treatments, with the CS-CNF-5%PFPP treatment (7 mL CO_2/kg/h) having significantly lower RR than the control (24.50 mL CO_2/kg/h) by 15 days. Total soluble solids increased progressively with higher PFPP concentrations, peaking at 15.77 Brix in CS-CNF-5%PFPP treatment by 15 days. Microbial counts significantly varied across concentrations, with CS-CNF-5%PFPP having the lowest microbial count (6.67 cfu/g) and the control having the highest (163.33 cfu/g) by 3 d. Higher concentrations of PFPP also retained the phenolic and anthocyanin contents and DPPH activity in the arils. These results demonstrate that CS-CNF-PFPP nanocomposite coatings effectively preserve and enhance the quality of minimally processed pomegranate arils, with CS-CNF-5%PFPP showing improved outcomes.

'Ready-to-eat' pomegranate arils, cellulose nanofiber, passion fruit peel powder, microbial count, phenolic and antioxidant activity, shelf-life extension

Kinetic modelling of ethylene biosynthesis and signalling pathways in tomato fruit during ripening and post-harvest storage

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Ethylene plays a pivotal role in governing various plant aging processes, including fruit ripening, through its signalling pathway. A transcriptomic-based kinetic model consisting of ordinary differential equation describing ethylene biosynthesis and signalling pathways in tomato during fruit development, ripening and post-harvest storage was developed. This model was calibrated against a large volume of transcriptomic, proteomic and metabolic data during on-vine ripening of tomato fruit grown in winter and summer. The model was validated using data on off-vine postharvest ripening. The ethylene biosynthesis pathway under different conditions appeared to be largely driven by the gene expression level. The current model is the first attempt to challenge the state-of-the-art theoretical concepts on the ethylene signalling pathway starting from gene expression, the various protein n protein interactions, including the link with ethylene production, internal ethylene levels and its receptors.

Ethylene biosynthesis; signalling; kinetic modelling.

A 3D reaction-diffusion model for ethylene transport in tomato fruit during ripening

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Tomato fruit has been intensively investigated as a model fruit for studying climacteric ripening involving the gaseous hormone ethylene. Our previous study showed that O_2 levels within tomato fruit varied across ripening stages and across tissue types at each stage. Different tissues of tomato fruit have also been reported to exhibit different ethylene biosynthesis capacities. All this suggests that ethylene might be distributed heterogeneously within tomato fruit and across the stages, which may be related to the ripening process of this climacteric fruit. The aim of this study was to develop a three-dimensional (3D) ethylene model to shed light on ethylene distribution within fruit and fruit ripening. This is achieved by 1) exploring the kinetics of O_2 -dependent ethylene production at different external O_2 concentrations; 2) coupling ethylene diffusion and production with a 3D model of tomato respiration; 3) exploring the interaction between the respiration and ethylene. The model helps in understanding the bidirectional interaction of O_2 and ethylene and its effect on climacteric ripening.

Tomato fruit; ethylene; climacteric ripening; internal oxygen and ethylene distributions

Conceptualizing the kiwifruit supply chain for integrated modelling of postharvest systems

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Understanding the biological processes occurring in fruit between harvest and consumption is essential for delivering fruits with exceptional taste and freedom from disorders. These processes may encompass a range of physiological and biochemical changes generally termed ripening and senescence. In addition to the process control, the postharvest industry must navigate a landscape shaped by stringent regulations and logistical constraints. The interaction between biological processes and regulatory frameworks highlights the complex nature of postharvest systems. As advancements in data science and sensor technologies continue to unfold, the development of large-scale data repositories accelerates, mirroring the escalating demand and trending pursuit of digitalized solutions for postharvest operations. These virtual counterparts can offer multiple capabilities, from process control and scenario testing to risk management and decision-making. However, the intricate nature of postharvest systems, characterized by their structural complexity and diverse objectives, manifests not only in the volume of data and their interoperability but also in the biological insights of fruits, industry norms, environmental constraints, and market incentives. Without a sound understanding of all contributing factors, mass data collection may result in ambiguous outcomes and ineffective resource management. We introduce a conceptual framework for the kiwifruit supply chain, serving as the foundation for digitalized postharvest systems. Unlike focusing on specific objectives like rot control or firmness prediction, our approach takes a comprehensive view of the entire supply chain journey. Drawing on insights from kiwifruit biology and industry requirements, we prioritize the state of the fruit as the central determinant of the system. This state exists within a complex interplay of external conditions, constraints, human interventions, and market performance indicators. Our conceptualization captures this dynamic interplay and offers formulations to address the multifaceted objectives of postharvest systems. As data capabilities progress, our conceptual framework represents a pivotal milestone in the digitalization of postharvest operations.

Actinidia, conceptual models, fruit, quality, optimization, process control

Improvements in postharvest apple handling from a pathology perspective

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Evaluating the effect of different treatments after a simulated shelf life is common in postharvest industry experiments. As fungal fruit decay development is closely linked to preharvest factors, fruit quality, and postharvest treatments, two other time points were added in recent experiments. When commercial packinghouses graded the different experimental units (from one to four big boxes) they made three different samples; 1: all the fruit manually discarded before size grading (mostly external symptoms of fungal fruit decay rot and physiological disorders), 2: a 100-fruit sample of the fruit not regarded as first class by the grading machine at size grading (fruit that could be used for industry purpose, processing fruit), and 3: packed fruit for shelf life testing. As expected, differences in pathogen presence were found varying with storage time, cultivar, season, treatments etc. but overall, some important factors could be pointed at: Up to 70% of the processing fruit had damages (caused by insects, weather or mechanical damage) that could be an entry point of fungal pathogens in storage. Apple scab was found on up to 60% of that fruit and up to 12% of the graded fruit in shelf-life tests, indicating a less effective fungicide strategy in some of the commercial orchards. The additional knowledge gained by having three sample types in the experiments is discussed.

Botrytis cinerea, Monilinia fructigena, Fusarium spp. Neofabraea spp. Colletotrichum acutatum species

A molecular tool to identify fungal postharvest pathogens of pear

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The pome fruit industry is facing the loss of several widely used fungicides, which have suppressed fungal decay of apples and pears for many decades. While grey mould and blue mould caused by *Botrytis cinerea* and *Penicillium expansum*, respectively are well known storage pathogens worldwide, less is known about the identity and presence of other fungal species that can lead to heavy crop losses. Therefore, a screening method, PCR-RFLP of the internal transcribed spacer regions ITS1 and ITS2 using the Tsp509I restriction enzyme, was optimized to determine which of the potential 17 postharvest decay-causing pathogens are present in Western Cape orchards in stored pears. Species identification was verified with phylogenetic analysis of barcoding genes such as translation elongation factor 1 alpha. The vast majority of symptomatic pears showed blue mould symptoms (*Penicillium* sp.; 33-57% of decayed fruit), closely followed by isolations of *Alternaria alternata*, which mostly caused superficial calyx or stem end mould (up to 50% in individual orchards). Of the 1200 fungal isolates collected, known pear pathogens could easily be distinguished to genus level using the PCR-RFLP method. Knowledge of the occurrence of the pathogens will enable more targeted and integrated management strategies in future.

fungal pear diseases, molecular detection, pear decay

On-orchard *Botrytis* detection tool for apples

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The fungus *Botrytis cinerea* causes postharvest storage rot of apple fruit and dry eye rot (DER), which deforms and rots the calyx end of apple fruit. The DER disease cycle is not well characterised because the disease is sporadic and unpredictable. Elucidation of the DER disease cycle will be useful for developing control strategies for DER and other postharvest botrytis rots. It is hypothesised that DER is caused by latent botrytis infections of flowers, and therefore spray applications in spring should control this disease. To confirm this hypothesis, we developed a method to quantify *B. cinerea* infections in flowers and latent infections in calyces of fruit. Two methods were tested: one that could be used by growers in the field (LAMP), and the second (qPCR) that would need samples to be sent to a laboratory for analysis. Although both methods were shown to detect botrytis, analysis of multiple samples was more practical with qPCR technology. This project was conducted over a 2-year period, with more inoculum detected from 2022/23 samples than from 2021/22 samples. The amounts of botrytis detected by qPCR in DNA extracted from flowers in spring and fruit calyces at harvest were strongly correlated, suggesting that flower infections were important for later development of DER in fruit calyces. These detection methods can be used in future projects to elucidate the complete disease cycle for DER.

Dry eye rot (DER), LAMP, qPCR

Non-wounding contact-based fungal fruit inoculation and multispectral imaging for early fruit infections

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Fungal infections have a significant impact on the quality of fruits and vegetables at different stages of the supply chain, leading to significant food losses. It is essential to understand how these persistent fungal infections occur and progress during postharvest conditions to develop effective control strategies. In this study, we developed a reliable and consistent inoculation protocol to simulate the spread of disease from infected fruits to adjacent healthy fruits by contact during postharvest storage. We tested different combinations of relevant fruit commodities, including oranges, tomatoes, and apples, against impactful postharvest pathogens such as *Penicillium digitatum, Penicillium italicum, Botrytis cinerea*, and *Penicillium expansum*. We assessed the efficacy of this protocol using fruits treated with various postharvest methods and multiple isolates for each pathogen. Disease incidence and severity were quantitatively evaluated to study infection success and progression. At the final evaluation point, we observed disease incidence rates of 80% or higher in all trials except for the fungicide-treated oranges inoculated with fungicide-susceptible *Penicillium* spp. isolates, as expected. Additionally, we used multispectral imaging (MSI) to assess pathogen establishment in the fruit prior to visible symptom development. MSI revealed changes in the reflectance profile of contact-inoculated oranges, allowing for a significant separation of healthy and infected tissues as early as 6 days post contact inoculation (dpci), preceding visible tissue maceration and mycelium only evident after 12 dpci. The proposed protocol has the potential to be tailored for other pathosystems, facilitating the study of fruit-pathogen interactions and the evaluation of innovative control strategies.

postharvest diseases, mould, Penicillium, Botrytis, orange, tomato, apple, early detection

Orange fleshed mangoes result in higher pro-Vitamin A content

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Mango flesh colour can vary depending on the cultivar, ranging from creamy yellow to a deep-dark orange. This varying colour is potentially an indicator of its pro-Vitamin A concentration, which is an important essential nutrient to human health. Pro-Vitamin A carotenoids include both orange (all-trans β-carotene and β-cryptoxanthin) and yellow carotenoids (α-carotene and α-cryptoxanthin), as well as their various-coloured isomers. In mangoes, all-trans β-carotene has been consistently reported as the principal carotenoid present in ripe flesh, but there has been less emphasis on how its proportion and concentration may affect flesh colour, both in regard to its hue and intensity of colour. This study investigated the differences in the concentration and proportion of individual pro-Vitamin A carotenoids of 25 cultivars of mangoes at a fully ripe stage. In addition to this, six cultivars were further selected to complete a ripening trial investigating the change in the proportion and concentration of these carotenoids over four stages of ripening (3, 5, 7 and 10 days after harvest). The carotenoid concentrations were then converted into retinol equivalents (RE). Objective colour measurements of chroma and hue angle of the mango flesh were also recorded concurrently in both trials. In the initial experiment, it was evident the orange-fleshed mango cultivars or those with lower hue angles had higher RE compared to those with higher hue angles. The highest RE observed (15.54 µg RE/g DW) was in a dark orange cultivar, whilst the lowest was 0.54 µg RE/g DW, belonging to a pale-yellow cultivar. In the ripening trial, a similar trend was observed at each ripening stage, with the orange varieties possessing higher RE values. In all cultivars, however, ripening was found to progressively increase the total pro-Vitamin A carotenoid concentration. An average proportional increase of 85% was observed, with the largest increase observed in a cultivar with orange-yellow flesh, increasing from 1.93 to 4.49 µg RE/g DW, or a 132% increase. In conclusion, RE was consistently observed to be highest in the orange cultivars, indicating a potentially greater source of nutrition than paler-coloured cultivars. Ripening was also shown to significantly increase RE, indicating the importance of ripening to increasing pro-Vitamin A concentration, regardless of cultivar.

Carotenoids, Vitamin A, flesh colour

Nutritional analysis of cassava leaves for human consumption

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Cassava leaves, despite their potential nutritional benefits as a vegetable, are often overlooked and require further comprehensive analysis to evaluate their suitability for human consumption. Therefore, cassava leaves grown under controlled condition in a greenhouse of University of Hohenheim (Stuttgart, Germany) were analyzed in terms of dry matter, ash content, total cyanide concentration, colorimetric attributes, vitamin C content, crude protein concentration, total phenolic content, and total solid content (AOAC, 2006). With a dry matter content of 21.03 ± 0.02 g/100 g FM and total solid content of 20.27 ± 0.01 g/100 g FM, ash content was 11.28 ± 0.315 g/100 g DM, indicating a high mineral content. Protein was found in significant amounts, with a crude protein content of 22.03 ± 0.215 g/100 g DM, suggesting the potential of cassava leaves to serve as a valuable protein source, especially in regions where access to animal protein is limited. Colorimetric analysis provided insights into their visual characteristics, with values of L=25.825, a=-5.49, and b=14.528. Moreover, the high vitamin C content of 266.762 ± 17.18 mg/100 g observed in cassava leaves underscores their significance as a source of this vital antioxidant, contributing to overall human health and well-being. Furthermore, the total phenolic content of 15.52 ± 1.14 mg/g DM suggests potential health benefits associated with antioxidant properties. However, concerns arise due to the presence of total cyanide at a concentration of 411.13 ± 32.84 µg/g DM and tannin content at 3.76 ± 0.21 mg/g DM, necessitating proper processing methods to ensure safe consumption. In conclusion, cassava leaves exhibit promising nutritional characteristics, offering a rich array of essential nutrients and antioxidants. Nevertheless, careful consideration of processing techniques is crucial to ensure safety and maximize the nutritional benefits of consuming cassava leaves, thereby enhancing food security and addressing malnutrition in regions where cassava tubers which are low in protein are consumed as s a staple crop.

Cassava leaves, nutrient composition, antinutrient composition, health benefits, Manihot esculenta

Nutritional composition of New Zealand grown macadamias

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The objectives of this work were to generate nutritional profiles for New Zealand grown macadamia nuts and determine the nutrient content and health claims they could make. Food Standards Australia New Zealand (FSANZ) regulations dictate what nutrient content and health claims can be made on foods in New Zealand and Australia. Hence, all results were interpreted to align with these requirements. A complete nutritional profile has been generated for New Zealand grown macadamias. In most cases, composition was in line with the existing data for macadamias in the New Zealand Food Composition Database (NZFCD), largely imported nuts, and overseas data, but there were some notable differences. The claimable nutrients were found to be: dietary fibre, vitamin B6, magnesium and manganese (the existing NZFCD entries do not reach the claim threshold for vitamin B6). Of interest, there were three nutrients that were significantly higher in a composite sample: vitamin B6, vitamin C and selenium, although only the B6 reached claimable concentrations. These findings are worth further exploration. A selected number of nutrients were analysed in several specific macadamia varieties. For some components there were significant differences between varieties with ranges as follows: protein: 6.7-7.4 g/100 g; dietary fibre: 5.9-6.9 g/100 g; sugars: 4.7-6.3 g/100 g; fat: 75.1-77.1 g/100 g; total phenolics: 30.2-48.6 mg gallic acid equivalents (GAE)/100 g. Of particular note, one variety had a slightly different profile of fatty acids. Based on the results for the composite sample there are a few other components (niacin, thiamine, vitamin B6, vitamin C and selenium) that may be worth investigating in the future by variety to see if the higher results compared with overseas nuts are due to one or more of the varieties being higher (and potentially claimable) or are more about the growing location.

Proximates, vitamins, minerals, soil, phenolics

Mushrooms: a sustainable and feasible food-based solution to vitamin D deficiency to include in dietary guidelines

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Vitamin D deficiency and insufficiency is a public health issue, with low dietary vitamin D intakes a contributing factor. Rates of vitamin D deficiency are 31% in Australia, 47% in New Zealand, and up to 72% in some regions globally. While supplementation is often prescribed as an alternative to additional sun exposure, complementary approaches including food-based solutions are needed. Yet, food-centric dietary guidelines are not always adequate for meeting vitamin D needs. Edible mushrooms such as *Agaricus bisporus* can produce over 100% of vitamin D recommendations (10 µg/day, Institute of Medicine) per 75 g serve (18 µg) on exposure to UV-light, with the vitamin D_2 produced showing good stability during cooking and processing. Our dietary modelling has shown that four serves/week of UV-exposed button mushrooms can support most Australian adults in meeting vitamin D recommendations; however, current mushroom intakes are less than one serving/week on average. To assess the feasibility of increasing intake of UV-exposed mushrooms in a vulnerable population, the MOM (Mushrooms on the Menu) study measured the acceptance, palatability, and uptake of UV-exposed mushrooms included as an option on the menu of the Shoreline Residential Aged Care (RAC) facility, NSW, Australia. Mushrooms were well-accepted by the participants with an average of 60.6% of residents ordering UV-mushroom meals per day (lunch and dinner), equivalent to the consumption of 66 out of a possible 109 meals containing UV-mushrooms. Although recent evidence suggests some differences between vitamin D_2 and vitamin D_3 in physiological activities, vitamin D_2 has been shown to increase vitamin D status in deficient individuals. UV-exposed mushrooms are a natural, vegan, feasible, and sustainable vitamin D food source that can be part of a larger solution to increasing dietary vitamin D intakes. Inclusion within dietary guidelines is warranted.

Vitamin D deficiency, UV-mushrooms, biofortification, vitamin D2, dietary guidelines

Controlled atmosphere conditions affect the ripe fruit quality of ‘Hass’ avocado

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The 'Hass' avocado (*Persea americana Mill.*) cultivar is an economically important crop widely cultivated in Peru. In 2023, Peru exported 558,430 tons from a production area of 67,800 ha. Most of the production is exported to Europe and the USA, with a small, but growing, volume going to more distant markets including China, Japan and India. Delivering high-quality avocados to consumers is the key factor in remaining competitive within an increasingly crowded marketplace where 'Hass' fruit is offered from numerous countries. Almost 90% of Peruvian 'Hass' avocados are shipped by sea in refrigerated controlled-atmosphere (CA) containers. Since the first Peruvian 'Hass' avocado exports ~20 years ago, a gas concentration of 4% O_2 and 6% CO_2, copied from neighbouring countries, has mostly been used. Recently, shipping under high CO_2 concentrations (8-12%) has been introduced by some container providers. These high-CO_2 atmospheres markedly delay fruit ripening. During the 2022 season, different atmospheres were tested to determine their impact on the storage life and quality of 'Hass' fruit from Peru's coastal region. Fruit was sourced from early-, mid-, and late-season harvests from Olmos, Chao, Chincha, and Barranca. They were stored at 5°C for 30, 45, and 60 days, in CA concentrations (% O_2 - CO_2) of 3-3, 5-5, 10-10, 17-10, and 21-0 (air, control). After storage, fruit were ripened at 20 C and assessed for quality when eating ripe. All CA treatments resulted in better quality fruit than the control. However, atmospheres with lower CO 2 concentrations in combination with low O_2, such as 5-5 and 3-3, were most effective in maintaining fruit quality after all storage times, and particularly after the longer 600day storage period. Better ripe-fruit quality was associated with reduced ripening time for the fruit after removal from storage.

Persea, storage, shipping, oxygen, carbon dioxide, disorder

Programmed cell death and the controlled atmosphere storage of ‘Conference’ pear fruit

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Ultra-low oxygen storage (ULO CA storage) is commonly used to extend the postharvest storage life of pears (*Pyrus communis* cv Conference). During ULO storage, the O_2 levels in the storage atmosphere are reduced to low levels that the fruit can tolerate (i.e. hypoxia). However, such conditions in practice have still led to tissue browning and cavity formation. Although browning usually occurs after long-term low-O_2 storage, it has also been observed after few months. The molecular regulation behind postharvest disorder development in pear fruit is still unclear; but the physical symptoms suggest a form of localized cell death. Programmed cell death (PCD) is a genetically regulated process which plants use in response to biotic and abiotic stresses. To verify the potential role of PCD in pear fruit during postharvest storage, 'Conference' pears were stored under three different conditions [control or regular air (RA); standard ULO: 3 kPa O_2, 0.7 kPa CO_2; and brown inducing conditions (BI): 1 kPa O_2, 5 kPa CO_2] at -1°C for 6 months. PCD hallmarks were tracked every 2, 4 and 6 months. After 6 months, the browning incidence of BI-stored pears increased to 60%, while the control and ULO-stored pears still appeared healthy and sound. Nuclear changes and DNA fragmentation, detected by DAPI (4’,6-diamidino-2-phenylindole) and Terminal deoxynucleotidyl transferase dUTP nick end labelling (TUNEL) assays, respectively, indicated a significantly higher cell death rate of BI-stored pears. By 6 months, however, ULO-stored pears showed a similar cell death pattern and vacuole collapse as the early stages of BI storage. To help resolve the molecular events of the different storage treatments, PCD-related genes were identified from the RNA-Seq data of a previous ULO storage experiment. Transcriptomic analyses via qPCR are ongoing to validate these potential PCD markers.

Programmed cell death, pear, low oxygen stress, tissue browning

Dissecting the effects of dynamic controlled atmosphere (DCA) hypoxic stress on 'Red Delicious' apple fruit postharvest physiology

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Dynamic Controlled Atmosphere (DCA) is the latest breakthrough technology applied for apple storage in which oxygen concentration surrounding the fruit is dynamically adjusted based on real-time monitoring the fruit physiological response. Different apple genotypes respond differently to DCA storage protocols. 'Red Delicious' (RD) is one of the most widely cultivated and consumed varieties, characterized by a pronounced ethanol accumulation and the development of storage disorders during long-term hypoxic storage. The main objective of the study was to evaluate the effectiveness of different DCA protocols for RD long-term storage along three consecutive seasons. Fruit was stored under static (0.3% and 0.8% oxygen) and dynamic (0.3-0.8% oxygen, with the oxygen shift performed at different storage times) conditions up to 6 months. Apple metabolic responses have been investigated applying an integrated metabolomic approach (GC-MS, LC-MS/MS, PTR-ToF-MS, 1 H-NMR) to assess the physiological response of the fruit. Apple quality parameters and transcriptome have also been investigated. Results indicated that shifting to a higher (safer) oxygen level within the first month of storage allows for a better firmness maintenance and reduced ethanol accumulation compared to static CA (0.3%) but resulted in an increased oxidative stress. Ethylene physiology was significantly and variably impacted, as well as central (amino acids, sugars, organic acids) and specialized (hormones, phenolics, VOCs) metabolism. Moreover, tissue (peel ad pulp) specific responses have been identified, and the onset of storage-related disorders in peel tissue has also been characterised via metabolomics. Overall, this work deepens our understanding on the molecular, physiological, and metabolic response of RD apples to long-term hypoxic storage, contributing to the optimization of CA protocols.

Low oxygen stress, metabolomics, long-term storage, Malus domestica

Impact of low-oxygen atmosphere on husk-scald in pomegranates

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We conducted preliminary studies on the effects of low oxygen levels and its key role in control atmosphere storage on husk scald (HS) incidence in pomegranate fruit. Pomegranates were stored at 11°C for 85 days under air and low levels of oxygen (3% O_2) and 95% relative humidity to expedite HS onset. Various skin attributes and biochemical markers were analyzed during storage. The findings indicated a notable decrease in the occurrence of HS and the preservation of marketability in storage with reduced levels of oxygen. Additionally, there was a similar delay in the development of the browning index (BI) after 85 days. Weight loss (WL) and aril sugar/acidity ratio were consistent in all treatments. Antioxidant activity (AA), total phenolics (TP), and total anthocyanins (TA) degraded slower in controlled atmosphere storage compared to air. Conversely, electrolyte leakage (EL), Malondialdehyde (MDA), and respiration rate (RR) were higher in air-stored fruit. Enzymes involved in the metabolism of phenolic compounds, including phenylalanine ammonolysis (PAL) and polyphenol oxidase (PPO), were increased in fruit stored in air. Firmness decreased in air-stored fruit and decreased slightly in controlled atmosphere stored fruit. Overall, the novelty of this study demonstrates that low oxygen levels in controlled atmosphere during storage plays a key role and creates conditions that inhibit enzymatic browning, preserve antioxidants, and maintain fruit firmness, all of which contribute to a reduction in husk scald incidence and the preservation of pomegranate fruit quality during storage, and is recommended for maintaining fruit quality and marketability.

Pomegranate, controlled atmosphere, low oxygen, cold storage, husk scald, fruit quality, postharvest physiology

Comparison of postharvest quarantine treatments on fresh fruit quality

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Many horticultural crops require end-point phytosanitary treatments to allow market access due to the presence of quarantine insects in the growing areas. These phytosanitary treatments include cold treatment, methyl bromide fumigation and irradiation but their effects on final product quality after treatment and out-turn are often variable. Indeed, there is a lack of information on the direct comparison of approved market access treatments on fruit quality. There are many studies on the effects of different market access treatments on final product quality, but there is no direct comparative information on the effects of the different phytosanitary tools (cold treatment, phytosanitary irradiation and methyl bromide). To fill this gap, a series of storage trials were undertaken to compare the effects of fruit quality following treatment and simulated export supply chain following different phytosanitary treatments. For each commodity, three pallets of fruit from three different growers were treated with low-dose irradiation, methyl bromide fumigation and cold treatment. The treatment times / doses used in the trial were industry standards. Following commercial treatment, fruit quality was compared to an untreated control and assessed at regular intervals with an additional shelf-life assessment for external and internal quality. The results showed that in general all phytosanitary treatments resulted in excellent fruit quality outcomes. It was found that storage time had a greater effect on final fruit quality than the phytosanitary treatment. There were some changes in fruit quality following the use of different market access treatments, but these effects were relatively small and could be managed in commercial supply chains. There was a significant difference in overall fruit quality between growers and this impacted upon some fruit quality attributes with the use of different treatments. As a result, further work is required to understand and manage these growers by treatment interactions. These results will be presented and discussed in relation to commercial handling and outcomes.

Quality, phytosanitary, market access, irradiation, fumigation

Developing novel postharvest treatments for insect removal and rot control

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The New Zealand industry is continually innovating to find new ways to improve pest and disease control to achieve sustainable outcomes. Through collaboration between researchers, engineering companies, New Zealand apple packhouses and industry body, a range of novel postharvest treatments and systems have been developed. A new generation of high-pressure washing systems using sets of rotary nozzles at 250-300 psi has improved fruit cleaning and insect removal. In terms of postharvest rots, organic growers need postharvest tools to reduce development of rots, and with the risk of loss of preharvest fungicide treatments, conventional growers may need these tools in the future. We have examined hot water dip treatments across multiple seasons on a wide range of cultivars, developing a treatment of 51°C for 2 minutes as an effective rot control treatment. Recently, in order to reduce treatment time, a drenching system (heavy shower of water over rollers) has been developed (54°C for 15-30 seconds), and a pilot commercial unit constructed that is in operation in a commercial packhouse. Other innovations to high pressure washing such as hot high-pressure washing are being examined and will be discussed.

Malus domestica, disinfestation, pressure washing, hot water dip, hot water drench, postharvest rots

Progress on establishing an X-ray sanitary and phytosanitary research and development program for horticulture in New Zealand

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New Zealand was the first country to import commercial quantities of fresh irradiated produce in 2004. There has been a steady growth in volumes and types of imported irradiated produce each year, particularly in the last two years, since the approval of phytosanitary irradiation for all fruit and vegetables by the regulator of food irradiation, Food Standards Australia New Zealand (FSANZ). X-ray is the preferred irradiation source for phytosanitary irradiation in New Zealand, however, there are no X-ray irradiation facilities capable of Research and Development (R&D) or commercial irradiation of fresh produce. Horticultural phytosanitary irradiation R&D is carried out by The New Zealand Institute of Plant and Food Research (PFR). Objectives of an X-ray Working Group at PFR set objectives to: 1) Scope the feasibility of establishing an X-ray facility at PFR for R&D phytosanitary irradiation; 2) Source an X-ray R&D unit that can treat trays of fruit in a uniform and timely manner; 3) Collaborate with overseas researchers and commercial X-ray facilities in Hawaii and Melbourne, to determine the impact of X-rays on apple and persimmon fruit quality; 4) Determine the impact of irradiation on diapausing apple leaf-curling midge; 5) Assess the response of retailers and consumers to purchasing X-ray treated produce; 6) Participate in international projects, conferences and workshops to establish a knowledge base and access a regional network of expertise in E-beam/X-ray technology to support R&D. Here we report on progress establishing linkages and research with international commercial and research collaborators, and engagement with NZ stakeholders and consumers. which has placed PFR in a strong position to capitalise on use of an R&D X-ray system.

X-ray, irradiation, phytosanitary, fruit quality, insects, consumers, retailers

Effect of phytosanitary irradiation on fruit quality of Thai pomelo cv. Khao Nam Pueng (*Citrus maxima* (Burm.) Merr.) during storage

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The 'Khao Nam Pueng' pomelo (*Citrus maxima (Burm.) Merr.*) is a distinctive cultivar of Thailand. It is famous for its good flavour and abundant total soluble solids content and honey flesh colour. Thai fresh pomelos must be treated with ionizing radiation at a generic dose as a phytosanitary treatment prior to exported to the US. Phytosanitary treatments are essential for preventing pests such as fruit flies into pest-free zones and are often mandatory for international trade. However, there is limited knowledge regarding irradiated pomelo treated during storage. This study evaluated the effect of gamma irradiation on the quality of pomelo cv. Khao Nam Pueng to observe the shelf-life during storage. The 'Khao Nam Pueng' pomelo was collected at maturity stage from an orchard. Afterward, washing and packing were carried out in a packing house, followed by packaging the fruit into corrugated boxes. Pomelos were irradiated at 0.4 kGy using gamma ray (1.25 MeV) from the Co 60 and stored at 13-15°C for 50 days, pomelos were not treated with radiation as a control group. It was found that gamma ray did not affect the quality of pomelo fruit during storage. Neither irradiation affected weight loss, fruit firmness, peel and flesh colour, TSS/TA ratio except for respiration rate and ethylene production. Additionally, decayed fruits were observed on day 30, with a lower incidence of 5.0% in both control and irradiated fruits. There is no difference in sensory evaluation was observed between control and irradiated fruits, and both were accepted by panellists. These results suggest that irradiation could serve as a potential quarantine treatment for Thai pomelo cv. Khao Nam Pueng, preserving its good qualities.

Ionizing irradiation, absorbed dose, generic dose, shelf-life

Post-storage softening of ‘Zes008’ kiwifruit

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Actinidia chinensis var. chinensis 'Zes008' is a commercial, red-fleshed kiwifruit from New Zealand. The fruit has a vibrant appearance and a more complex berry-like flavour than the traditional green- or yellow-fleshed kiwifruit. The fruit has a sigmoidal softening pattern typical of kiwifruit, which can be slowed by controlled atmosphere (CA) storage. 'Zes008' softens rapidly when warmed to room temperature after storage. The aim of this study was to investigate warming-inducing post-storage rapid softening, and particularly any role of ethylene metabolism. Results from the CA trial showed that on transfer from CA to air at 1°C, softening resumed at the same rate as fruit stored in air at 1°C, with rapid softening occurring on transfer to 20°C. After air storage at 1°C for 3 weeks, fruit from a separate temperature trial were transferred to 1, 5, 10 or 20°C for one week. Fruit at 10°C and 20°C softened faster than fruit at 5 and 1°C. After 1 week at 10 or 20°C, fruit were of a similar firmness (~3 kgf) but only the fruit at 20°C were producing ethylene. This ethylene production was associated with the activities of 1-aminocyclopropane-1-carboxylate synthase (ACS), 1-aminocyclopropane-1-carboxylate oxidase (ACO) and the ethylene precursor 1-aminocyclopropane-1-carboxylic acid (ACC), along with specific AcACO and AcACS expression. As a further check on the roles of temperature and ethylene on softening control, results from ethylene treatments of fruit at different temperatures suggested that the temperature response was considerably stronger than the ethylene response. In conclusion, it appears that the softening of 'Zes008' fruit that occurs on warming after storage is not obviously mediated by ethylene, and that the softening response of 'Zes008' fruit to temperature appears to be greater than to ethylene.

Actinidia, ethylene, fruit, kiwifruit, softening, temperature

The ethylene responsiveness of ‘Hayward’ kiwifruit

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'Hayward' kiwifruit (*Actinidia chinensis var. deliciosa*) is often referred to as a climacteric fruit. However, most of the fruit ripening occurs before any detectable increased ethylene production by the fruit. Increased ethylene production of 'Hayward' kiwifruit is a late event, occurring after fruit has ripened and reached eating ripe. It has been demonstrated that fruit ripening on vine and after harvest can be induced by low temperature (e.g. 8-10°C). This study uses a combination of low temperature, ethylene and 1-methylcyclopropene (1-MCP, that blocks ethylene receptors and thereby prevent ethylene-dependent responses) treatments to elucidate the changing response to ethylene and role of ethylene through fruit maturation. 'Hayward' kiwifruit was harvested at weekly intervals from mid-March until June 2024, when ripening started on vine. Fruit was monitored for maturation from seed colour, dry matter accumulation, soluble solids content (SSC) and firmness. Harvested fruit were held at 20°C or 8°C for up to 10 days after ethylene or 1-MCP treatment. Treated fruit were monitored for ripening as indicated by softening and increased SSC from starch conversion. Response to ethylene or 1-MCP treatment will be analysed to identify the changes in ethylene responsiveness and any possible role of low-level ethylene inhibited by 1-MCP during maturation. The results will be discussed with respect to the role of ethylene in kiwifruit maturation and ripening.

Actinidia, 1-methylcyclopropene, low temperature, maturity, ripening, softening, starch degradation

Evaluation of MAP bags and ethylene absorbers in cold storage of different varieties of kiwifruit

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FAO (Food and Agriculture Organization) data, sets global kiwifruit production at over 4.4 million tonnes by 2020, with a total cultivated area of around 270,000 hectares which grew exponentially by around 37% in the decade 2007/2017. China contributes about half of this production followed by Italy and New Zealand, Chile and Greece. The varietal scenario of the Actinidia genus has radically changed in the last 20 years towards a series of new cultivar belonging mainly to A. chinensis var. chinensis characterized by different flesh colour: yellow, yellow-green, yellow-red and usually with more aromatic and sweeter fruit. The value of these productions and the need to guarantee their availability on the global market throughout the entire year, require a review of the storage techniques. For this purpose, the possibility of using MAP (modified atmosphere packaging) bags was evaluated in the two-year period 2022-2023 on three different kiwifruit varieties, stored in normal refrigeration at 0.5°C. The introduction of granular ethylene absorbers (Greenkeeper®) inside of the MAP bags was evaluated at the same time. The fruit samples were kept in cold storage for a variable period (90-150 days), depending on the variety tested. Fruit quality was monitored over time through fruit quality parameters (firmness, brix, flesh colour indices) as well as the onset of physiological disorders (Storage Breakdown) and rots. The monitored concentrations of oxygen, carbon dioxide and ethylene confirm the role of the MAP films and ethylene absorbers. Fruit quality and storage ability were positively affected by the MAP applications without any negative side - effects.

Ethylene absorbers, storage breakdown, modified atmosphere packaging, physiological disorders, quality profile

Post-harvest behavior characterisation of a new variety of *Actinidia chinensis* var. *chinensis* (cv Ac 459 011)

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Ac 459 011 (*Actinidia chinensis var. chinensis*) is the result of an Italian breeding program aimed at integrating the characteristics of yellow-fleshed *A. chinensis* fruits (sweetness, intense aroma) into the green-fleshed kiwifruit segment. Given it is a novel cultivar and considering that, compared to *A. deliciosa*, A. *chinensis* fruit are physiologically less characterized, the ripening evolution and the behaviour of Ac 459 011 fruit during storage were analysed. The effects of 1-MCP and exogenous ethylene treatments were compared during post-harvest ripening and after different period of cold storage in normal and controlled atmosphere (CA). The pattern of flesh firmness decrease, and soluble solids accumulation were studied in relation to the respiratory and ethylene climacteric, indicating that Ac 459 011 fruit are highly sensitive to ethylene. The volatile organic compound (VOC) profile of this cultivar includes 34 compounds belonging to the classes of alcohols, ketones, aldehydes, esters, and terpenes. The compounds with the highest relative abundance belong to the class of aldehydes and alcohols, which contribute to fresh, herbaceous and green notes. Interestingly, several terpenoids have been detected and may play an important role in conferring to this kiwifruit a distinctive aroma. Moreover, preliminarily results indicate a strong effect of 1-MCP treatment on several aroma components. Preliminary trials indicate that cold storage (0.5°C) is in general effective in maintaining firmness and the flesh colour, but the cold storage behaviour (including the appearance of the Storage Breakdown Disorder, SBD) appears to strongly depend on pre-harvest climactic factors, ripening stage at harvest and curing conditions. CA enhances storage efficiency by reducing SBD occurrences, and maintaining firmness and flesh colour for longer, and extending also the shelf life of the fruit. CA reinforces positive cold effects throughout the downregulation of genes involved in cell wall and chlorophyll degradation, while it does not prevent fruit ripening and aroma development once the fruit are removed from CA conditions, showing great potential in order to extend its storage ability and preserving the characteristic fruit quality.

Kiwifruit, ripening physiology, ethylene, cold storage, controlled atmosphere, volatile organic compounds

Next generation postharvest tools

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Functional genomics is an emerging technological frontier in Rosaceous fruit production systems, and the use of artificial intelligence/machine learning approaches to process massive, genome-scale datasets (e.g. hundreds or thousands of big data files) offer new insights into the genetic control of plant traits. Our parallel approach includes forward and reverse genetics, comparative genomics, novel methods for transcriptome analysis, and computer vision methods all aimed at learning about the genes that control important crop traits. Our recent work on 'Gala' apple aims to characterize the long-term response of apple fruit to low O_2 and develop predictive biomarkers that can estimate risk for loss of fruit firmness. We also address open questions about the use of AI/ML as a research tool in functional genomics by studying model systems that have abundant and freely available big data, as well as computer vision approaches to enhance the accuracy and granularity of visually scored fruit traits. Altogether, we show that our approach reveals opportunities to develop new postharvest tools for research and production.

Functional genomics, artificial intelligence, machine learning, controlled atmosphere, apple, fruit quality

Targeting pectin degrading enzymes using CRISPR-Cas9 for improving tomato fruit shelf-life and processing quality

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Tomato fruit is an important and popular commodity worldwide. Over the years, tomato breeders have tried to improve the quality of tomatoes by focusing on factors such as shelf-life in fresh market varieties and consistency in processing varieties. However, traditional breeding methods can take a long time and may impact consumer-based quality traits such as flavour and nutritional value. Our work demonstrates that CRISPR Cas9 gene editing is a targeted and effective strategy that can improve tomato fruit quality while minimizing undesirable traits. By using this technique to knock out the pectin-degrading enzymes polygalacturonase (SlPG2a, Solyc10g080210) and pectate lyases (SlPL, Solyc03g111690) simultaneously in a fresh-market tomato variety, we improved fruit shelf-life attributes like firmness and water loss. This led to the fruit remaining marketable up to 36 days postharvest at room temperature while maintaining other quality traits such as sugar: acid ratio, skin colour, and even improving aroma volatiles. Similarly, we have used CRISPR-Cas9 gene editing to knock out three key genes: SlPG2a, SlPL, and pectin methylesterase (PME, Solyc07g064170) in a processing tomato line. This was done to study the impact of pectin depolymerization in processing traits, and it is currently being evaluated. We expect this study to improve the consistency and viscosity of tomato juice without affecting other characteristics such as pH, titratable acidity, colour, and total soluble solids. Overall, our research shows that using CRISPR Cas9 can improve tomato fruit and product quality while ensuring consumers' expectations. Finally, this tool also provides valuable information for conventional breeding of tomatoes.

Polygalacturonase pectate lyases, marketability, firmness, postharvest, gene editing

Development of innovative tools for understanding postharvest senescence in inflorescence vegetables

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Inflorescence vegetables such as broccoli, cauliflower, and artichoke are multitude of colourful and n nutrient -dense vegetables and invaluable for human health, but their quality deteriorates during distribution before reaching consumers due to ongoing biochemical processes and compositional changes. The current lack of any objective indices for defining " freshness " of fruits or vegetables limits our capacity to control product quality and leads to food loss and waste. In this work, we undertook interdisciplinary research to address plant science challenges related to plant maturation and postharvest senescence in broccoli and artichoke. It will leverage plant physiology, genomics and gene-editing tools, and machine learning technologies to understand deterioration of inflorescence vegetables. We therefore propose a comprehensive research program to identify genes, proteins, and compounds as "freshness-indicators" and to aid development of an innovative and easy-to-use accessibility tool to accurately estimate the freshness of produce. The findings give insights into postharvest senescence and signal transduction at the tissue-specific level in broccoli and artichoke and provide guidance on how to extend shelf life and reduce its economic losses, which also generate genetics and molecular recourses for marker-assisted breeding and expand the general scientific knowledge of regulating senescence of inflorescence vegetables.

Omics, CRISPR, machine learning

The Ri-technology: improving postharvest performance of ornamental potted plants

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The development of transgenic lines via genetic modification has developed and improved several ornamental plants, but there are strict commercialization regulations for these plants in several countries. However, breeding through natural transformation with the soil bacterium *Rhizobium rhizogenes* successfully generated compact growth in many ornamental plants with particular emphasis on Kalanchoe. Hence, the method provides a bio-sustainable alternative to application of chemical growth retardants. In the transformation process, transfer-DNA fragments of the root-inducing (Ri) plasmid including root oncogenic loci genes (rol-genes) and less characterised open reading frames (ORF s) are inserted into the plant's genome during infection, thus termed as Ri-technology. Most interestingly in respect to postharvest performance, improved flower longevity was encountered in Kalanchoe. Ri-lines. When exposed to ethylene, the flowers of Ri -lines exhibited a lower degree of in-rolling compared to WT lines. This feature was encountered in both parental transgenic lines as well as F1 and F2 offspring lines. Moreover, it has been shown that the overexpression of OFR14 contributes to this increased ethylene tolerance as well. However, postharvest studies are in general lacking in Ri ornamental plants. Importantly, Ri transformation is labelled non-GMO when unmodified bacterial strains are solely used therefore it is directly applicable without regulatory obstacles on approvals of new cultivars. Furthermore, the natural transformation label is supported by evolutionary studies where several plants, e.g. tobacco, sweet potato, tea and blueberries have been shown to carry Ri-genes from the bacterium through horizontal gene transfer during evolution.

Ethylene, flower longevity, horizontal gene transfer, natural transformation, root oncogenic loci

Modelling infection periods for apple bull's eye rot

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The postharvest apple disease bull's eye rot (BER) is caused by the fungus *Phlyctema vagabunda* syn. *Neofabraea alba*. A putative disease cycle was proposed for BER based on our knowledge of inoculum availability and sources, and infection timing. A conceptual model based on this disease cycle was used as a basis for an infection period model (Model 1) into which were included parameters derived from combining data from a number of laboratory and field experiments. These parameters included temperature, windrun, leaf wetness and rainfall. The model is currently being validated using a combination of spore trapping, fruit traps and leaf analysis in combination with quantitative polymerase chain reaction analysis of extracted DNA.

Phlyctema vagabunda, Neofabraea alba, spore germination, spore traps, qPCR

Postharvest *Phytophthora*-rot of pome fruit

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Apple (*Malus domestica)* and pear (*Pyrus communis*) are important fruit crops in the Netherlands. In recent years, postharvest fruit rots were observed on the apple varieties such as 'Elstar' and 'Kanzi', and pear varieties such as ''Conference and 'Doyenne du Comice'. The symptoms were found after storage in controlled-atmosphere storage facilities on fruits from different orchards across the Netherlands. Disease incidences up to 50% of the stored fruit were observed. The diseased fruits showed circular brown to black spots with irregular and diffuse margins that enlarged rapidly to form distinctive rings, typical of *Phytophthora* infection. Isolation and identification revealed a number of *Phytophthora* species, e.g. *P. cactorum* , and *P. syringae* . Some of the rot incidences could be related to orchard infections; due to overhead irrigation (sprinkler rot) or to heavy rain fall near harvest. In addition, surveys were performed at several packinghouses and storage facilities to assess the presence of *Phytophthora i*n water flumes. These assessments were carried out with *Rhododendron* , apple and pear fruit baits. Next to the most commonly *Phytophthora* species, also *P. chlamydospora* was abundantly detected in water. *P. chlamydospora* is normally found in streams and wet soil worldwide and has only rarely been recovered as a pathogen from ornamental and woody species. These surveys revealed serious potential risks for *Phytophthora* infections during the grading and sorting process of pome fruit. Results will be presented and discussed.

Phytophthora, fruit rot, control, risk assessment

Pre- and postharvest *Fusarium* findings in apple

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Core rot in apple has only been considered a problem in a limited number of cultivars and has not been a focus in Norway, or in many other countries. There is currently a high demand for apple juice and cider in Norway. As core rot is not detectable on the fruit surface until the rot reaches the outer fruit flesh, it is possible for infected fruit to be used for juice without noticing the rot. Since *Fusarium*, one of the known core rot causes, is a known producer of mycotoxins precautionary investigations is needed. Over several seasons it was found that both pre- and postharvest rot of *Fusarium* were common on most of the cultivars grown in Norway. As in other countries, *F. aveneacum* has dominated so far, but *F. paeoniae* was also identified on apple. Inoculation experiments with attached fruit and in storage were successful both in establishing core rot and detecting different mycotoxins from the fruit. There were evidently differences between isolates of *F. aveneacum* in both the type of mycotoxins produced and the amount. A potential life cycle for *Fusarium* in apple growing in Norway is suggested, and possible ways of reducing the incidence both pre- and postharvest are discussed.

Mycotoxins, fruit rot, pre- and postharvest connections

Postharvest apple diseases: a gauge for tree health in Mid-Atlantic USA apple orchards?

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In the USA, most of the postharvest apple decay research has occurred in Washington, Oregon, and New York, where *Penicillium expansum* and *Botrytis cinerea* are the dominant fungi. Unfortunately, postharvest apple decay is an under-researched area in the Mid-Atlantic USA, and significant knowledge gaps exist. We aimed to evaluate the causal fungi infecting apples while in storage in Mid-Atlantic packinghouses. Ten packinghouses were sampled, with fifty rotten apples per packinghouse randomly selected after five to six months in storage in spring 2021 and 2022. From 975 apples, the infecting fungi were identified based on colony morphology and DNA sequencing and classified as the following: *Alternaria* spp. (29.6%); *Phlyctema vagabunda* (27.6%); *Penicillium* spp. (14.6%); *Botrytis cinerea* (7.1%); *Diaporthe* spp. (3.9%); *Colletotrichum fioriniae* (3.5%); "other" fungi, which include *Fusarium* sp. *Cadophora* sp. *Neonectria* sp. *Epicoccum* sp. and *Monilinia* sp. (7.4%); and non-pathogen rots (6.9%). In contrast to other USA apple growing regions, blue mould, caused by *Penicillium* spp. (14.6%) is not the dominant causal rot in Mid-Atlantic packinghouses. Multiple pathogens are causing postharvest rots, the majority (72%) likely infecting apples before harvest. Of these pathogens, *P. vagabunda*, *Diaporthe* spp. and *Neonectria* sp. predominantly exist in the orchard as canker pathogens, with fruit infections being incidental. The discussion of these results will be approached from the perspective of using postharvest apple rots as a monitoring tool for tree health with an emphasis on influences such as climate change. A goal of this understanding is to optimize orchard management to improve resiliency while also helping to reduce postharvest apple rots.

Apple decay, packinghouse, blue mould, Alternaria spp. Phylctema vagabunda, Diaporthe spp. climate change, orchard health

Garcinia mangostana L. aqueous rind extracts protect human chromosomes from gamma irradiation

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Technological advancements have exposed humans to more sources of ionizing radiation known to cause mutagenesis, carcinogenesis, and hereditary diseases. Plant secondary metabolites are possible sources of radioprotective agents. This study aimed to evaluate the radioprotective effects of the aqueous rind extracts of the Southeast Asian native *Garcinia mangostana* L. on human chromosomes against gamma irradiation. Whole human blood containing the positive control (treated with 2 mg/mL N-acetylcysteine), an untreated setup, and three concentrations of aqueous *G. mangostana* rind extract (100 µg/mL, 200 µg/mL, 300 µg/mL) were subjected to a dose of 4 Gy of gamma radiation. Chromosomal aberrations were visualized and scored under OIO (1000x magnification) using a compound microscope. Aberration counting showed that the lowest aqueous concentration (100 µg/mL) had 68 aberrations while the 200 and 300 µg/mL concentrations had aberration counts of 112 and 115, respectively. The positive control (N-acetylcysteine) had an aberration count of 119 and the negative, untreated setup tallied 191. All three mangosteen rind extract concentrations showed radioprotective potential, reflected in their lower aberration counts and backed statistically as the three treatments were significantly different from the negative control. The highest radioprotective effect was seen at the 100 µg/mL concentration; this effect decreased in the 200 and 300 µg/mL concentrations. Extract from *G. mangostana* rind have the potential as radioprotective agents against gamma irradiation. This can be attributed to the large amount of antioxidant compounds found in mangosteen rind, the most abundant being the xanthones.

Cytogenetics, antioxidant, mangosteen rind, xanthones, secondary metabolites, ionizing radiation

Unlocking the immunomodulatory capacities and gastrointestinal impact of apple-derived vesicles in human health

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Introduction: Living organisms release nano-sized lipidic vesicles into the extracellular compartment for various purposes, including defence and intercellular communication. Plant-derived vesicles (PDVs) carry biologically active molecules and play roles in plant-pathogen interactions and interactions with mammals. This cross-kingdom communication offers new potential applications for PDVs in human and animal health, directly influencing mammalian cellular metabolism and microbial flora. Our research concentrates on apple-derived vesicles (ADVs) sourced from apple production by-products, in line with circular economy principles. Specifically, we investigate inflammation, a prevalent feature of numerous pathologies, including inflammatory bowel diseases (IBD).

Material and methods: ADVs were isolated from fresh *Malus domestica* fruit (var. Golden Delicious) following patented technology (PA 02022000000719). They have been thoroughly characterized regarding their size, shape, and content through various analyses, including Nanoparticle Tracking Analysis (NTA), Transmission Electron Microscopy (TEM) imaging, miRNAomic profiling, lipidomic analysis, and proteomic analysis. Furthermore, the biological effects of ADVs on mammalian cells have been investigated, encompassing studies on i) cytotoxicity; ii) influence on macrophage polarization, evaluated through gene and miRNA expression analysis, as well as immunofluorescence techniques; iii) reduction of mitochondrial oxidative stress.

Results and Discussion: ADVs act as carriers for various biomolecules, including peroxidases and linoleic acid, which contribute to their biological effects on human cells. They reduce mitochondrial oxidative stress by decreasing reactive oxygen species (ROS) through a Ca^{2+}-triggered molecular pathway. Additionally, ADVs possess anti-inflammatory properties, influencing tissue-resident macrophages by suppressing the NF-kb pathway and promoting macrophage repolarization towards a regenerative phenotype, by upregulating miR-146a, miR-125a, and let-7e, coupled with downregulation of IL-1b. They also carry plant miRNAs and proteins, such as plasm membrane (PM) H(+)-ATPase and lipid-transfer proteins (LTPs), which aid in defence against pathogens by apoplastic acidification and bleaching lipids on fungal membranes, respectively.

Conclusion: With their immunomodulatory effects and antimicrobial cargo, ADVs offer promising avenues for addressing gastrointestinal tract pathologies. They have the potential to treat inflammation-related diseases like IBD by restoring intestinal health and balancing the gut microbiota.

Apple-derived vesicles, immunomodulation, intestinal health, circular economy

Effects of apple intake on intestinal microflora in human volunteers and its bifidogenic factors

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To prevent lifestyle-related diseases through diet, it is important to improve intestinal microflora. In this study, we investigated the effects of apple intake on the intestinal microflora and blood components in human. Fourteen healthy subjects were administered 1.5 to 2 apples per day for 3 weeks, and the effects on intestinal microflora, faecal characteristics, and blood components were examined. This study was done in accordance with the Helsinki Declaration. *Bifidobacteria* tended to increase with apple intake. *Clostridium perfringens* was decreased or eliminated by apple intake in subjects in whom it was detected before apple intake. The pH of faeces was decreased by apple intake, which means faecal characteristics were improved. Evacuation frequency also significantly increased. The effects of apple intake on blood components were examined. Triglyceride levels decreased, and vitamin C in the blood significantly increased. These results suggest that daily apple intake is effective in preventing lifestyle-related diseases in healthy adults because of its prebiotic-like effects on intestinal microflora, evacuation, and faecal characteristics, as well as improvement of blood components. Furthermore, to identify oligosaccharides derived from apples with bifidobacterial growth activity, we investigated in vitro the availability by intestinal bacteria of oligosaccharides produced from apple pectin based on the structure of apple pectin. Apple pectin is characterized by arabinose-rich side chains. Arabinose is more or less selectively utilized by *Bifidobacterium*. Arabino-oligosaccharides were selectively utilized by *Bifidobacteria*, especially *B. adolescentis* and *B. longum*, which are important in adults. These results suggest that arabino-oligosaccharides are bifidogenic factors that selectively increase bifidobacteria, and that the effect of apple intake on bifidobacterial growth is due to the arabinose-rich side chains of apple pectin.

Apple, arabino-oligosaccharides, Bifidobacterium, intestinal bacterial flora

Evaluation of the radioprotective properties of the aqueous extracts of *Curcuma longa* L. rhizomes on human chromosomes

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Radiation has been increasingly used in medicine and industries, in particular gamma-radiation is being used for radiotherapy in cases of malignancies. Non-medical exposures can include occupational workers using gamma-radiation for sterilization and other purposes in industries. Upon exposure, gamma radiation can induce various DNA damages through radiolysis of water which produces various free radicals. This study aimed to evaluate the radioprotective effect of the aqueous extract of *Curcuma longa* in human lymphocytes in vitro. Lymphocytes were obtained through extraction of human peripheral blood and later applied with various concentrations of the *C. longa* aqueous extract (10 µg/mL, 40 µg/mL, 100 µg/mL) prior to irradiation of 4 Gy of gamma-radiation. Subsequently, all blood samples were cultured then harvested after 72 hours. All harvested cells were dropped on microscope slides then analysed for chromosomal aberrations (dicentrics, tricentrics, chromatid breaks, chromosome breaks, ring chromosome, chromosome exchanges, and acentric fragments). A total of 75 metaphase spreads were analyzed for each group. After statistical analysis, 10 µg/mL was found to be the treatment group with comparable radioprotective effect as the positive control, N-acetylcysteine. The other two treatment groups (40 µg/mL, 100 µg/mL) displayed no radioprotective effect as there was no significant difference with the negative control group. Thus, the aqueous extract of *C. longa* exhibited a radioprotective effect on human lymphocytes specifically only at a certain dose (10 µg/mL). The radioprotective properties of *C. longa* can be attributed to the various anti-inflammatory agents and antioxidants in *C. longa* such as flavonoids and polyphenols.

Antioxidant, cytogenetics, aberrations, rhizome, radioprotection

Influence of canopy position on initial starch content, conversion rate, and storability of ‘Rosy Glow’ apples

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It is well-established that apple maturity varies within the tree canopy and between trees in a single orchard, likely due to differences in light exposure. The aim of the study was to investigate if maturity variations extend to starch content and conversion rate, ultimately affecting storability. 'Rosy Glow' apples were sampled weekly for six weeks prior to commercial harvest in Grabouw, South Africa. Four distinct canopy positions were targeted namely, outer top, inner top, outer bottom, and inner bottom. Full maturity analysis was conducted at each sampling point. Starch content analysis was performed on apples collected at three time points: six weeks pre-harvest, three weeks pre-harvest, and at harvest. Results indicated a significant difference in maturity between apples from various canopy positions. Apples on the outer top appeared more mature (higher starch breakdown percentages) compared to other canopy positions. Conversely, apples from the inner bottom position showed signs of slower ripening (lower starch breakdown percentages). Additionally, a trend suggests that apples on the inner top have a slower rate of starch breakdown compared to other canopy positions. The significance of these findings will be discussed in relation to starch content analysis and post-storage fruit quality assessment. This knowledge could be instrumental for apple growers in optimizing harvesting methods, timing and storage strategies for improving fruit quality and shelf life.

Starch content, apple, canopy position, storability

The impact of cultivation light intensity on the postharvest quality of *Perilla frutescens*

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The quality of fresh leafy vegetables post-harvest is heavily influenced by the cultivation conditions, particularly in controlled environment agricultural systems (CEA), where the intensity of artificial lighting is a crucial factor in the economic efficiency of CEA production. Proper lighting conditions can enhance the nutritional value and prolong the shelf-life of leafy vegetables, making it a key area of study for researchers. The objective of our research was to evaluate the impact of cultivation light intensity on the postharvest nutritional quality and duration of the green and red Perilla frutescens cultivars. the experiments were conducted in hydroponic systems within a walk-in controlled environment chamber, with day/night temperatures set at 21/17 ± 2°C. Four experimental treatments were performed that represent photosynthetic photon flux densities (PPFDs) of 150, 200, 250, and 300 µmole m^{-2} s^{-1} while maintaining an equal spectral composition consisting of deep red 61%, blue 20%, white 15%, and far red 4% light emitting diode (LED) light at a 16-hour photoperiod. After three weeks of germination, the plants were harvested and stored at -4°C in the dark for postharvest storage. Our research demonstrates that the impact of PPFDs on the response of perilla antioxidant system and dynamics of nutritionally valuable metabolites during postharvest is cultivar specific. Our study contributes to the growing body of knowledge in controlled environment agriculture and artificial lighting and provides insights into the cultivation of leafy vegetables to enhance their nutritional value and prolong their postharvest shelf-life.

Controlled environment agriculture, artificial lighting, lighting intensity, plant metabolites, nutritional value

Apple fruit cutin components during storage are governed by orchard heat and sun exposure

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Apple cuticle is the primary surface barrier governing liquid, solute, and gas flux. It is composed of multiple layers of cutin overlaid and intercalated with a complex mixture of waxes and various freely soluble non-polar compounds. Cutin is a polymeric protective coating of most aerial plant surfaces is primarily composed of aliphatic mono, di, and tri-hydroxy mono- and dioic fatty acids. As composition and structure may influence cell and fruit physiology to the point of altering fruit appearance or even ripening, we sought to determine the impacts of sun exposure and heat on apple appearance and cuticular composition. To accomplish this, we harvested 'Granny Smith' apples with contrasting sun exposure between sides as well as peel heat treated in the orchard. Apples were removed from cold air storage after periods of up to 6 months. Appearance was graded, photographed, and extracuticular components, including cutin, analysed following various combinations of extraction and hydrolysis using HPLC-MS. Differences of non-polymerized cuticular and cutin composition related to pre-harvest light and heat exposure were evident at harvest and continued to diverge during storage. Production pentacylic ursane, oleane, and betulane triterpenes was influenced differentially during storage by light and heat exposure. Anticlinal cutin deposition, including "pits" within the structure, was evident in some sun exposed peel. Cutin from sun exposed peel was different in composition and, most conspicuously, associated with higher amounts of pentacyclic triterpenes. Levels of these triterpenes were only different following cutin hydrolysis indicating they are either intercalated within the cutin structure or actually part of the polymer. These differences of cutin composition with sun exposure may provoke or be related to development of sunscald or other apple peel disorders.

Stress, Malus domestica, cold chain, epidermis, coating

Selenium biofortification of kale microgreens improves postharvest quality and shelf-life

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Selenium (Se) is an essential nutrient for human health. Following the successful biofortification of kale microgreens with Se in our previous studies, this study aimed to investigate whether Se could reduce postharvest losses and enhance the shelf-life of microgreens. Given that Se can potentially delay senescence by boosting the antioxidant activity of plant tissues, this study sought to evaluate the postharvest quality attributes of Se-enriched kale microgreens grown in a soilless cultivation system. Four preharvest Se treatments (0, 10, 20, and 40 µM) were applied using two application methods, nutrient solution (NS) and foliar, in a completely randomised design with three replicates. From each replicate, a 10 g sample was harvested and stored in clamshell containers for 14 days at 4°C. Ethylene synthesis, respiration rate, tissue electrolyte leakage (TEL) and leaf pigment content of stored kale microgreen samples were assessed. Results showed that the postharvest attributes of kale microgreens were notably affected by Se treatments and differed significantly by application method. Nutrient solution (NS) application at 20 µM Se significantly improved total chlorophyll content by 47% ($p<0.05$), lowered TEL by 53%, and ethylene synthesis by 3-folds. The foliar application method was less effective than the NS application method in improving the postharvest quality of kale microgreens. These findings provide important insights for facilitating sustainable commercial adoption of kale microgreens by enhancing their postharvest quality and minimising wastage while emphasising their capacity to deliver Se to consumers' diets.

Selenium, fortification, postharvest quality, shelf-life, microgreens, vertical farming, soilless culture

Improved tolerance and postharvest loss reduction in tomato (*Solanum lycopersicum* L.)

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Tomato (*Solanum lycopersicum* L.), a major crop in Sri Lanka, is known for its extreme perishability during harvesting, handling, transportation, and storage, leading to significant postharvest and financial losses. This study investigated the effect of Partially Burned Rice Hull (PBRH) soil application on tomato firmness, quality, and postharvest losses. Three treatments were applied: R0 (control), R1 (1 kg/3 m^2), and R2 (2 kg/3 m^2) PBRH. 'Platinum-701' tomato cultivar was grown, and fruits were harvested at the breaker and pink maturity stages. Quality parameters were evaluated: weight, color, firmness, shelf-life, storage quality, drop resistance, and keeping quality with a gas absorbent. The storage quality of the pink and breaker stage tomatoes in different treatments was checked under room temperature (RT) and refrigerated conditions. The R2 treatment significantly improved tomato quality, resulting in the highest average fruit weight (breaker: 47.49 g, pink: 46.73 g), overall firmness (breaker: 6.42 N, pink: 5.94 N), and longest shelf-life (14 days). R2-treated tomatoes also exhibited lower weight loss (0.88% at room temperature, 0.30% in cold storage) and reduced firmness loss (17.52% at room temperature, 13.88% in cold storage) after 14 days. Additionally, R2 tomatoes showed delayed ripening, improved drop resistance (10 days shelf-life after drop test), and enhanced quality retention. Treatment R2 showed a lower weight loss percentage (0.37%) and lower reduction of overall firmness (14.72%) with ethylene absorbent followed by three days of storage. These findings demonstrate the impressive improvement in tomato quality with the soil application of PBRH at 2 kg/3m^2, potentially minimizing postharvest losses and enhancing economic viability for growers.

Postharvest losses, quality parameters, firmness, shelf life, ethylene absorption, drop resistance

Growing and preserving quality

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The quality of horticultural plant products is determined by overall appearance, colour, texture, and flavour. In addition, fruits and vegetables are often loaded with bioactive phytochemicals contributing to a healthy human diet. During cultivation, physiological and biochemical processes lead to changes in colour, texture, taste and aroma, generating a more appealing product. However, once harvested, maintaining this quality becomes challenging. Over time, ripening and senescence processes diminish product desirability, reducing value, and leading to food waste. Furthermore, these products perceive and respond to external factors. On one side, it conditions and limits postharvest handling, but on the other side, we can use physical and chemical treatments to manipulate products' inner processes and shape their attributes. Our current research demonstrates that temperature, light spectrum, $CaCl_2$ -spray, and relative humidity during cultivation or postharvest storage determine physiological and biochemical processes leading to a wide variety of product's organoleptic properties. To improve plant product quality, we must understand how to use cultivation and postharvest practices to achieve the best quality. This requires a study of the mechanism of signal transduction from the abiotic signal to the response in the plant product. Another promising technology to minimize quality loss is the automatization of product handling. The use of harvesting robots and robotic grippers during postharvest can address the loss of the required product properties, labour shortage, and costs. However, successful implementation of these technologies demands strict protocols that allow both, the optimization of the gripping strategies and the assurance of the product quality preservation. We are currently developing protocols which include physiological and biochemical methodologies to identify and quantify fruit mechanical damage forging the path to enhanced horticultural product quality and sustainability.

Postharvest, quality, physical and chemical treatments, physiology, biochemistry, metabolites, mechanical damage

Application of remote supply chain monitoring for optimising temperature management and extending mango shelf life

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Modern wireless real-time monitoring technology can be used to efficiently track fresh produce consignments and identify when and where handling conditions deviate from recommended practice. Regular monitoring of perishable product temperatures is an essential element of continuous improvement to reduce the risk of quality loss. Thirty-eight 'R2E2' mango consignments were tracked from three orchards in northern Australia to importers in China and Korea across four consecutive seasons using real-time data loggers. Green-mature fruit were harvested and prepared for export according to standard commercial procedures that included vapour heat insect disinfestation treatment. Data loggers that recorded temperature were inserted into at least one pallet per consignment. The pallets were consolidated and pre-cooled at the packhouse. They were transported by road or rail in refrigerated containers to a freight forwarder. The consignments were then air-freighted to the destination country and transported by truck to the importer warehouse. Fruit arrival quality and shelf life at 20°C was assessed. In season 1, the airfreight consignments were handled relatively warm with an average temperature of 16.8°C. Three critical control points (packhouse, freight forwarder, importer) were identified where fruit were not cooled to the recommended 12-13°C. The mango producer and freight forwarder used the monitoring data to improve temperature management over the next three seasons. Logger alert features were activated to notify users when handling temperatures varied from the preferred range. This triggered sharing of data in real-time and correction of handling temperatures to reduce the risk of fruit heat damage and chilling injury. By season 4, the average airfreight consignment temperature had decreased to 13.2°C. This reduction in temperature was associated with an increase in average fruit shelf life from 7.0 to 9.4 days. Regular monitoring and communication have helped the mango producer establish collaborative supply chains that maintain optimal handling conditions for delivering sufficient shelf life for consumers.

Export, Mangifera indica, monitoring, postharvest, temperature, shelf life

A field-based cooling rig for rapid removal of field-heat from strawberries

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Ensuring strawberries are cooled immediately after harvest is essential to maintain fruit quality attributes and limit the rise in moisture loss and disease development. A field-based prototype cooling rig was designed and developed in the UK to cool a single pallet of strawberries (300 kg) providing rapid removal of field heat. The rig was designed with four independent cooling zones, each capable of cooling separate tiers of the pallet stack individually. By deploying a series of air-off thermistors at the distal end of the pallet alongside thermistors inserted into individual fruits, it was possible to track declining fruit temperature changes through the cooling process. A feedback system monitoring fruit temperature or the air temperature exiting the different zones of the pallet controlled the variable fan speeds in each zone. This allowed for uniform cooling across the pallet of strawberries by providing additional cooling to regions that were slower to reach the final set point temperatures (5°C). After the removal of field heat fruits were stored at 1°C for 3 days and transferred to either 10°C or 18°C to mimic different supply chain scenarios. The benefits of rapid cooling in strawberry var. Malling Champion were reduced rates of weight loss during storage at 1°C and a lower incidence of Botrytis rots and weight loss when fruits were subject to shelf-life conditions of either 18°C or 10°C. The effect of delays in cooling between 1-4 hours after harvest on strawberry respiration rate and sugar profiles were monitored. Where the cooling of strawberries was delayed beyond 1 hour after harvest an increase in fruit respiration and a decrease in final sugar profiles was observed.

Strawberry, removal of field heat, respiration, weight loss, disease

Influence of the innovative HDCOLD ® air-cooler technology on fruit quality

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Fresh fruits are living tissues that continually release water after harvest, especially in environments with low relative humidity. As water losses detrimentally affect fruit quality and can lead to substantial economic losses for the whole supply chain, they need to be maintained as low as possible. Given that various pre- and postharvest factors influence water losses, fruits are stored at low temperatures and high relative humidity levels after harvest to mitigate the rate of transpiration. However, condensation of water on the product surface should be avoided, as it could promote microbial growth, leading to decay and further losses. In this study, we evaluated the storage of various fruits with an innovative algorithm and air-cooler technology known as HDCOLD®. This technology enables the storage of fresh products at high humidity levels (> 95%) without water supply and the need for defrosting and the occurrence of condensation. The influence of the system was evaluated on classical quality parameters, weight loss, development of decay and physiological disorders of different cultivars of apples, pears, cherries and apricots. Relative humidity was kept between 96 and 98% in the cold room equipped with the HDCOLD® technology compared to 90-95% in the classical cold room. Weight losses were reduced on average by 20% for apples, 30% for pears and cherries, and 40% for apricots. Firmness, total soluble solids, acidity and colour were not strongly impacted by the storage with HDCOLD® technology and for some cultivars, the parameters were better maintained under these conditions compared to the classical cold room. Fungal decay was not increased at higher humidity levels and was, in some trials even reduced with the HDCOLD® system.

Fruit, cooling, storage, quality, decay

Pallet spinning to alleviate temperature heterogeneity during blueberry cooling

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Forced draft cooling is a critical step in fresh produce supply chains for successful long-term preservation. For blueberry, cooling is applied at a single pallet scale in a complicated multicomponent packaging system. Due to the small size of the fruit, cooling is relatively fast, but also creates potential for significant temperature heterogeneity in the pallet. One potential solution to create more temperature homogeneity in the pallet is to spin the air direction (or the pallet) during pre-cooling. In this work, an in-depth temperature survey of industrial cooling for blueberry was conducted to evaluate performance and implications of pallet spinning during cooling. Fruit and air temperatures, air velocity, and pressure drop across individual pallets at 2 different facilities. Beyond cooling rate, an overall heterogeneity index (OHI) was applied to assess cooling performance and effectiveness of operations. The results demonstrate some of the challenges of cooling fresh produce in real-world industrial conditions and provide an indication of potential best practice scenarios and potential for improvement.

Precooling, packaging, temperature control, refrigeration

Temperature kinetics of whole canopy and sweet cherry clusters by means of 4D point clouds

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Climate change has had an increasing impact on fruit safety and quality along the supply chain. Moreover, due to marked heat waves, several fruit damages such as sunburn at the fruit skin can cause food losses in orchards. Likewise, unexpected summer rains are commonly associated to trigger fruit cracking, due to a sudden osmotic difference between the fruit surface and its inner matrix. Recent advances in close range remote sensing technologies in orchard can capture physical fruit properties, which can characterise the microclimate at the fruit level. Thereof, integration of LiDAR scanning and thermal imaging provide real time local temperature at fruit surface by means of temperature annotated point clouds (4D point clouds). This research aimed to analyse temperature change of sweet cherry after cooling. Five cherry trees were kept in cold rooms at 6°C. Subsequently, all trees were placed in ambient room temperatures (19°C) and scanned at different time steps up to 90 minutes after cooling. The temperature annotated point clouds were obtained for entire canopies, and fruit clusters were manually segmented. Additionally, presence of wetness at fruit surface was visually registered using an annotation software at different locations within the canopy. Fruit wetness classes were established according to the amount of water visually assessed. The relationship between fruit temperature and ambient dew point temperature was compared with visually rated occurrence of moisture at fruit surface. Temperature at fruit surface was found to be lower in comparison to the mean canopy temperature at all measuring scenarios. Estimating the temperature change of sweet cherry by means of 4D point clouds was validated against manual readings. Moreover, the fruit surface temperature was correlated with dew point temperature in the room and wetness class of fruit surface, allowing the potential the estimation of fruit surface wetness from the non-invasive close-range sensing approach.

4D point clouds, dew point temperature, sweet cherry, wetness

The state of bulk cold stores used in handling perishable agricultural produce in Ugandan cities

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Investment in the food cold chain has been reportedly identified as a solution to extensive postharvest losses worldwide. However, cold chain investment in the Ugandan food value chain is largely unknown. This study located, characterised, and determined the efficacy of bulk cold storage facilities used in handling perishable agricultural food produce in the 16 city districts of Uganda. Only 9/16 city districts had bulk cold storage facilities, translating to a cold storage capacity of 4.5 m 3 per 1,000 inhabitants. The private sector owned the highest proportion by volume (90.3%) of these facilities with the highest volume used for handling multiple perishable products (11,590 m^3). Generally, temperature varied significantly from the respective set points in the facilities. Variations were observed for between 1/3 to 3/4 of the logged period above maximum allowable storage temperatures for the different products, showing efficacy lapses. These results indicate investment and management gaps and opportunities in this indelible sector in food value chain by both government and private sector players.

Refrigeration, refrigeration capacity, Uganda, food storage

Food loss and waste data gaps in the horticultural value chains: a review of literature

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Horticulture plays a key role not only for food and nutrition security but a source of livelihoods for the actors involved in the supply chains. Globally, there is a rise in malnutrition and lifestyle diseases associated with unhealthy diets and low consumption of nutritious and protective foods such as fruits and vegetables (F&V). Low consumption of F&V is in part attributed to availability and cost, especially among the low-income populations. While there are many factors that contribute to the high cost and unavailability of F&V, their high perishability and inefficiency in their supply chains, which in turn leads to high postharvest losses, significantly contributes to this scenario. It is estimated that 30-40% of the all the F&V produced are lost or wasted along the supply chain n from harvest to consumption. There have been efforts to reduce food loss and waste (FLW) in fruits and vegetables, but interventions are often misguided due to lack of reliable data on critical loss points, the causes/driver of losses, extent of losses and context-appropriate interventions. As a result, there is the tendency of putting in place blind intervention strategies that do not bear much fruit due to insufficient data. A report on the extent of FLW which was published by FAO in 2011 remains the most comprehensive and highly cited data source to date, 13 years later. Although this report has limitations because of the many assumptions made in the estimates presented, the data therein has been adopted as the baseline and/or reference point for many interventions. The aim of this mini review is to highlight the FLW data gaps with a focus on fruit and vegetable value chains. The mini review borrows heavily from an FLW database created by FAO as an online collection of literature on FLW and their causes. The purpose of the database is to draw attention to the areas that have insufficient data and spur the required action to address these gaps. A look at the database indicates that most studies focus on cereals and pulses understandably because most of them are staples. The database highlights 589 publications on FLW, whose distribution includes cereals and pulses (44%); fruits and vegetables (30%); Roots, tubers and oil-bearing crops (20%) and meat and animal products (6%). Among the 176 articles (30%) on fruits and vegetables, only three fruit crops take up 92% of all the published studies. These include tomato (45%); mango (26%) and banana and plantains (21%), and only 8% for other fruits and vegetables. With regard to where the FLW occurs along the supply chain, most of the studies focused on the farm and in distribution stages (wholesale and retail). In addition, most of the studies have focused on Asia and Africa hence a regional imbalance with little reported on food loss status in North America and Europe. From the foregoing, there is urgent need to address the data gaps in order to inform targeted interventions towards FLW reduction. The need for data is even more urgent for fruit and vegetable value chains because of the high losses and need for targeted interventions guided by reliable data in order to achieve the anticipated impact which can be measured and reported.

Food loss, food waste, FLW, data gaps, horticulture, postharvest

Quantifying and assessing causes of postharvest losses

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Reduction of postharvest food losses has become increasingly important, not only due to economic significance, but also of environmental and social reasons. However, more detailed knowledge of amounts that are lost, and the main causes for products being discarded or used as animal feed are often lacking. Additionally, some parts of a product which are fully edible, may not be harvested. Here we present carrots as an example of how quantification and assessment of postharvest losses in the primary production may be performed, including results from major producers as well as from smaller companies. Losses in fields, during storage and during sorting of the carrots were investigated. Seasonal variation of losses during storage of the carrots were studied. Beside storage diseases, a major cause for products becoming food losses was wrong size due to trade standards. Furthermore, investigating the potential of using discarded or unharvested plants parts, broccoli leaves was used as an example of a mostly unutilized product part. The nutritional quality was analysed, using HPLC-MS. The fresh broccoli leaves contained high amounts of vitamin C, vitamin K, pro-vitamin A carotenoids and other carotenoids, as well as other healthful substances. Differences between different parts (leaf and leaf stem) as well as seasonal differences were found. Apart from being used as a fresh product, the leaves can also be used as healthy raw material for processed food. In summary, the results show that future food availability can be increased by identifying the major causes of the losses to be able the reduce these, and by a more efficient utilization of the produce.

Food losses, food waste, carrots, storage, broccoli

Impact of harvest season and processing practice on microbial decay and food waste of carrots

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The carrot (*Daucus carota L.*) is one of the most economically important vegetables in the world. Postharvest handling before marketing includes mechanical harvest in the field, transport to the processing plant, unloading into a water bath to remove soil, debris and stones, washing using mechanical agitation and brushing, hydro cooling, sorting, and packaging in plastic bags. The shelf life of packaged carrots varies from several weeks to less than one week, which disappoints customers and causes food waste. This work aimed to evaluate the impact of harvest season and processing practices on the microbial decay and food waste of washed carrots. The disease incidence increased from 36% on day 6 to 45% on day 12 at 10°C following harvesting, washing and packaging in April 2018 of carrots from 2017. The disease incidence in October 2018 and 2019 of carrots from 2018 and 2019 also increased after harvesting, washing, and packaging. Interestingly, symptoms of decay varied during the season. In the autumn, shelf life terminated due to black root rot (*Berkeleyomyces basicola* (formerly *Thielaviopsis basicola*), while soft tips and watery tissue with slimy and white lesions terminated the shelf life in the spring. In November 2019, the disease incidence was zero following the initial wash, increasing to 75%, 79%, 92%, and 100% of black root rot following polishing, hydrocooling, sorting and packaging. Similarly, the disease incidence was higher following packaging than polishing in January 2024, with the main symptoms being water-soaked tissue, collapsed tissue, and tissue with white mycelium. The total aerobic count of the process water was also determined, but the results were the opposite. The results indicated that microbial decay is the main cause of carrots being wasted in the supply chain and that disease incidence varies in response to harvest season and processing practices.

Carrots, season, processing, disease decay, microorganisms, food waste

A critical assessment of bell pepper postharvest losses among small-scale farmers in South Africa

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South Africa's bell peppers are mainly produced by small-scale farmers delivering to the local market with few large commercial producers targeting the retailer markets. The lack of production knowledge and extent of postharvest losses are evident in small-scale farmer systems. Hence this study aimed to assess postharvest losses among small-scale bell pepper farmers and identify associated pathogens. The study involved interview-guided questionnaires focusing on production knowledge, observations, and fruit sampling in three regions of Gauteng Province, South Africa. The study results indicated that small-scale farmers lose approximately 21% of their produce mainly due to rots and moisture loss. Rots alone contributed to 13-25% of total postharvest losses across the farms. The rot pathogens included *Alternaria*, *Fusarium*, and Colletotrichum species. Reasons for losses were associated with poor farm management systems and handling practices. The study highlights the need for extensive farmer awareness, training programmes, and incentives to improve management practices for better quality and profitability.

Postharvest losses, plant health, food security, small-scale farmers

Wastages and profitability of different fruit and vegetables in wholesale markets of Pakistan

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Assessments were made for wastages and profitability of different fruit and vegetables at three wholesale markets. The studied fruits included pomegranate, guava, citrus (mandarin, orange, grapefruit) and grapes, while the vegetables included potato, cauliflower, peas, onion, carrot, green chilies, tomato, turnip, bitter gourd, cabbage, brinjal and radish pods. Highly significant difference was found for the quantity of wastages in different fruits and vegetables at wholesale level with an average wastage up to 4.7% in the fruits and 6.7% in the vegetables. The fruit business at wholesale level was more profitable with net profit earing as compared to vegetable business. The paper provides detailed account of quantity losses, unit prices at purchase and sale levels and net earnings.

Value chains, F&V, Fresh produce, profitability index

Value chain mapping and assessment of pre and postharvest losses of purple passionfruit in Viet Nam

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Passionfruit is widely grown mostly by smallholder farmers in Viet Nam's central and northwest highlands. However, the industry faces several issues such as low productivity and poor fruit quality. Poor harvest and postharvest handling practices and inefficient supply chain operations also make it difficult to consistently meet quality standards and volumes for high-value markets. Assessing the amount of postharvest loss along the passionfruit value chain will provide benchmark information for determining loss reduction interventions to increase profitability and competitiveness of smallholder farmers. This study was conducted to map the traditional supply chain and determine losses from farm to wholesale markets of passionfruit produced in So'n La Province, Viet Nam. Results suggest that most the losses occur as early as during harvest due to rough fruit handling and use of packaging materials such as recycled plastic sacks that do not protect fruit from mechanical damage. Scuffing, bruising, cuts, and compression damage were the major issues observed. From harvest to the collection centre all the way to retail at the Long Bien wholesale market in Ha Noi, a typical sack-full of passionfruit undergoes three to four sets of sorting and repacking. In most cases, rejection rate, or the amount of fruit going into processing grade, can be as high as 50-60%.

Passiflora edulis Sims. postharvest loss, value chain

Comparative analysis of physiological responses and proteomic profiles during early chilling stress and recovery in peel sub-epidermal tissues of mature green banana

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Chilling injury (CI) symptom development represents a progressive change in chilling sensitive crops. The banana fruit (Musa acuminata , AAA group, Cavendish type), particularly its peel sub-epidermal tissues, exhibits pronounced susceptibility to chilling, manifesting as peel vascular browning at 14°C. Physiological alterations and proteomic profiles of the subepidermal tissues of mature-green banana peel were followed during 1, 12 or 72 hours at 5°C plus 2-day rewarming (20°C) to investigate the early progress of chilling stress. Chilling exposure at 5°C suppressed the rates of respiration and ethylene production, as well as Y(II) and Fv/Fm, while concurrently inducing increases of peel vascular browning and electrolyte efflux as chilling stress accumulated. Longer chilling exposure (72 hours) exacerbated the bursts of respiration and ethylene production during rewarming, indicating more severe damage. Electrolyte efflux, Fv/Fm and Y(II) showed recovery patterns when the fruit were returned to room temperature, but vascular browning, as an irreversible CI symptom, continued to increase. Proteomic analysis revealed low temperature-induced increases of proteins related to responses to external stimuli (e.g. cold, oxidative stress or drought), amino acid metabolism (e.g. glutamate, methionine, or cysteine), translation (ribosomal proteins), transcription (transcription initiation factors), and transporter or signal transduction (e.g. Ca_2+ channel or signalling). Notably, decreased protein abundance ratios for energy-related processes (e.g. glycolysis) were observed. After rewarming, the most severe CI treatment (72 hours) resulted in increased numbers of down-regulated proteins, particularly in primary metabolism (leucine, pyruvate, or lipid), energy metabolism, protein destination, and stress responses. Interestingly, 9S-LOX (1 hours) appeared to be drastically changed in abundance, suggesting early membrane oxidation and breakdown during the development of CI.

Chilling injury symptoms development, peel vascular browning, membrane breakdown, stress response, 9S-lipoxygenase (9S-LOX)

MaHsf24, a novel negative modulator, regulates cold tolerance in banana fruit by repressing the expression of HSPs and antioxidant enzyme genes

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Transcriptional regulation mechanisms underlying chilling injury (CI) development have been widely investigated in model plants and cold-sensitive fruits, such as banana (*Musa acuminata*). However, unlike the well-known NAC and WRKY transcription factors (TFs), the function and deciphering mechanism of heat shock factors (HSFs) involving in cold response are still fragmented. Here, we showed that hot water treatment (HWT) alleviated CI in harvested banana fruits accomplishing with reduced reactive oxygen species (ROS) accumulation and increased antioxidant enzyme activities. A cold-inducible but HWT-inhibited HSF, MaHsf24, was identified. Using DNA affinity purification sequencing (DAP-seq) combined with RNA-seq analyses, we found that three heat shock protein (HSP) genes (MaHSP23.6, MaHSP70-1.1 and MaHSP70-1.2) and three antioxidant enzyme genes (MaAPX1, MaMDAR4 and MaGSTZ1) were the potential targets of MaHsf24. Subsequent electrophoretic mobility shift assay (EMSA), chromatin immunoprecipitation coupled with quantitative PCR (ChIP-qPCR) and dual-luciferase reporter (DLR) analyses demonstrated that MaHsf24 repressed the transcription of these six targets via directly binding to their promoters. Moreover, stably overexpressing MaHsf24 in tomatoes increased cold sensitivity by suppressing the expressions of HSPs and antioxidant enzyme genes, while HWT could recover cold tolerance, maintaining higher levels of HSPs and antioxidant enzyme genes, and activities of antioxidant enzymes. In contrast, transiently silencing MaHsf24 by virus-induced gene silencing (VIGS) in banana peels conferred cold resistance with the upregulation of MaHSPs and antioxidant enzyme genes. Collectively, our findings support the negative role of MaHsf24 in cold tolerance and unravel a novel regulatory network controlling bananas CI occurrence, concerning MaHsf24-exerted inhibition of MaHSPs and antioxidant enzyme genes.

Banana fruits, cold tolerance, HSF, antioxidant enzyme genes, transcriptional regulation

Predicting the risk of banana fruit chilling injury based on postharvest handling temperature and time

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Williams Cavendish banana fruit are sensitive to chilling injury when exposed to temperatures below 13°C. Chilling injury is a physiological disorder that is visible as a dull grey-brown discolouration of the banana peel. The extent of injury is a function of chilling temperature and exposure time. Over the past 3 years, monitoring of random Australian banana consignments revealed that 25% of domestic road freight loads (n=35) and 69% of air freight export shipments (n=16) experienced temperatures below 13°C for 6 to 168 hours. A series of experiments were completed to simulate the monitored supply chain conditions and determine banana fruit sensitivity to chilling injury. Cavendish fruit were harvested green-mature from plantations in north Queensland during the summer production cycle over 2 seasons. Fruit was exposed to a range of low temperatures (3, 5, 6, 7, 10, 11, 12, 13, 14°C) for different durations (4, 8, 16, 24, 48, 96, 144, 168 hours) either before or immediately after treatment with 100 μL^{-1} ethylene at 16°C for 48 hours. Control fruit were maintained at 20°C. Following low temperature exposure, all fruit were transferred to 20°C for evaluation. An increase in chilling injury incidence and severity was associated with decreasing temperatures and extended exposure times. Using this data, a generalised linear model (r^2 =0.81) was developed to predict chilling sensitivity and yielded significant (P<0.05) coefficients for temperature, time and the temperature x time interaction. The model accuracy was validated in simulated and commercial export supply chains. This study highlights the potential to predict the risk of chilling injury occurring in Cavendish banana fruit during postharvest handling. The model is being incorporated into a decision support tool to inform improved postharvest handling practices or interventions that minimise the risk of chilling injury.

Banana, chilling, temperature, prediction model, postharvest

Synergistic effect of postharvest oxalic acid dip treatment and modified atmosphere packaging on storage life and quality of ‘Fuyu’ persimmon

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Postharvest application of oxalic acid (OA) has emerged as a potential treatment to mitigate storage constraints particularly chilling injury in fruits. In the present work, the freshly harvested 'Fuyu' persimmons were separated into four groups; untreated control, OA 5 mM dip treatment for two min, modified atmosphere packaging (MAP), and combined application of OA (5 mM) followed by MAP bagging, and fruit were stored for 60 days at 0 ±1°C and 95 ± 5% RH. Compared to the control, the OA dip application and MAP bagging alone mitigates CI, but the combined application of OA followed by MAP was more effective in reducing skin and flesh chilling injury (CI) in persimmon fruit stored at 0 ±1°C for 45 and 60 days followed by a one-day shelf period. The OA treatment followed by MAP application synergistically decreased lipid peroxidation by lowering the accumulation of malondialdehyde and hydrogen peroxide content during cold storage. Similarly, the relative electrolyte leakage (REL) and weight loss were reduced in the combined application of OA and MAP, and enhanced the antioxidants by preserving higher phenolics, flavonoids, and ascorbic acid content in 'Fuyu' persimmons. In conclusion, the combined application of OA followed by MAP bagging could be a useful approach for extending storability and minimising skin and flesh CI in 'Fuyu' persimmons.

Oxalic acid, MAP, chilling injury, oxidative stress, cold storage

Fumigation of lemon oil and modified atmosphere packaging alleviates chilling injury and maintains fruit quality of ‘Fuyu’ persimmon

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The fumigation of organically produced essential oils is one of the postharvest approaches currently being tested to extend the storage life and maintain quality in fresh fruits. In the present study, the 'Fuyu' persimmon fruit were fumigated with 4 µM lemon oil (LO) for 12 hours in sealed plastic container, followed by storage at 0 ± 1°C and 95 ± 5% RH for 47 and 64 days following one day at ambient conditions. At each sampling interval, skin and flesh chilling injury (CI), firmness, relative electrolyte leakage, oxidative stress indicators, and antioxidant quality parameters were assessed. LO fumigation, modified atmosphere packaging (MAP) alone, and their combined application lessen CI and maintained cold storage quality of 'Fuyu' persimmons. LO fumigation followed by MAP significantly alleviated skin and flesh CI incidence, reduced electrolyte leakage, production of malondialdehyde, hydrogen peroxide content, and maintained higher firmness during cold storage following one day shelf period. The combined application of LO fumigation and MAP markedly preserved higher total antioxidants, flavonoids, phenolics, and the activities of superoxide dismutase, catalase, and peroxidase enzymes in 'Fuyu' persimmons. Conclusively, the combined application of LO fumigation and MAP bagging seems to be promising in alleviating CI during long term cold storage of 'Fuyu' persimmon fruit.

Chilling injury, essential oils, fumigation, lemon oil, oxidative stress, persimmon

Preharvest spermidine treatment reduces chilling injury in ‘Sanguinelli’ blood orange

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'Sanguinelli' is one of the most common and widespread blood oranges varieties in the Mediterranean area, mainly southern Italy and Spain. Although the production of blood orange varieties in Spain is limited, only in regions where the climate favours the biosynthesis of red pigments, present both in the skin and in the flesh. The most crucial factor is therefore the temperature difference between night and day, one of the factors most affected by climate change. The presence of anthocyanins has been of increasing interest in recent years, as it is not only responsible for the reddish colouring of the orange but also contribute to the organoleptic and nutritional properties. Spermidine is a type of polyamines, which are classified as plant growth regulators (phytohormones). Therefore, spermidine could intervene in a wide range of physiological and biochemical processes, such as cell division, embryogenesis, fruit development and fruit ripening, among others. Furthermore, spermidine is involved in the defence reaction of plants against biotic and abiotic stress conditions. Considering the importance of blood orange production in Spain, the aim of the present study (included in the project PROMETEO/NAC/00075) is to analyse the effect of preharvest treatment with spermidine (Spd) at concentration of 0.01 mM on blood orange, 'Sanguinelli' cultivar, during its postharvest storage at 2°C (chilling temperature). The concentration was selected based on previous assays where different concentrations were studied, obtaining a significant improvement with Spd at 0.01 mM. The present study was carried out in a commercial plot of blood oranges in Alicante, where the treatments were applied by foliar spray at three key moments along fruit growth and ripening cycle. Blood oranges were harvested in accordance with the company's commercial criteria and were stored for 80 days at 2°C. At harvest and each 20 days of cold 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, firmness showed significant differences, being higher in blood oranges treated with spermidine compared to the control. Similarly, weight loss was significantly delayed in treated fruit. On the other hand, Spd treatment at 0.01 mM significantly increased external colour of the fruits, TSS content and TA. Finally, the content of total anthocyanins and total phenolics increased significantly in blood oranges treated after 80 days of cold storage, compared to the control fruit. In conclusion, 0.01 mM Spd treatment could be an environmentally sustainable tool capable of reducing the susceptibility of 'Sanguinelli' to chilling injury, while maintaining the organoleptic quality parameters of the fruit and increasing the content of bioactive compounds during postharvest storage.

Sanguinelli, spermidine, anthocyanins, chilling injury, antioxidant enzymes

KEYNOTE: Natural solutions for postharvest decay control. Commercialization readiness and challenges

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The postharvest control on different pathogens is mainly dependent on traditional methods of preservation that often involve the use of synthetic pesticides. However, these are more and more under pressure and, as a result, the need for pesticides from natural origins is constantly increasing. However, experience learns that green chemistry treatments hardly ever make it to the market.

When evaluating a new (natural) active ingredient, it is important to follow a systematic approach to ensure its safety, efficacy, and suitability for various applications. The evaluation process typically involves several key steps: The first step is a pure theoretical assessment and consists of gathering relevant information about the new natural solution. This includes searching for scientific literature and patents, safety information, any existing regulatory approvals, or certifications.

In a second step a more in depth but still high-level assessment is made. A sample of the new product is subjected to several tests, starting with efficacy testing which implies conducting various controlled in vitro and in vivo studies to determine potential effectiveness as well as potential phytotoxicity issues. At the same time stability and compatibility testing is performed reviewing the behaviour of the product under different conditions. Besides these laboratory-based assessments, other relevant departments also start a high-level evaluation. The legal and regulatory affairs departments do an assessment of the requirements, timeline, and cost to register the product in the countries and crops of interest, while the supply chain department evaluates the production process and assesses the potential to upscale to commercial volumes. Simultaneously, the commercial department does an assessment of the market potential, the need for and the potential interest in such a product.

Only if the high-level assessment is positive the further specialised assessment and development starts. This involves further efficacy testing including field trials, a toxicological and ecotoxicological assessment, residue testing, evaluation of environmental fate and behaviour, determination of the best registration route, production scale up, packaging, transport investigations etc.

This presentation will go through these different processes and steps, highlighting where the pitfalls are, and where most of these natural products fail.

Pesticides, synthetic, natural, evaluation

Protective and curative ability of postharvest potassium phosphite treatment to control *Phytophthora* brown rot of citrus fruit

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Brown rot is a postharvest disease of citrus caused in South Africa by *Phytophthora nicotianae*. Fungicide management of brown rot in South Africa currently consists only of preharvest strategies with no postharvest chemical management options available. The objective of this study was to evaluate the curative and protective efficacy of potassium phosphite (1500 ug/mL) as aqueous dip treatment for the postharvest management of *Phytophthora* brown rot on different citrus types (lemons, oranges and mandarins). Results indicated that the potassium phosphite had very good curative action, reducing brown rot incidence significantly when the fungicide was applied 12 h after infection. Applications done 24 h after inoculation also provided some curative action but not as effective as earlier applications. Potassium phosphite furthermore provided very good protection against infection if inoculations were done up to 48 h after application on all three citrus types. Results obtained from this study indicate that potassium phosphite is a good option for the curative and preventative postharvest management of *Phytophthora* brown rot of citrus.

Phytophthora nicotianae, lemons, oranges, mandarins, aqueous treatments

Application of *Melaleuca cajuputi* extract

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Exporting ‘Gross Michel’ bananas, known as "Kluai Hom Thong" in Thailand, to Japan involves several considerations to ensure compliance with Japan's stringent food safety and quality standards, especially regarding pesticide residues and other contaminants. The research aimed to evaluate the impact of various concentrations of *Melaleuca cajuputi* Powell crude extract on controlling postharvest anthracnose disease in ‘Gross Michel’ bananas, focusing on developing a non-toxic production method. The 70% ripening stage bananas were dipped with 0, 800, 1,000, and 1,200 ppm crude extract for 2 minutes before spraying with 10^{-6} spore mL^{-1} of *Colletotrichum musae* spore suspension, followed by a 2-day incubation, subsequent spraying with 500 ppm of ethephon solution, and a further 1-day incubation at ambient temperature (29 + 2°C). The 800 ppm of *M. cajuputi* crude extract resulted in the lowest percentage of anthracnose disease at 92.5% and the longest shelf life of 8 days.

Melaleuca, banana, anthracnose, Colletotrichum

Effect of SO_2 treatment on *Penicillium* spp. the cause of blue mould of table grapes, and increased sensitivity to pyrimethanil when combined with Timorex Gold®

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Blue mould caused by *Penicillium* spp. is becoming one of the main postharvest rots of table grapes in Chile. Most of the field and postharvest management have been focused on the control of grey mould (*Botrytis cinerea*) regardless of the presence of other pathogenic fungi such as *Penicillium* spp. The objective of this research was to evaluate the effect of sulphur dioxide on *Penicillium* spp. and determine the sensitivity of *Penicillium* spp. to pyrimethanil alone or mixed with Timorex Gold. The commercial fumigation process consisted of injecting 1,200 mL of SO_2, recirculation for 6 min and 7 min of ventilation, it was repeated injecting 1,800 mL and recirculating for 10 min. Red globe table grapes were taken from 4 clusters before and after SO_2 fumigation, each berry was placed in a tube containing 2 mL of sterile distilled water, vortexed for 1 min and a 100 mL aliquot was plated in acidified water agar, incubated at 20°C for 7 days. The result was expressed as CFU cm^2 of berry. The sensitivity of 18 *Penicillium* spp. isolates was studied in minimum medium amended with pyrimethanil alone or mixed with Timorex Gold®, at pyrimethanil concentrations of 0, 0.1, 1 and 10 mL^{-1}. After incubating at 20°C for 18 h the conidial germination percentage was determined. The commercial SO^2 treatment did not affect the amount of CFU of *Penicillium* spp. while the alternative treatment reduced the amount of CFU of *Penicillium* spp. in two of three trials. All isolates tested had increased sensitivity to pyrimethanil when mixed with Timorex Gold®.

Postharvest rots, fungicides, tea tree oil, integrated disease management, sulphur dioxide

Reduction of imazalil doses for the control of citrus postharvest green and blue moulds through the combination with sodium benzoate and heat

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Green and blue moulds, caused by the fungi *Penicillium digitatum* and *P. italicum*, respectively, are the most economically important citrus postharvest diseases in Mediterranean climate areas such as Spain. Due to its high efficacy, persistence, and antisporulant activity, imazalil (IMZ), an imidazole, is the most used synthetic chemical fungicide to control these diseases worldwide. However, due to health and environmental issues, export markets and commercial channels are increasingly demanding citrus fruit with null or reduced fungicide residues. Furthermore, in the European Union, this is also an important requirement of the Farm to Fork strategy for agricultural production within the European Green Deal. Nevertheless, in terms of design of antifungal postharvest treatments, fungicide residue reduction needs to be correctly done to avoid the lack of treatment effectiveness and the proliferation of resistant strains of the target fungal pathogens. In this work, very low IMZ doses (25 and 50 ppm) were combined with the food additive and generally recognized as safe (GRAS) compound sodium benzoate (SB) (3% w/v) and heat in dip trials with citrus fruit artificially inoculated with *P. digitatum* or *P. italicum*. Dip treatments at 50°C for 60 s with IMZ+SB resulted in reductions of the incidence of green and blue moulds with respect to control fruit (treated with water at 20°C) higher than 90% on 'Valencia' oranges incubated at 20°C for 7 days, while IMZ or SB alone at 20 or 50°C reduced disease incidence by 50-70%. Similar results were obtained when 25 ppm IMZ, 3% SB, and the combination of these treatments, all applied at 50°C for 60 s, were tested on artificially inoculated 'Lanelate' oranges and 'Ortanique' mandarins. Therefore, heated mixed aqueous solutions of IMZ at low doses and SB may be an interesting integrated tool to reduce postharvest fungicide residues on citrus fruit while obtaining high decay control levels.

Citrus spp.; Penicillium digitatum; P. italicum; integrated postharvest decay control; fungicide reduction; GRAS compounds; heated solutions

Decrease in fungicide concentrations in reused post-harvest treatment waters by interaction with soil and field substances and treated fruit

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Currently, post-harvest treatments for decay control in citrus fruits are applied mostly by aqueous means and by reusing the treatment waters, in order to optimize logistics, consume less water and reduce the volume of wastewater. However, despite the use of automatic dosing systems, when the waters are reused, different disturbances occur that alter the concentration of the fungicides applied, and that causes the concentration to deviate from the optimal working value, both by excess, which can generate a danger to food safety, or by deficient actives, leading to less protection of the fruit. Among the main phenomena that can lead to a reduction in concentration are the absorption by clays carried from the field or the degradation by the action of organic and inorganic matter carried from the fruit and the field soil, including the presence of substances foreign to the post-harvest treatment (products applied in the field, etc.). In the present work, we present for the first time the results of absorption and degradation of imazalil, pyrimethanil, orthophenylphenol and potassium sorbate in real treatment waters of citrus drenchers from different packinghouses. The behavior of these samples was evaluated as a function of time, amount of fruit treated, physicochemical characteristics and geographical origin, and the possible causative factors were studied. In some samples, significant and highly variable degradation rates were observed for imazalil (30-100%), which could not be correlated with any sample parameter, while pyrimethanil, orthophenylphenol and sorbate showed lower degradations. In terms of absorption, very variable rates were also observed (5-95%), being on average higher for pyrimethanil, intermediate for imazalil and very low for sorbate and orthophenylphenol. These results demonstrate that, due to the changing and unpredictable nature of disturbances, it is difficult to find a universal solution to maintain constant concentrations, it would be necessary to have a real-time monitoring and control system.

Treatment application, reused water, fungicide concentration, fungicide degradation, fungicide absorption, industrial conditions

Examine the impact of rising temperatures during fruit development on metabolic profiles in blueberries

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Fruits, and small berries, such as blueberries, are universally promoted as healthy due to their nutritional value and health-promoting properties. Blueberry growing areas have been expanded in the past decade due to consumer demands and the availability of new cultivars with low chilling requirements. Global warming effects, such as elevated temperature, increased frequencies of heatwaves, and decrease in precipitation, are the main risks for the sustainability and chemo-sensorial properties of fruits, which may lead to lower yields, inferior fruit quality, changes in metabolites production, loss of health-promoting properties and/or changes in flavour. Our research aimed to study the effect of high temperatures during the growing season on physiological properties and metabolomic profiles in blueberries. Two blueberry species, Rabbiteye (*Vaccinium virgatum*, CV. Titan) and Highbush (*V. corymbosum*, cv. Biloxi), were grown under controlled day/night temperatures 22/16°C and 30/24°C (greenhouse), during two consecutive seasons. We have systematically characterized both volatile and non-volatile volatile metabolites by HPLC-RI/PDA, GC-MS, and LC-QTOF-MS to generate a comprehensive picture of the temperature-related metabolic changes. Our data provide unique insight into the metabolic changes that are affected by temperature and the unique response of each of these cultivars, representing a species-dependent response to a certain extent. Our findings demonstrate that increased temperature during the growing season had a consistent and significant impact on both primary and secondary metabolites governing flavour and phenols, potentially altering their flavour and health-promoting properties.

Blueberries, VOCs, temperature, health-promoting properties

Effects of selenium and sulfur interaction on the nutritional quality and bioactive substances accumulation in broccoli

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Broccoli (*Brassica oleracea* var. *italica*) is widely consumed and has anti-cancer benefits for human health. To strengthen the nutrition of broccoli, the effects of Na_2SeO_3 and K_2SO_4 treatments on the nutrient profiles and bioactive components in broccoli were studied. The results showed that the content of vitamin C increased by 17.18% after 150 g/m^2 sulfur and 25 mg/L selenite combined supplementation (hereinafter referred as S150+Se25). The total polyphenols content of S150+Se25 increased by 37.54% compared with the control. The accumulation of total flavonoids was inhibited most significantly under the treatment of 25 mg/L Na_2SeO_3. The highest contents of both individual glucosinolates and total glucosinolates were observed in the treatment of 25 g/m^2 sulfur combined with 50 mg/L Na_2SeO_3 (S25+Se50). Meanwhile, after S25+Se50 addition, the sulforaphane content was significantly increased by 8.31% compared with the control, but the myrosinase activity was not significantly affected. These results suggested that S150+Se25 combination treatment improved the nutritional quality of broccoli, while S25+Se50 combination treatment was beneficial for increasing the content of individual glucosinolates, total glucosinolates and sulforaphane content of broccoli.

broccoli, nutritional quality, glucosinolates, sodium selenite, potassium sulfate

How do biodynamic and organic production systems impact nutritional density?: A review

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This literature review aimed to understand what the current scientific body of evidence is regarding whether biodynamic and organic food production systems produce foods with greater nutritional density, compared to conventional production practices. Each food has its own distinct nutritional and phytochemical profile. Nutritional profiling, and specifically nutrient density measures, has been used in an attempt to assess the overall nutritional value, and hence potential health benefits, of foods. There are various different measures/tools that have been reported in the literature. However, the relevance of any particular nutrient density measure in terms of an impact on human health depends on several things including: which components are included, how those nutrients are expressed (unit and dietary context) and if comparing at a food, meal or diet level. No existing published nutrient density tool is probably appropriate for the study of impacts of growing practices on composition for a variety of reasons, including sufficient granularity. Examining the totality of the evidence there do appear to be some advantages of biodynamic practices in terms of increasing some aspects of nutrient density (at present primarily increases in phenolic concentrations) and improving aspects of the soil health. However, there are large gaps in the research when it comes to fully understanding the impacts of biodynamic growing practices on the composition, health benefits and sensory properties of foods, particularly in a New Zealand context. Even when comparing organic and conventionally grown produce, the evidence for an advantage of organics is variable. Findings are not always consistent and there is a lack of multiple studies on the same crop with other parameters controlled to understand the reasons for differences. Thus, there is considerable potential for further research to understand and build the evidence base for the possible advantages of biodynamic growing practices.

Fruit, vegetables, human health, soil, phytochemicals

Production of nickel-free strawberries and tomatoes in Central Italy

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Recently, the introduction of "free from" products represents a consumption trend that is increasingly rooted in eating habits worldwide, so much so that even in Italy real aisles dedicated to these products have appeared in large-scale retail trade. Nickel hypersensitivity reactions are one of the most common in the modern world. The prevalence of nickel allergy is constantly growing in many countries and represents a major health and socioeconomic problem. The nickel in fruit and vegetables is on average 4 times higher (0.5-5 µg/g) than that found in meat, milk, dairy products, eggs, and other foods of animal origin (0.1- 5 µg/g). In this context, the Regional "Nickel Free" Project (ID 59655) aims to develop soilless cultivation techniques for producing Nickel-Free strawberry and tomato fruits, which are suitable for the diet of people with allergies to this element. In particular, in this study the characteristics of different types of substrate, of strawberry and tomato plants of different origins and different genotypes belonging to these two species are being analysed, to evaluate their interaction and their influence on the quality of the final product. More specifically, the substrates and plants were evaluated to determine the presence or absence of nickel in the starting material, while the fruits obtained during the production cycle were evaluated for the presence or absence of nickel, and their sensorial and nutritional quality. All cultivation practices (especially irrigation and fertilization) were carried out using nickel-free resources, so as not to introduce contamination factors during the production process. The first preliminary results show a substantial maintenance of fruit quality both starting from nickel-free and non-nickel-free substrates and plants, while the nickel content in fruits seems to be more difficult to reduce in strawberries than in tomatoes. This study is still in progress, but it represents an important trial because it represent a good example of how the modern agriculture should work to take into consideration the needs of different consumer groups, comprising the ones that present allergies or hypersensitivity reactions to some elements.

Allergy, Fragaria x ananassa, Solanum lycopersicum, nutritional quality, soilless production

Molecular mechanism of hypoxia inhibiting the occurrence of superficial scald in ‘Ya’ pear

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Superficial scald is a major physiological disorder occurred in pears during long period storage under low temperature, and it is a bottleneck problem restricting the long-term stable supply of pears. Controlled atmosphere (CA) is one of the most important commercial methods to prevent the superficial scald, however the molecular mechanism of the superficial scald inhibited by CA is unclear. In this study, on the basis of previous studies, the relationship between postharvest ethylene biosynthesis and the occurrence of superficial scald was further elucidated. The effects of low oxygen, exogenous ethylene and 1-MCP treatment on superficial scald incidence, alpha-farnesene and its oxidation products, ethylene biosynthesis and signalling of pears during long-term storage were clarified. The relative expression patterns of key genes such as PbERF4, PbCBF3 and PbAFS1 in response to environmental hypoxia stress, exogenous ethylene and 1-MCP treatment were elucidated. The subcellular localization of two transcription factors, PbERF4 and PbCBF3, was determined. The interaction among PbERF4, PbCBF3 and PbAFS1 be investigated by yeast one-hybrid, EMSA and LUC/REN techniques. Both PbERF4 and PbCBF3 could directly bind ProPbAFS1 and regulate the transcriptional expression of PbAFS1.

Pears, superficial scald, hypoxia, ethylene. chilling injury

The effect of different cooling protocols and storage durations on soft scald and bitter pit development in a susceptible apple cultivar 'Scifresh'

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Cooling and storage protocols can aid in maintaining fruit quality and mask or prevent storage disorders from developing. Delayed cooling at warmer temperatures can reduce certain storage disorders, such as soft scald, but it can also reduce fruit quality by increasing softening rates. This study's aim was to evaluate the effect of various storage protocols on 'Scifresh' apple fruit quality as well as ROS, total phenolics, total antioxidant capacity and apple volatiles. Apples were subjected to three cooling protocols to determine their effects on soft scald and bitter pit development and on general fruit quality. The first protocol entailed that the fruit was immediate subjected to room cooling at 0.5°C followed by storage at 0.5°C for the remainder of the storage duration. For the second protocol the fruit was preconditioned at 10°C for 7 days after harvest followed by storage at 3.5°C for the remainder of the storage duration. The third storage protocol used stepwise cooling as follows: after harvest the apples were left at ambient temperature overnight prior to cold storage (20°C); the following morning the fruit was placed at 16°C and the temperature was subsequently decreased over a 14-day period until a pulp temperature of 0.5°C was reached followed by storage at 0.5°C. This study on 'Scifresh' apples has found that bitter pit and soft scald susceptibility are influenced by both harvest maturity and the rate of cooling after harvest. However, the driving factors differ between the two storage disorders, displaying an inverse relationship when looking at susceptibility. Less mature fruit are more susceptible to the development soft scald. Immediate room cooling at -0.5°C reduced bitter pit expression but increased soft scald development. On the other hand, preconditioning and stepwise cooling reduced soft scald but increased the expression of bitter pit. 'Scifresh' apples are best stored for longer periods such as 4 months to reduce the incidence of bitter pit. The final temperature does not seem to induce soft scald, but rather the rate at which the fruit is cooled down to that final temperature. Stepwise cooling should be performed to limit the incidence of soft scald. The risk of bitter pit development should be reduced by better pre-harvest, harvest and storage practices which inhibit the action of ethylene.

Antioxidant, chilling injury, hexanol, precondition cooling, reactive oxygen species, stepwise cooling, storage temperature

The growing season affects the result of temperature preconditioning before cold storage of 'Honeycrisp' apples (*Malus domestica* Borkh.)

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'Honeycrisp' apples suffer chilling injury during cold storage, manifesting in soft scald (SS) development. Although this physiological disorder is of multi-factorial origin, preconditioning for 7-10 days at 10°C before cold storage is widely recommended to reduce its incidence. To evaluate this practice, fruit from different orchards and growing seasons (2020-2023) were preconditioned or not, and later stored at 1°C for 6 months. Fruit quality (firmness, malic acid, chlorophyll degradation (I AD value), starch degradation (1-6)), and disorders incidence evaluations were carried out monthly after 1 and 7 days at 20°C ('shelf-life'). In general, SS development was season and orchard dependent. In 2020, SS was higher ($P<0.05$) in non-preconditioned fruit than in preconditioned one from one of the orchards. In 2022, in 2/4 orchards preconditioned fruit had higher incidences than non-preconditioned ones ($P<0.05$). In 2021 there was very little SS development overall (5%) with the absence of SS in non-preconditioned fruit. The opposite was found in 2023. In general, the I AD values significantly decreased with time in storage regardless of the preconditioned treatment for most years, and flesh firmness decreased in a block-dependent manner. Starch was fully degraded after 2 weeks of storage, regardless of the treatment. Malic acid (%) decreased over time with no significant differences between treatments. These results indicate that the decrease of SS through temperature preconditioning at harvest in Honeycrisp apples, depends on preharvest factors, such as seasonal weather, which modulates their response to this cold acclimation practice.

Chilling injury, acclimation, fruit quality, postharvest

Characterizing carbon dioxide-related postharvest disorders in apple cortex

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Many apple cultivars are sensitive to elevated carbon dioxide (CO_2) during storage. Consequently, there may also be an enhanced risk of CO_2-related disorders of cortex tissue that contribute to annual losses for producers. The appearance of CO_2 -related symptoms can vary by cultivar, and some cultivars develop similar symptoms not related to elevated CO_2 levels, confounding diagnosis and subsequent mitigation. Fifteen apple cultivars were selected to determine sensitivity to CO_2 during storage, CO 2 -related symptom appearance, means for identifying CO_2 -related disorders, and how to best mitigate CO_2 -related disorders of these cultivars. Fruit were harvested at early (2-3 weeks before first commercial pick) and late (1 week after commercial pick) timepoints, half were treated with diphenylamine (DPA, 2000 ppm), then all fruit were stored in controlled atmosphere (CA) for 4 months at 0.6 kPa O_2 and 5 kPa CO_2, keeping DPA-treated fruit separate from non-treated fruit. DPA was used as a contrast due to its use in controlling disorders associated with CO_2 sensitivity. After storage apples were visually rated for injuries, then asymptomatic and symptomatic tissues were sampled, frozen, and ground for chemical analysis. Of the tested cultivars, 11 were sensitive, displaying a variety of injuries including lens shaped cavities and/or radial browning of the cortex. DPA drench was mostly effective at eliminating symptoms of CO_2 sensitivity, and highlighted cases where CO_2 sensitivity was not the cause of internal injuries. Results of chemical analyses indicate clear differences in tissue metabolism between asymptomatic and symptomatic tissues for CO_2 -related injuries. Cultivars 'Honeycrisp' and 'Pazazz' developed disorders related to CO_2 sensitivity as well as those not typically associated with CO_2 (soft scald, non-radial internal browning). When multiple disorders were observed, levels of specific metabolic compounds, such as phytosterol conjugates, products of tocopherol metabolism, pentacyclic triterpenoids, and sphingolipids, were impacted when symptoms were related to CO_2 sensitivity.

Malus domestica (Borkh.), carbon dioxide, storage, metabolic profiling, phytosterols, triterpenoids

Core browning in ‘Honeycrisp’ offspring

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Core browning develops during storage of susceptible apple cultivars, including 'Honeycrisp'. The disorder is usually associated with senescence or low storage temperature, but the mechanism of core browning development is still unclear. Two cultivars from crossings of 'Honeycrisp' and 'SQ-159' are planted in Norway and marketed as 'Eden' ('Wursixo') and 'Fryd' ('Wuranda'). Storage experiments have been carried out over two seasons to determine the susceptibility of these cultivars to physiological disorder development. The most notable disorder in both cultivars was core browning, with up to 90% incidence and an association with senescence in 'Wursixo' and low temperature stress in 'Wuranda'. Incidence of core browning in 'Wuranda' was still lower in fruit stored for shorter periods, but conditioning at 10C for seven days before storage at 4C or 1C greatly decreased incidence. From initial measurements, 'Wuranda' seems to be a low ethylene producing cultivar. Three other related cultivars, 'Honeycrisp', 'MAIA-1' (EverCrisp®), and 'NY1' (SnapDragon®), are also susceptible to core browning, with lower storage temperatures, storage without conditioning, or 1-MCP application increasing disorder incidence. Although symptoms in these four cultivars somewhat mimic those of chilling injury, the core browning is also impacted by inhibition of ethylene production and limited ability for the fruit to respond to stress in storage. The cause of core browning in 'Wuranda', 'Honeycrisp', 'MAIA-1', or 'NY1' might be due to chilling, low-ethylene, or both. However, causes are clearly different from those in 'Wursixo' despite genetic similarities. These results highlight a need for cultivar-specific research into core browning aetiology.

Malus domestica var. Borkh, ethylene production, storage temperature, chilling injury, senescence, ethylene inhibitor

Step-down cooling treatments in conjunction with 1-Methylcyclopropene, to reduce the risk of internal browning of ‘Cripps Pink’ apples

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Internal browning of 'Cripps' Pink' apples has its potential determined by pre-harvest factors such as climatic variables and growing region, orchard factors and its potential realised by harvest maturity, and postharvest factors such as storage temperature, cooling rate, gas composition and storage duration. While pre-harvest factors are often difficult to manage, postharvest factors can be manipulated to mitigate the risk of internal browning. The objective of this study was to investigate different step-down cooling regimes utilised in conjunction with 1-Methylcyclopropene (1-MCP) to mitigate the risk of internal browning of controlled atmosphere stored 'Cripps' Pink' apples. Apples were sourced in the Grabouw and Ceres regions (5 orchards per region) of the Western Cape, South Africa and subjected to step-down cooling protocols compared to no step-down cooling, with or without 1-MCP, stored for 9 months in CA (0.5% CO_2 and 1.5% O_2), followed by 4 weeks regular air (RA) -0.5°C and a 7-day shelf-life period at 20°C. Diffuse and radial browning development was higher in fruit that received no step-down cooling treatment prior to long-term storage, after ripening. A potential region and/ or maturity related risk was exhibited with diffuse browning seeming more prevalent in post-optimum harvested orchards and radial browning more prevalent in pre-optimum harvested orchards.

Malus domestica (Borkh.), long-term storage, diffuse browning, radial browning, controlled atmosphere, harvest maturity, 1-MCP

Postharvest resilience strategies for strawberry: Unveiling the preharvest impact of glycine betaine and calcium formate on fruit quality and storability

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Strawberry is highly susceptible to losing water and perishable fruit with a short storage life. Glycine betaine (GB) has a crucial role in preventing fruit from oxidative stress and pathogen growth, maintaining membrane integrity under abiotic stress. On the other hand, calcium plays an essential role at cell wall and membrane integrity. However, no studies exist addressing the role of GB and calcium formate (CF) as preharvest treatments on quality attributes of strawberry, which is the main aim. Based on previous research, GB and CF were applied at 15 mM in 'Red Sayra' cultivar in a commercial plot (Huelva, Spain). Foliar treatments were: 1) Control (distilled water); 2) GB (GREENSTIM®); 3) CF (CALIBITT®); and 4) GB+CF (GREENSTIM ® +CALIBITT®), being applied in 3 key stages along the crop cycle. A randomized plot design was used with a total of 4 blocks with 2 replicates (n = 8) per treatment. Strawberries were analysed at 5 days at 4ºC, 5 days at 4ºC + 3 days at 20ºC, 10 days at 4ºC, and 10 days + 3 days at 20ºC. Results showed that GB, alone or in combination with CF, significantly reduced weight losses and respiration and ethylene rates during postharvest storage. All treatments significantly delayed the loss of colour compared with control. Firmness was significantly enhanced in GB, CF and GB+CF-treated fruit than control at harvest, and a delay of firmness loss was also observed. These results were strongly correlated with the membrane integrity parameters. Furthermore, these treatments significantly influenced the volatiles emission and the content of TSS and TA, delaying fruit senescence. The antioxidant system was also stimulated in those fruits treated with GB and GB+CF. Finally, decay incidence was reduced and shelf-life improved, specifically with the GB+CF treatment, acting synergically in both membrane and cell wall.

Fragaria x ananassa Duch. firmness, spray treatments, chemical attributes, shelf-life

Preharvest methyl jasmonate spray maintains postharvest quality of cold stored raspberries by modulating cell wall stability and phenolic metabolism

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This study was conducted to elucidate the effect of preharvest methyl jasmonate (MeJA) application on postharvest quality of raspberries during cold storage. MeJA application significantly alleviated decay incidence, fruit softening and weight loss. MeJA application resulted in higher shikimic dehydrogenase and phenylalanine ammonia lyase activities, leading to higher endogenous phenolics in raspberries during cold storage. Additionally, degradation of cell wall was reduced in MeJA-treated raspberries leading to higher total pectin and protopectin, and delayed activities of cell wall hydrolysing enzymes. Furthermore, preharvest MeJA application maintained higher activities of antioxidant enzymes and suppressed hydrogen peroxide radical accumulation. In conclusion, preharvest MeJA treatment extended the cold storage life of raspberries by reducing cell wall degradation, free radical production, and fruit decay, and increasing endogenous phenolics and antioxidants during 10-day cold storage.

Rubus idaeus; softening; phenolic biosynthesis; methyl jasmonate; cold storage

Improving Camarosa strawberry fruit characteristic by forchlorfenuron (CPPU) preharvest application

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Consumers today are showing more interest in foods that are both high in nutritional value and have health-promoting qualities. Strawberry is a unique berry with various antioxidant metabolites, but the most important challenge in its production is to supply a high-quality fruit to the consumer. Cytokinins are a diverse chemical group of plant growth regulators that exhibit a wide range of functions in cell division and differentiation and many physiological processes, so they are exploited in agriculture to improve and manage different products. In this study, the researchers assessed the effects of applying CPPU (0, 5, and 10 ppm) in the flowering stage in some qualitative characteristics of Camarosa strawberry fruit. The results showed that the highest total sugar (8.63 mg/g), antioxidant activity (87.23%), total anthocyanin (0.84 µmol/g), and flavonoid content (0.203 mg/g) were recorded for 5ppm CPPU treatment. The application of 10 ppm CPPU increased the titratable acidity by 67% compared to the control. Also, the highest amount of vitamin C with a 142% increase compared to the control was observed in the application of 5 ppm CPPU. However, total phenol was not affected by CPPU. Generally, preharvest CPPU application improved the biochemical and qualitative strawberry fruit characteristics of Camarosa cultivar.

Anthocyanin, antioxidant activity, cytokinin, polyphenol

Preharvest application of 1-MCP on persimmon

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This study investigated the preharvest 1-MCP application (Harvista® (HV)), as a novel strategy to maintain 'Rojo Brillante' persimmon postharvest quality at two commercial scenarios: 1) to extend the commercial period in fruit treated with ethephon at the beginning of the season; 2) to improve quality after cold storage in fruit treated with gibberellic acid (AG3) at the end of the season. The results of this study showed that HV applied 1, 7 and 10 days after ethephon treatment was effective in delaying ethephon-induced flesh softening during the harvest period. The application of HV 1 day after ethephon treatment maintained the highest flesh firmness during the posterior period of 3 days at 3ºC plus 6 days at 20ºC. In addition, the combined use of pre- and postharvest treatment with 1-MCP improved fruit quality during the marketing period compared to the single postharvest 1-MCP application. In AG3-treated fruit, application of HV was carried out 7days (HV7), 3 days (HV3), or a double application at 7 and 3 days before harvest (HV7+3). After harvest, the fruit were treated or not with the commercial postharvest 1-MCP application and cold stored for up to 60 days plus 6-days at 20ºC. After cold storage and subsequent shelf life, HV applied 7 days before harvest had the same effect on firmness maintenance as postharvest 1-MCP treatment. Fruit from HV3 and HV7+3 treatments exhibited higher firmness than the 1-MCP postharvest treated fruit. In addition, in HV-treated fruit, a postharvest 1-MCP application did not improve firmness during commercialisation. Therefore preharvest 1-MCP application could be a useful tool for optimizing handling operations in packinghouses.

1-metilcyclopropene, fruit firmness, cold storage, harvest moment, Rojo Brillante persimmon

Effect of five fruit bags and subsequent hot water treatment on the physico-chemical and antioxidant quality of ‘Çarabao’ mango

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Preharvest bagging is a safe option that addresses some preharvest fruit production issues with pests and diseases while hot water treatment is a postharvest treatment that can control postharvest diseases. We evaluated the effect of various preharvest bagging materials (newspaper, high-density polyethylene (HDPE), biodegradable plastic, white Taiwan paper, and non-woven spunbond polypropylene (NSPP)), and hot water treatment (HWT, 52-55°C, 5 min) on the harvest and physicochemical qualities of 'Carabao' mango. Among the bagging materials, Taiwan paper bags showed an increase in good quality fruit acceptable for export (12.8%). It tended to show higher fruit retention at 85% compared to newspaper and biodegradable plastic bags, both at 70%. Fruit and growth cracks were more prevalent in biodegradable plastic-bagged fruit. The use of Taiwan paper and NSPP bags extended the shelf life of mango fruit due to better quality, lower weight loss, delayed disease onset, reduced diseases, and delayed colour change. Shelf life of fruit bagged with these new materials was further improved at 12.0 and 10.7 days in Taiwan paper and NSPP bags, respectively, when subjected to HWT. Taiwan paper bags delayed the onset of stem end rot by two days, while subsequent HWT further delayed the onset of anthracnose by four days. Higher Vitamin C content and DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity were also recorded in fruit bagged with Taiwan paper and NSPP. At four days, total phenolic content was higher in fruit bagged with Taiwan paper bag, however, it did not vary from newspaper bag. The new bagging materials such as Taiwan paper and NSPP bags showed potential in improving the harvest quality of mango. The subsequent use of HWT further improved the physico-chemical quality of 'Carabao' mango fruit, particularly when wrapped in Taiwan paper bags.

Taiwan paper bags, shelf life, antioxidant activity

ReTain and Harvista effects on maturity and interactions with postharvest 1-MCP on storage quality of ‘Honeycrisp’ apples

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The 'Honeycrisp' apple is a major apple in the USA, being popular with consumers and highly profitable for growers. However, the cultivar is susceptible to a range of physiological disorders that can result in economic losses. The use of the preharvest plant growth regulators ReTain (aminoethoxyvinylglycine) and Harvista (1-methylcyclopropene; preharvest 1-MCP) is common, but there is concern about the effects of these treatments on fruit quality, especially on the incidences of physiological disorders. In a two-year experiment, an orchard block of 'Honeycrisp' apples in each of the Hudson Valley, western New York and Champlain regions of New York were untreated, or treated with ReTain or Harvista. Harvested fruit were either untreated or treated with postharvest 1-MCP and stored in air or controlled atmosphere (CA). ReTain and Harvista delayed fruit drop and color development. Ethylene production of the fruit was inhibited, as were starch indices and flesh firmness, although not consistently so. Little effect of preharvest treatment on firmness, soluble solids concentration (SSC) and acidity after storage was detected. CA stored fruit were superior to air stored fruit, but preharvest treatments sometimes increased risk of carbon dioxide injuries in CA storage. 1-MCP treated air stored fruit had higher titratable acidity, SSC, and lower greasiness than untreated fruit, and quality characteristics were similar to those of CA stored fruit.

Malus domestica, quality, controlled atmosphere storage, bitter pit

Disorders, rots, and the appearance of fruit: determining consumer responses to visual cues of quality

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Visual examination is a critical component of most postharvest assessments of fruit quality. For example, quantification of the incidence and severity of disorders and rots often requires expert postharvest evaluators to subject fruit to intense scrutiny n but how does this compare to what consumers see when eating? A range of approaches have been used to understand consumers' visual assessment of produce from eye-tracking to conjoint studies. Eye-tracking is particularly useful, in that a subject's attention to a localised disorder or defect can be quantified, for example using measures of the percentage of subjects who fixated on an area of interest, time to first fixation, total fixation counts and duration. Conjoint studies have contributed to knowledge of how consumers respond to the incidence and severity of defects (damage, disorders, and rots) relative to price. As such, this information provides postharvest scientists and industry with information on how their own assessments predict consumer outcomes. In this presentation, we overview a series of Plant and Food Research studies on apple, pear, and avocado in terms of how they inform postharvest science and technology. These studies include observations that the percentage of consumers fixating on a defect (defined as the eye movement velocity at the area of interest less than 30 visual degrees per second) is related to rejection of that product (consumers will not purchase again) and that consumers are more willing to throw away a portion of a fruit rather than the whole fruit when the area of the defect is small. Furthermore, we have found that assessments based on external appearance are similar for postharvest experts and consumers.

Appearance, visual assessment, consumers

Improving instrumental prediction of postharvest eating quality of fruit: barriers and future opportunities

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There is an increasing literature demonstrating that physicochemical measures can predict the sensory experience and associated hedonic responses of consumers. In some cases, these predictive relationships are used to establish industry quality standards as applied at harvest or during distribution. The range and sophistication of tools available to predict eating quality are increasing (e.g. genomics and metabolomics approaches), although it remains a struggle to demonstrate their predictive abilities. A fundamental barrier arises from the high variability in human sensory perception, ability to describe texture and flavour, along with the frequent contradictions in consumer preferences. Several approaches are discussed that can be used to minimise the influence of human variability and it is recommended that positive controls be included so that the unreliability of the sensory-consumer panel can be excluded as a reason for poor results. One successful approach to overcome human variability has been to avoid multiplying it with the inherent variability associated with fruit and hence, postharvest sorting procedures are implemented to ensure each consumer receives a series of treatments that differ from one another according to the targeted instrumental measure (e.g. all fruit are presented to consumers at the same ripeness but differing in dry matter content). This can introduce several risks, including: (1) that only those instrumental measures that can be used in real-time to sort fruit before presentation to consumers can be robustly assessed, and (2) the study limits biological variability to an extent that the study is not a reasonable representation of reality in the market. The alternative is to pursue research with larger numbers of consumers assessing unselected produce, and perhaps in the marketplace rather than the laboratory. This review assesses barriers to future progress and opportunities to build improved approaches.

Eating quality, fruit, consumer, sensory, physicochemical measures

Environmental and genetic effects on postharvest sensory quality of salad rocket (*Eruca vesicaria* subsp. *sativa*)

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Understanding how food is perceived by people with different taste perception genotypes is key to developing foods with appealing sensory qualities that people want to consume. Many of the highly nutritious leafy vegetables that should be eaten as part of a healthy diet are shunned by consumers who perceive them to be bitter. We show that individuals with 'taster' genotypes for a bitter taste receptor (TAS2R38) and high tastebud density (Carbonic Anhydrase VI, CA6; gustin) encoding genes cannot perceive the distinctive aroma and flavour traits of the leafy vegetable rocket (*Eruca vesicaria subsp. sativa*) as strongly as 'non-tasters', due to their heightened perception of bitterness, which overwhelms the flavour profile. In addition, comprehensive metabolomics and transcriptomics analyses were performed on salad rocket lines grown in the UK and Italy. These data demonstrate the underlying environmental effects impacting rocket phytochemistry and the generation of taste and flavour. This in turn means that where a crop is grown has significant impacts on postharvest quality traits. Crops that form key components of a healthy diet should be bred, grown, and selected for sensory appeal for a wide range of consumers, and across varied cultivation regions, so food that is good for us also has a pleasurable taste and flavour.

Flavour, glucosinolates, isothiocyanates, Brassicaceae, bitterness, sensory analysis, postharvest quality

A comprehensive sensorial analysis and flavanones profiling in a new red-fleshed pomelo x grapefruit hybrid (‘Redson’) after harvest and during storage

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'Einat' (trademarked name 'Redson') is a new triploid, red-fleshed pomelo & grapefruit hybrid developed by the Israeli citrus breeding program. We examined the quality, flavor, bitterness, and flavanone composition of 'Redson' fruit compared to pomelo, grapefruit, 'Oroblanco', and orange. 'Redson' fruit are seedless with a yellow peel and red flesh and have unique quality characteristics. Comprehensive and systematic sensorial analyses were conducted, including a descriptive sensory test, consumer sensory test, Just-about-right (JAR) scaling test, and ranking sensory test. The sensory tests revealed that 'The Redson' fruit is more bitter than other citrus fruits but earned a high acceptance score and ranked first among all bitter citrus fruits, including pomelo, grapefruit, and hybrids. To validate the contribution of flavanones to the bitterness sensation, metabolic profiling was performed. The results indicated that 'Redson' fruit contained the highest amount of the bitter flavanone naringin but had low levels of other bitter flavanones (neohesperidin and poncirin) and non-bitter flavanones (hesperidin and narirutin). Then, naringin levels were examined after harvest and during storage, and we did not detect significant changes in naringin levels during storage. Furthermore, we detected a high correlation ($R^2 = 0.957$) between naringin levels and the sensation of bitterness among citrus fruit, featuring the importance of naringin in determining citrus bitterness.

Citrus, flavour, fruit quality, bitterness, naringin

Postharvest quality and sensory attributes of four blackberry cultivars

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Consumer preferences are based on different aspects of blackberry fruit quality, such as appearance, firmness, flavour, and nutritional value. Even though consumers prefer fruit with a good external appearance, repeat purchases depend on fruit flavour. Three harvests and sensory evaluations were conducted during the 2023 blackberry season in Georgia. Blackberries of four cultivars ('Caddo,' 'Ouachita', 'Ponca' and 'Osage') were hand-picked, field-packed, and hand-sorted before being placed in cold storage. Blackberries were stored for up to 21 days, and quality assessments were performed every 7 days. Quality assessments included visual quality, weight loss, colour, firmness respiration rates, red drupelet reversion (RDR) presence, titratable acidity, and total soluble solids. 'Caddo' was the largest of the four cultivars, exhibited the least amount of RDR, had a firmer berry, and higher total soluble solids. In addition, consumers preferred 'Caddo' among the four cultivars, and 'Ouachita' was the least preferred.

Quality, sensory evaluation, appearance, blackberries

What sensory qualities and emotion responses do U.S. consumers want in premium olive oil and what role does country of origin labelling play in their purchase?

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Pacific Northwest-based olive oil producers are targeting domestic U.S. markets, where 95% is currently supplied by imports. To support these industry aspirations, we have sought to understand consumers' motivations for purchasing specialty olive oil and the associations between country of origin and product-related factors in an online consumer survey (n=1.851, 65% female, aged 18 and over, USA) and have explored the taste perceptions, emotional descriptive measurements and purchasing decisions of frequent olive oil consumers in a central-location test (CLT; 119 consumers, Portland, Oregon, USA). The CLT evaluated high phenolic oils from Oregon, alongside similar oils from California, Greece, and Italy for overall liking, colour, aroma, flavour strength, fruitiness, spiciness, pungency, bitterness, and astringency compared to their ideal. Products were rated first blind coded, then branded. Of interest was how consumer perception of a novel product changes when country of origin was revealed. Utilizing check-all-that-apply methodology, consumers described the sensory properties and their emotions toward each product. Results show that sensory characteristics with a significant (p=0.00) positive sensory impact included balanced, clean, bright, fresh, fruity, fragrant, complex and buttery. Textural must have attributes included silky, full-bodied, buttery and smooth. Significant (p=0.00) positive emotion responses included luxurious, pleased, sophisticated, satisfied, excited, impressed and nourished. In unbranded testing, one Oregon olive oil was liked significantly more ($p < 0.05$) than all other oils tested except the Italian oil. Acceptability ratings pre and post disclosure of country-of-origin labelling were significantly different. In a penalty analysis conducted on just-about-right data, significant penalties came from lack of fruitiness and weak flavour strength, among others. Significant findings include specific, actionable recommendations for branding and marketing arguments that olive growers/producers of olive oil can use to increase the competitiveness of their marketing.

Olive oil, consumer acceptability, CATA, sensory characteristics, emotions, country of origin labelling

Mango value chain development in Pakistan: A success story of research for development model

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Pakistan is one of the leading mango-producing and exporting countries of the world. In the past, the local industry faced several supply chain issues downgrading fruit quality and fetching lower prices in domestic and export markets. As a result of an agreement, the Australian Center for International Agricultural Research (ACIAR) launched the Australia- Pakistan Agriculture Sector Linkages Program (ASLP), in two phases (2007-2015) which included the mango industry as well. Initially, a team of scientists from both countries jointly identified research gaps through a scoping study and found poor quality nursery and tree management as the major production issues, while poor cosmetic quality and shelflife, along with high postharvest losses as the main postharvest issues. Fruit quality was inferior at the retail end showing sap burn injuries, wrinkling, ripening issues, and postharvest rots. Previously, negligible scientific information was available regarding harvest maturity, fruit ripening, cold storage, pre-cooling, controlled and modified atmosphere storage, and quarantine treatments etc of local cvs. The project comprehensively addressed these issues by developing standards operating protocols based on critical control points, for three major cultivars (Sindhi, Sammar Bahist Chaunsa, and Sufaid Chaunsa) for distribution locally and export to China, the Middle East, and EU, etc. Industry capacity was built by walking the chain activity of stakeholders to the Australian mango supply chain and establishing demonstration supply chains. The project also demonstrated success in the sea shipment of cv. Sindhri to the EU. Overall, the project helped improve Pakistan's mango supply chains, with increased economic returns to the stakeholders and the country. The project had long-term impacts inspiring a new generation of entrepreneurs to start clean nurseries and farm direct export to new international markets. This paper provides details of a successful internationally collaborative ACIAR model of “Research for Development” in the Pakistan mango industry.

Mango, fruit quality, value chain, export, postharvest, shelf life

Value chain improvement through postharvest research and development: case studies with small-scale onion and potato growers in Pakistan

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Onion and potato are leading vegetable crops grown in Pakistan for local consumption and export. Small-scale farmers contribute a major share in the production of these vegetables. However, improper production, harvest, handling and marketing techniques generally result in poor-quality produce and low returns to farmers and downstream stakeholders. So, a comprehensive study was initiated under an ACIAR HORT/2016/012 project to strengthen these vegetable value chains and improve the livelihood of small-scale farmers. Key issues revealed during baseline surveys of conventional supply chains included poor production practices, lack of harvest indices and defined quality standards, storage potential of commercial cultivars, and improper curing and storage techniques. Growers were then facilitated to understand customer needs and commercial quality grades. These 'walk the value chain' exercises helped identify opportunities in quality production and better postharvest management. Need-based research was conducted, and outcomes from trials were integrated into the farmer fields. Key strategies included the development of commercial quality grades, understanding the storage potential of commercial varieties, and capacity building of gender-inclusive farming communities in implementing pre-harvest considerations (withholding irrigation before harvest) and proper pre-storage curing, sorting, grading and packing as per market requirement. This led to better produce quality and enhanced marketability during long-term storage. Growers were also directly linked with the market via consignment trials using a postharvest best practice package. Conclusively, the value chain-based R&D approach markedly enhanced produce quality and increased gross profit for growers.

Vegetable value chain, postharvest interventions, potato, participatory action research, small-scale growers

Postharvest temperature management of fresh produce using a cold chain for smallholder farms and small retailers

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Cold chain services for fresh produce in the Philippines are mostly in urban areas and cater to imported produce. Smallholder farmers and community retailers cannot access these facilities and are forced to sell at low prices to avoid spoilage, make frequent trips to procure produce and store unsold produce overnight in ambient conditions.

This study developed a prototype cold chain system for small-volume operations (< 500 kg) that includes a trailer-mounted forced-air precooler, insulated pallet wrap, and a collapsible cold room. Trials were conducted using freshly harvested cabbage for precooling, mixed loads of unsold produce stored overnight using the pallet wrap, and cold storage using mixed loads. Freshly harvested cabbage reached 7/8th-cooling (27°C to 8°C) after 7 hrs, with a weight loss of 0.94%, with an estimated cost of approx. US$1.13 for cooling 177 kg. Using frozen water bottles as a cooling source, the pallet wrap was able to reduce air temperature from 30°C to 10°C within 4.5 hrs after sealing; the estimated cost was US$2.10 for holding 80 kg of unsold produce. Cold storage at 10˚C extended shelf life to 3-4 weeks; shelf life at ambient temperature was 2-10 days only. The estimated cost of holding 135 kg was US$57.

The prototype cold chain system can help small growers and retailers plan marketing and procurement activities by reducing the pressure to dispose of fresh produce before significant deterioration develops. The system is flexible and can be easily established where household electricity is available, and any non-refrigerated vehicle with cargo space can be used.

Cold chain, precooling, postharvest, loss reduction, smallholders

Case studies of concrete and iron solar refrigerated evaporatively cooled storage structures in India: Successes and failures

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Off-grid, batteryless, solar refrigerated and evaporatively cooled (SREC) storages for perishables were built in 3 villages: Picholiya (Rajasthan), Chamrara (Haryana), and Cullakpur (Delhi) in India. The following details observations related to success and failure of the SREC enterprise. At Picholiya, there was a partnership between the farmer/landowner and a processor, who operated a small plant adjacent to the SREC. The SREC performed well for 2 years while a youthful, digitally engaged field worker was employed to look after it. However, the field worker resigned when our industry partners neglected to pay him and soon after the SREC structure became non-functional. During this period, relations between the processor and farmer had soured; there was a lack of interest/ investment by the grower and the processor to take on responsibility for operating the SREC. Complicating the scenario, the region suffered from a lowering of the water table leading to the loss of some local farms and infrastructure loss in the form of a broken access road. The SREC was disassembled, and components returned to IARI. The SREC at Chamrara, Haryana was run by elderly but diversified perishables farmer who also managed a small processing facility. The installation worked well and maintained fair temperature control (10 to 15°C). The farmer overseeing the structure observed that the structure was working well and met his expectations. The facility underperformed slightly relative to its potential because solar panels were not washed frequently indicating a lack of routine maintenance. The grower, however, also expanded his processing facility after the build of the SREC and his business of processing and storage in FSF facility was satisfactory. He and some nearby growers around are using the SREC for storage of produce (e.g. potatoes), but the produce appeared to be mostly for personal consumption or informal sales/trading. More could be done to fully utilize the capabilities of the cold storage to access higher value markets. In contrast, the SREC at Cullakpur was used by a farmer who managed a farmer-producer organization (FPO), a young digitally savvy farmer/entrepreneur. The SREC structure was used for precooling and for longer-term storage. Products, primarily spinach, were lightly processed (Washed and bunched) and sold to various companies based on orders received through online markets. The light processing permitted transfer of the crop to retail containers and the field boxes were returned immediately to the grower, minimizing logistical hurdles. The cost economics for spinach alone shows that the cold store operator was able to make an annual profit of $62,370 for this one crop, potentially recovering the cost of the SREC structure in as little as 3 months.

Developing world, refrigeration, solar, photovoltaic, evaporation, cooling

Off-grid solar-powered cold storage of tomatoes in Nigeria

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Tomato production in Nigeria is steadily growing, reaching more than 3.7 Mt in 2022 (FAOSTAT, 2024) and the postharvest harvest losses are rated between 45 and 60% (CBI, 2021). Cold storage for controlled ripening after harvest is expected to reduce losses considerably. However, conventional facilities require reliable electricity supply that is lacking in rural areas. Therefore, a photovoltaic-powered off-grid cold room system was developed in cooperation between the University of Hohenheim (Stuttgart, Germany), the Nigerian Stored Products Research Institute (Ilorin, Nigeria) and Solar Cooling Engineering GmbH (Memmingen, Germany) in order to deliver precise control over temperature and relative humidity. The turnkey system consists of a heat-insulated storage chamber that is cooled by a water/air heat exchanger and is supplied with a humidifier. The energy required to power the water chiller, circulation pump, and fans is supplied by a combination of two 360 W photovoltaic (PV) panels and two 230 Ah VDC batteries. The system was tested and optimized under local conditions in Nigeria. Batches of 300 kg of freshly harvested tomatoes (cv. Batool-1) at various stages of ripeness (green mature, breaker stage, and ripe) were subjected to storage at a temperature range of 10-12.5°C and a relative humidity range of 90-95%. Conventional ripening in a vegetable shed under ambient conditions was used as the control. Continuous measurements of temperature and relative humidity were taken at different locations within the cold room and in the vegetable shed. Samples were collected at 2-day intervals to measure the colour index, firmness, and total soluble solids (TSS) of the tomatoes. The cold room successfully preserved the quality of the stored tomatoes throughout the entire 16-day storage period, even those that were stored at full ripeness, in contrast to the noticeable losses observed in the control group.

Colour index, decentralized energy provision, humidity control, photovoltaic energy, postharvest loss, Solanum lycopersicum, tomato ripening

Effect of storage temperature on shelf-life and quality of purple passion fruit grown under Viet Nam conditions (*Passiflora edulis* Sims.)

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Purple passion fruit grown in Viet Nam's highlands. It is bright red when ripe, has slightly high acidity, develops a fragrant aroma, and with smooth, glossy skin. However, there is little information about the optimum storage requirements of purple passion fruit grown under Viet Nam conditions. In this study, passion fruits were harvested at peel colour index 3 (more green than red) and stored at 3, 5, 7 and 9°C ± 1°C and an equivalent lot stored at 20°C ± 1°C for 14, 21 and 28 days. Fruit quality and postharvest disease incidence were evaluated 5 and 6 weeks after storage plus 3 days at ambient condition. Results showed that under ambient conditions (20°C ± 1°C), passion fruit could be stored for a maximum of 14 days as the significant reduction in the overall sensory quality afterwards. Meanwhile, storage at low temperature (3 and 5°C) led to the development of chilling injuries and were highest in fruit stored at lower temperature (3°C). Keeping fruit at 7 and 9°C ± 1°C for 5 weeks and 3 days' shelf life resulted in lower disease incidence and severity compared to other treatments. These temperatures produced better colour development compared to fruit stored at lower temperatures (3 and 5 °C ± 1°C). Fruit stored at 9°C however, had the highest percentage of weight loss and lowest fruit firmness, meaning lowered visual quality in terms of shrivelling and shrinkage. Overall, storage temperature had no effect on juice pH, total soluble solids, and titratable acidity. Our results showed that passionfruit quality could be maintained up to 35 days at 7°C ± 1°C.

Chilling injury, postharvest handling, fruit quality

Steritech’s phytosanitary irradiation journey - Applying research for commercially significant outcomes

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Over the past two decades Steritech has built a successful phytosanitary irradiation treatment business. In 2005, Steritech delivered the world's first phytosanitary irradiation treatment to an international consignment of fresh produce. This shipment was Australian mangoes treated for the New Zealand market. Today, the company remains the international leader in the field, operating two specialised fresh produce facilities using both cobalt-60 and X-ray sources. The business provides treatments for the Australian produce industry 52 weeks a year, and services over 80 crops. Post harvest research along with several other fields of research has been critical to realising the commercial success of the treatment. Once considered a novel technology, it is now a mainstream solution in Australia. Postharvest research was critical for building confidence in the treatment, and in some cases optimising it where there were issues identified. Scientific research has also helped establish specifications used in critical parts of legislation and regulation that allow the industry to exist and grow. Examples include food standards development and trade protocol treatment requirements. These developments directly contribute to resolving two of the three hearsl barriers (Food Standards, Protocols and Facilities) identified in AM19002 Building Capacity in Phytosanitary Irradiation - Pathways to Export. Steritech's journey has been long and challenging, facing many unforeseen challenges. Research & development continues to be critical to the growing us of the end-point-treatment. This oral presentation will use Steritech and Australia's success in developing phytosanitary irradiation. It is intended to provide insights for designing efficient and commercially significant research, and the often-complex challenging process of turning research into commercially significant outcomes. The presentation will also provide a brief update on fresh produce trade facilitated by the treatment, to create awareness and understanding for the treatment technology, including its impact on future research opportunities.

Irradiation, x-ray, gamma ray, phytosanitary, ispm18, ismp28, end-point-treatment, export market access, protocol, trade, development

Epigenetic regulation on pathogenicity and patulin biosynthesis in *Penicillium expansum*

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Penicillium expansum is one of the most important postharvest pathogens that causes blue mould disease and produces mycotoxin patulin, leading to huge economic losses and food safety issues. Many virulence factors and transcription factors have been proven to be involved in the pathogenicity and patulin biosynthesis of *P. expansum*. Histone H3 lysine 4 (H3K4) methylation is well recognized for its association with chromatin regulation and gene transcription. However, regulation of H3K4 methylation to pathogenicity and patulin biosynthesis is not well elucidated in *P. expansum*. Here, we identified seven components of Set1/COMPASS in *P. expansum*, a well-known histone methylation complex. The PeSet1, PeSwd1, and PeSwd3 involves in the H3K4me1/me2/me3, and PeBre2p, PeSdc1, PeSpp1, and PeSwd2 involves in the H3K4me3. The absence of each component impaired growth, pathogenicity, and patulin biosynthesis, as well as altered stress responses. The core component PeSet1 regulates patulin biosynthesis by mediating the expression of patulin cluster genes and crucial global regulatory factors. Moreover, subunit PeBre2p was found to interact with the conserved global regulator PeVelB at Asp294 of PeBre2p. This interaction affected fungal growth and utilization of fructose, lactose, glycine, and proline in *P. expansum*. In conclusion, this study revealed the important roles of epigenetic regulation on pathogenicity and patulin biosynthesis in *P. expansum*, which provide potential targets for the *control of blue mould disease and patulin contamination*.

Blue mould, fruit, histone methylation, postharvest, Set1/COMPASS

Rapid identification of quiescent *C. gloeosporioides* in fruits: A new approach to minimize postharvest losses

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The problem of postharvest food losses is a major issue, having been estimated at 40% to 50% of harvested crops worldwide, mostly due to rots caused by fungi. After penetrating the unripe fruit, *C. gloeosporioides* (i.e. pathogenic fungi) remain quiescent ("sleeping") until the fruit ripens. The quiescent infections are microscopic and cannot be visually detected during packaging or subsequent transport. Thus, there is a need to design assays that allow the identification of the fungi at an initial quiescent stage of infection to prevent potential fruit decay during the supply chain and consumer storage. A rapid and easy-to-use paper-based LAMP assay was designed for detecting the enoyl CoA hydratase quiescent marker of *C. gloeosporioides*. The developed method requires a cheap cellulose membrane and heat block, enabling this method to be employed in resource-limited settings. The paper-based LAMP assay evinces superior specificity as it effectively prevents the formation of spurious products during amplification. The assay was found to be highly specific for the quiescent stage of *C. gloeosporioides* with an analytical sensitivity of 0.5 pg of total extracted RNA. The developed assay generated the results within 40 min and hence can be efficiently employed for identifying *C. gloeosporioides* presence and pathogenicity states in resource-limited settings. The unique ability of the proposed system to detect and recognize the fungus during the quiescent (latent) stage will decrease food losses by allowing improved postharvest management. For example, fruit with a high inoculum rate will be sold to the local market or as processed food, whereas fruit with low inoculum rates can be stored for long periods or exported.

Postharvest food losses, fungal infections, LAMP assay, C. gloeosporioides detection

Sequencing and comparative genomics of *Athelia bombacina*

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This is the first report of the genome-scale assembly and annotation of *Athelia bombacina*. It is a new and important pathogenic fungus on fruits during storage. This study aimed to develop genomic resources for *A. bombacina* and to thus provide both high quality data in this study. The genome is 29.00 Mb in size, with an N 5 0 scaffold size of 2,943,476 bp and an N 5 0 scaffold size of 1,878,669 bp, and 4,879 genes were successfully annotated by KOG . By comparison with databases, *A. bombacina* ABD-3 strain was successfully annotated with 2,807 proteins by GO. Most of the annotated molecular functional proteins were catalytic activity, the most of the cell components were cell membranes, and the most of the biological processes were metabolic processes and cellular processes. The number of proteins successfully annotated by KEGG database was 3,116, and they participated in 108 metabolic pathways. Among the 8,974 proteins successfully annotated with the NR database, and the *Moniliophthora roreri* genome had the highest correlation. A total of 501 proteins were successfully annotated with the CAZyme database. The GHs protein family had the highest proportion of genes, which was 45.91%. Among them, four gene families: GH16, GH18, GH5, and GH43, had a higher proportion of GHs. Computational genomic findings were validated in the laboratory and it was found that *A. bombacina* can produce soluble sugar, oxalic acid, laccase, neutral xylanase and polygalacturonase in fermentation broth.

Athelia bombacina, sequencing genomics, comparative genomics, secondary metabolites, pear

Molecular pathogenic mechanism and regulatory network of postharvest important fungal pathogen *Botrytis cinerea*

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Botrytis cinerea is one of the most destructive phytopathogenic fungi, causing grey mould rot to horticultural crops, particularly postharvest fruits and vegetables, leading to an annual economic loss of over $10 billion in the world. This fungal pathogen has a wide range of hosts, strong adaptability and difficult control. Due to its substantial economic impact and scientific importance, *B. cinerea* ranks second among the top ten plant fungal pathogens worldwide. Based on more than 15 years of systematic research, we established a library of *B. cinerea* mutants, obtained more than 5300 transformers, and identified more than 20 key pathogenic genes involved in different biological processes, such as ROS production/transmembrane transport, secreted proteins, light signal transduction and DNA methylation, as well as methyl jasmonate synthesis and capsaicin synthesis. These findings revealed the molecular pathogenic mechanism and regulatory network of *B. cinerea* and provided new evidence for in-depth understanding of the complex infection mechanism of the fungal pathogen. Moreover, these molecular targets are beneficial for the development of precise control technology to grey mould disease in fruit and vegetable crops.

Postharvest disease, Botrytis cinerea, regulatory network, molecular mechanism, interaction

New discoveries on emerging postharvest diseases of apples in Northern Italy

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Postharvest apple diseases are mainly caused by fungal pathogens entering fruits through wounds during harvesting, handling, storage, transport, and marketing. *Penicillium* spp. *Botrytis* spp. *Rhizopus* spp. and *Mucor* spp. are common wound pathogens. Other pathogens are characterized by latent infections in field and symptom development during the postharvest phase. Latent pathogens are increasingly relevant on Italian apples during postharvest. *Neofabraea alba* and *N. kienholzii* cause bull's eye rot, infecting late-harvested varieties as Cripps Pink via lenticels. Propagules of *N. alba* are found in rainwater collected from apple orchards. Another pathogen infecting the lenticels is *Ramularia mali*, agent of dry lenticel rot, common on Golden Delicious and Ambrosia apples. White haze, reducing fruit quality, is attributed to various basidiomycetous genera, with *Entyloma*, *Golubevia*, and *Tilletiopsis* species being common in Northern Italy. New species like *E. mali* sp. nov. and *G. mali* sp. nov. have been identified. Fruit microbiome analysis showed that the agents of white haze are only epiphytic and they occur on the fruit skin just before harvest. On the contrary, *Ramularia mali* first appears as an endophyte at least 3 months before harvesting, but it becomes epiphytic starting from September and during storage. Changes in microbiota assembly and composition over time are crucial for understanding postharvest pathogen epidemiology. A SYBR Green qPCR assay detects and quantifies *R. mali* in apples, revealing its presence on asymptomatic fruits. *Ramularia mali* was found early in the season in the aerial microbiome analysed from spore traps placed in apple orchards. Other latent pathogens are emerging on apples in Italy, as *Colletotrichum* spp. agents of bitter rot, and *Alternaria* spp. agents of black rot. Fruit and aerial metabarcoding are valuable tools for the assessment and prediction of postharvest diseases, and to design targeted crop protection strategies.

Latent pathogens; Colletotrichum spp.; fruit microbiome; metabarcoding; Neofabraea spp.; Ramularia mali; spore trap; white haze

Benzothiadiazole-mediated disease resistance and fruit ripening of harvested banana and the possible mechanism

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Benzothiadiazole (BTH) works as a plant activator. The effects of different BTH treatments and fungicides SPORGON on fruit ripening and disease incidence and the possible mechanism of action were investigated. The results showed that BTH treatment significantly delayed banana (*Musa* spp.) fruit ripening, maintained fruit quality, and dramatically reduced the incidence of disease. BTH effectively inhibited the invasion and development of pathogenic bacteria and controlled the occurrence of disease, via enhancing the activities of defence-related enzymes, increasing the content of hydrogen peroxide and total antioxidant capacity. Cellular structure analysis after inoculation confirmed that BTH treatment effectively maintained the cell structural integrity. SPORGON did not provide benefits for delaying fruit ripening or for the resistance system, while it can control the disease only during the earlier stage and not at later stages. Transcriptome analysis identified 10,430 differentially expressed genes (DEGs) during the ripening process compared with freshly harvested fruit. Many DEGs were identified between the BTH and control group or prochloraz treatment, but only a few DEGs were found in the prochloraz treatment compared to the control group. A Kyoto Encyclopaedia of Genes and Genomes (KEGG) analysis showed that the DEGs induced by the BTH treatment were primarily enriched in the synthesis of terpenoid quinones, plant-pathogen interaction, plant hormone signal transduction, phenylpropanoid biosynthesis, phenylalanine metabolism, peroxisome, and fatty acid biosynthesis among other pathways. BTH also induced the expression of many transcription factor (TF) families, including those in the WRKY, NAC, MYB and bHLH families, with the WRKY family being the most enriched. The WRKY TF interacts with many ripening- and secondary metabolism-related genes to regulate fruit ripening and disease resistance. Our results showed that, compared with the fungicide prochloraz, BTH alters the transcripts of the genes related to hormone signalling, secondary metabolism and resistance in the banana peel, and key TFs, thereby delaying fruit ripening, enhancing fruit resistance, and maintaining fruit quality.

Benzothiadiazole, banana, fruit ripening, disease resistance, transcript level, WRKY

Postharvest disease control – the fourth dimension and the pathobiome paradigm

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Harvested commodities are prone to a wide range of diseases originating from various types of infections occurring pre- and postharvest. Understanding all factors involved in the pathosystem is the key to developing successful management strategies. In this regard, the commodity should be viewed as a dynamic system in which complex interactions exist between resident microbial communities and their host. Advanced tools and technologies currently available have dramatically enhanced our understanding of the association of plants with their microbiome and mechanisms of disease development. Looking at the disease as a process in this context has changed our perception of the single pathogen-single disease concept. Ample evidence shows that non-pathogenic microorganisms cooperate with pathogens to enable infection and enhance the severity of the disease. Unravelling the fundamental ecological processes involved in the disease process is crucial. In our recent work, we show that the postharvest disease development is likely to be complex and may involve, besides the pathogen, other components of the microbiome. In this relation, the "pathobiome" concept is introduced and discussed. Additionally, the mechanisms underlying the assembly, dynamics, and functional profiling of fruit microbiome in the context of disease development and its management using biological strategies are also presented. Considering the dynamics and plasticity of the microbiome of harvested commodities in response to pre- and postharvest treatments and practices, the approach of using a single antagonist for biocontrol should be re-examined.

Postharvest pathogens, fruit microbiome

From field to fork- do postharvest procedures ensure food safety?

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In recent years, consumer demand for fresh food has increased significantly. Fresh fruits and vegetables include important nutrients, vitamins, minerals, dietary fibres, and other compounds that have been linked to improved human health. Fresh produce undergoes minimal processing from field to fork and is generally consumed in raw form. Along with their increased consumption, there is a surge in foodborne infections linked to human foodborne pathogens such as Listeria and Salmonella. According to the CDC, fresh produce accounts for more than 10% of all reported food poisoning outbreaks and illnesses. Today, postharvest treatments are available to minimize microbial load and the prevalence of foodborne pathogens on fresh produce. In most cases, the success of such treatments is assessed by the minimal inhibitory concentration for culturable bacteria in laboratory settings. The current study aims to investigate how postharvest procedures (disinfection and storage conditions) affect the survival of two prominent foodborne pathogens, Listeria and Salmonella. We combine traditional microbiology methods for estimating foodborne bacteria viability with advanced molecular and metabolic methods that allow us to distinguish between culturable and non-culturable bacteria in vitro and on fresh produce. Our data indicate that diverse disinfection treatments, such as peracetic acid and chlorine-based compounds, induce a viable but non-culturable (VBNC) state, which maintains bacteria vitality but inhibits their identification in common pathogen detection assays that rely on their ability to grow in lab conditions. Furthermore, we observed that low storage temperatures promote the transition to the VBNC condition. Overall, our findings provide new insight into the safety of postharvest fresh produce and highlight the need to develop novel, effective postharvest methods to ensure safer food while maintaining quality.

Food safety, postharvest procedures, foodborne pathogens, disinfections, storage conditions, VBNC

NZ horticultural food safety responses to Cyclone Gabrielle flood event Feb 2023

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In February 2023, Tropical Cyclone Gabrielle devastated some important horticultural areas of New Zealand. The Cyclone and subsequent flooding caused significant damage to agricultural/horticultural land and infrastructure. The cyclone had a US$0.5 billion impact on the horticulture industry, comprising crop losses, replanting costs and infrastructure replacement. The timing was particularly challenging, occurring during or near to fruit harvest. Food safety questions of immediate concern included: identifying and segregating submerged and contaminated product, how to determine the safety of any salvageable produce, and how to harvest, transport produce and mitigate food safety risks. Challenges included: the wide-spread scale of the destruction, inaccessibility of sites, workforce disruption, lack of knowledge about potential risks, relative absence of local or international guidance, and lack of on-site capacity for laboratory-testing. The flood response included food safety guidelines issued within 24 hours and detailed recommendations in seven days, with Zoom meetings for discussion. Regulators, researchers and industry stakeholders met to develop research plans. Emergency funding by government and donations of time and resources by stakeholders (researchers / industry) eventually enabled on the ground assessments to commence, but a lack of capability and the challenging conditions meant that it took 33 days before well-structured food safety testing programs commenced. Fruit that was submerged or contaminated was destroyed and not harvested or consumed. Interestingly, testing indicated that risks from agrichemicals (pesticides, fertiliser) or micro-organisms (from silt, manure, dead animals) had not significantly increased, possibly due to dilution effects and the contaminants being reduced post flood overtime by sunlight and rain. Additional research was carried out to determine impact of postharvest washing systems on microbial levels including optimising sanitiser treatments (concentration and time). We suggest that there is a need to pre-emptively develop event response sampling strategies, including providing "kits" in key sites to facilitate immediate sampling.

Apple, kiwifruit, emergency response

Patulin risk in apple within a month after harvesting

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Negative publicity when the mycotoxin patulin, which is highly toxic for humans, is found in apple juice indicates the need for pre-emptive investigations on risk factors. A major causal agent of patulin is *Penicillium expansum*. In Norway freshly made apple juice is popular among consumers, and a high price is obtained both for juice and cider fruit. Juice fruit are either picked directly into separate boxes or sorted out at grading. The majority of the fruit in Norway is graded within four to six weeks of harvest due to a combination of tradition, higher tax on imported fruit during the main sale season, a short growing season, and choice of cultivars grown. The combination of short storage and a relatively cold growing season should indicate a rather low risk of rot caused by *P. expansum*. However, incidence was observed over years in commercial fruit and in storage experiments with fruit from commercial or experimental orchards. Inoculation experiments were performed to estimate how quickly the pathogen produces patulin in amounts causing risk over acceptable limits in juice. It was clear that the risk of patulin in apple juice increased with time in cold storage. Three days in room temperature doubled the amount of patulin in the juice. Risk reduction treatments for growers, packinghouses, and juice producers are discussed.

Mycotoxin, risk factors, pre and postharvest treatments

Physical degradation of onion quality after storage identified using X-ray CT

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Sub-optimal storage conditions riskily degrade the quality of onion, even in a short-term period. Quality degradation of onion during storage is typically known from the physical appearance, but other physical defects also occur inside the onion that is visually undetectable. The internal defects may lead to uncountable losses of the onion. This research aims to identify and quantify the quality degradation of onion over different storage conditions non-destructively using X-ray computed tomography (CT). To this end, onion was stored in 5, 20, and 35°C temperatures, with two relative humidity levels of 76 and 96%. Initial and final conditions of the onion were imaged using X-ray CT at a macro scale to see the internal and external structural changes. The physical parameters such as porosity and moisture content were spatially mapped in an intact onion. Also, the weight loss and transpiration rates were periodically monitored to be linked to the physical degradation occurring throughout the storage. The results showed that temperature and relative humidity strongly determine the external and internal physical changes of onion. As expected, the highest increase in weight loss occurred under the condition of 35°C and 76% RH.

Postharvest, food loss, transpiration, shelf-life, storability

Non-destructive measurement of mechanical properties during browning development in the compressed area of apples and nectarines

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Fresh fruit are subjected to high forces during picking, transportation and storage. These forces might cause browning of the compressed tissue, making the fruit less attractive to the consumer. Browning of the compressed flesh is observed as the bursting of cells releases the phenolic compounds which oxidate through the action of the polyphenol oxidase enzyme (PPO). The oxidated phenolics then react with other compounds creating melanin. The oxidation of phenolics is not immediate and will depend on the PPO activity and ascorbic acid content which is an inhibitor of oxidation. Depending on the oxidation process, browning can be observed a few minutes or a few days post-compression. Browning is often studied as the change in colour observed through the skin as well as a change in near-infrared absorption or thermal diffusivity. However, the heavy melanin molecules provide mechanical strength to the compressed area changing its mechanical properties. In this work, mechanical changes due to browning development in 'Pink Lady' apples and 'Mayglo' nectarines were measured, immediately after the induction of water soaking due to cell bursting and after the bruise development. A non-destructive method based on mechanical wave propagation was used. The mechanical waves are affected by the mechanical properties of the medium they travel through allowing the medium assessment. A piezoelectric transducer was used to excite monochromatic mechanical waves and their propagation was monitored using Laser Doppler Vibrometer to estimate mechanical strength in the form of shear storage and loss moduli. We expect a decrease in the stiffness in the compressed area soon after the compression and then an increase in stiffness after the bruise development, which will be discussed.

Bruising, surface waves, velocity dispersion, shear modulus, laser doppler vibrometer, Mayglo, pink lady, postharvest

Fruit firmness by impact response analysis; theory, practice, new device and a curious observation

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The theory and practice of impact response analysis (IRA) for fruit firmness measurement is outlined, highlighting capabilities and limitations for application in the postharvest supply chain space. A new hand-held device is presented, the Soft Fruit Tester (SFT), with its long development history curated in terms of successes and failures. Experimental studies are reported that demonstrate SFT application across a wide variety of fruits undergoing post-harvest softening, indicating its potential usefulness across different supply chains. The essential non-destructive nature of the device was also comprehensively confirmed. Large experimental studies on kiwifruit are reported involving comparisons against both industry standard penetrometer and manual 'hand-feel' assessments. A curious feature of the kiwifruit studies is the observation of high linear correlation against penetrometer firmness at any time point during post-harvest softening but overall, across all time points, a strong curvilinear relationship. A plausible explanation for the curious observation is given in terms of the physical softening processes occurring in the fruit at different times.

Fruit, firmness, softness, non-destructive, impact response

A non-contact acoustic resonance method for fruit firmness measurement

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The method of acoustic resonance for fruit firmness assessment is outlined, both in theory and historical practice, with a new method described that involves no mechanical contact with the fruit and is fast enough for high-speed fruit grading applications. The new method impacts the fruit with a vortex of pressurised air, sufficiently short and sharp to initiate resonant acoustic wave generation in the fruit. The optical schlieren technique is used, with high-speed camera footage, to characterise the vortex. Fruit surface movement due to the resonant wave is measured using a laser doppler vibrometer. Fourier and wavelet analysis are examined as alternative algorithmic methods for extracting key resonant features. The method has been developed into a proof-of-concept device for high-speed fruit grading. Experimental trials on apples and kiwifruit are detailed, with comparisons with standard penetrometer and compression measurement methods. Conclusions are reached as to its potential effectiveness in grading different fruit types.

Fruit, firmness, acoustic resonance, non-destructive, grading

Phenylalanine: Improve fruit quality and resistance against biotic and abiotic stress

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Phenylalanine is an aromatic amino acid that initiates the biosynthesis of the phenylpropanoid metabolic pathway. Both preharvest and postharvest application of phenylalanine to several fruits have shown efficacy in reducing decay caused by pathogens such as *Colletotrichum gloeosporioides*, *Alternaria alternata*, *Lasiodiplodia theobromae*, or *Penicillium digitatum*. This reduction is achieved by stimulating the metabolism of phenylpropanoids and the synthesis of antioxidant and antifungal flavonoids. Additionally, phenylalanine application induces the expression of genes associated with fruit defence mechanisms. The activation of the phenylpropanoid pathway and the overall defence response in fruits also enhances their tolerance to storage at suboptimal temperatures. Notably, a preharvest spray of phenylalanine, when combined with wounding, accelerates the curing of potato tubers by promoting phenylpropanoid metabolism up to lignin synthesis. Similarly, combining preharvest phenylalanine application with sunlight exposure in mango and apple trees leads to the production of anthocyanins, resulting in the induction of red-coloured fruit and increased resistance to pathogens. Fruits treated with phenylalanine are preferred by tasting panels due to their enhanced aroma and sweeter taste. Furthermore, the antioxidant properties of flavonoids in these fruits contribute to slower oxidation of fresh-cut produce. Employing an active edible coating of polysaccharides like chitosan or carboxymethyl-cellulose supplemented with phenylalanine has an additional positive effect on fruit quality improvement and protection against postharvest pathogens and chilling injury in avocado fruits. Hence, application of the amino acid phenylalanine induces a general defence response, thereby enhancing resistance to fungal pathogens and chilling stress. Furthermore, in combination with wounding, the phenylpropanoid pathway directs its flow towards lignin biosynthesis, facilitating tissue curing. Similarly, when combined with sunlight radiation, the pathway channels towards anthocyanin biosynthesis, resulting in the development of red colour peel. Overall, whether applied before or after harvest, phenylalanine amino acid enhances fruit quality, boosts resistance to both biotic and abiotic stresses, and improves the storability of produce.

Induced resistance, phenylalanine, phenylpropanoid pathway, flavonoids, Anthocyanins, chilling, curing, flavour, coating, postharvest decay

Impact of oxygen micro-nano bubble water on the quality and safety of 'Fan Retief' guava (*Psidium guajava* L.)

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Micro-nano bubble (MNB) water has emerged as an innovative technique with improved oxidative reactivity of aqueous-phase gases, which enhances the antimicrobial efficacy. Thus, this study explored the impact of oxygen enriched MNB (O_2 -MNB) on changes in colour parameters (hue angle and chroma), physiological properties (weight loss, respiration rate), biochemicals, visual appearance and microbial load of guava fruit packaged in clamshells stored at 13°C for 21 days. Commercial packhouse treatment (sodium hypochlorite, NaOCl) and untreated samples were used as controls. It was found that a 15-minute exposure to O_2 -MNB effectively preserved the colour of guava fruit and resulted in higher hue angle ($P > 0.001$), chroma ($P = 0.003$) and overall good appearance ($P > 0.001$). In contrast, untreated control and NaOCl samples had a poor visual appearance with skin pitting and browning. Our results further revealed that O_2 -MNB washing for 15 minutes significantly delayed peak in respiration rate ($P > 0.001$), and consequently lowered TSS/TA compared with control and commercial NaOCl samples. In addition, fruit weight loss increased as storage duration progressed across all the treatments, however, O_2 -MNB effectively minimized fruit weight loss at the end of storage. Immediately after treatment O_2 -MNB resulted in 2 Log reduction in the natural microbial load on fruit surface. These results indicated that O_2 -MNB for washing can be used as an alternative method of preserving guava fruits.

Activated water systems, fruit quality, spoilage microbes, sodium hypochlorite

Postharvest methyl jasmonate application curtails decay incidence and alleviates oxidative stress by mediating reactive oxygen species and antioxidant defence system in cold stored jackfruit bulbs

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Methyl jasmonate (MeJA) plays a key role in the plant defence system. The positive effects of postharvest MeJA application in maintaining fruit quality and delaying senescence have been widely studied, however, its effect and mechanism of action in jackfruit is unknown. Therefore, the efficacy of postharvest MeJA dip application (0, 0.25, 0.5, and 1 mmol L^{-1}) in reducing decay incidence and maintaining the antioxidant potential of jackfruit bulbs under cold storage conditions over the storage period of 20 days was investigated. MeJA dip application maintained the quality of jackfruit bulbs as observed by reduced fruit weight loss and decay incidence in 0.5 mmol L^{-1} and 1 mmol L^{-1} MeJA treatments, respectively. The soluble solids content was highest in bulbs treated with 1 mmol L -1 MeJA, while 0.5 mmol L^{-1} MeJA treated bulbs exhibited the highest titratable acidity as compared to the control. Following the 20 days cold storage period, 1 mmol L^{-1} MeJA treated bulbs maintained higher levels of carotenoids (17.31%), ascorbic acid (28.57%), total phenolics (18.12%), and flavonoids (22.32%) as compared to the control. Similarly, the bulbs dipped in 1 mmol L^{-1} MeJA showed higher activities of catalase, ascorbate peroxidase, superoxide dismutase, monodehydroascorbate reductase, dehydroascorbate reductase, and glutathione reductase as compared to other treatments. In addition, 0.5 mmol L^{-1} MeJA dip application considerably suppressed lipoxygenase activity, hydrogen peroxide radicals, and malondialdehyde content compared to other treatments. In conclusion, 0.5 and 1.0 mmol L^{-1} MeJA dip application is effective in controlling postharvest decay, maintaining antioxidant potential, and consequently mitigating oxidative stress in jackfruit bulbs.

Jackfruit, methyl jasmonate, antioxidant potential, fruit decay, oxidative stress

Glucose treatment extends the vase life of gerbera cut flowers by improved water uptake

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Gerbera (Gerbera x hybrida), one of the most popular cut flowers known for its wide range of flower colours and large composite flower head (*pseudanthium*), belongs to the Asteraceae family. A cut flower has a flower head and a stem (scape) without leaves. Many studies on gerbera cut flowers focus on stem bending, however other factors are still unclear. Gerbera 'Orange Cake' cut flowers were treated with 80 g L^{-1} (234 mM) sucrose or 42 g L^{-1} (234 mM) glucose solutions with 0.5 mL L^{-1} Kathon CG and 50 mg L^{-1} aluminium sulfate. The vase life of gerbera cut flowers with 5 cm of scape was 13 days without sugars, 18 days by sucrose treatment and 20 days by glucose treatment, respectively. Similarly to other cut flowers, glucose treatment significantly extends the vase life more than sucrose treatment. The water uptake of gerbera cut flowers with 20-55 cm scape was measured and related to the scape length. On the first day after treatment (DAT), only the scape length affects the water uptake. From 2 DAT, treatments affect the water uptake; higher water uptake was observed with glucose treatment. From 6 DAT, the interaction between the scape length and treatment was observed. Longer scape treated with glucose kept higher water uptake. The longest vase life was observed with a 55 cm scape and glucose treatment. The vase life of gerbera cut flowers is related to its water uptake.

Gerbera x hybrida, longevity, stem length, sucrose

Exploiting large-scale packinghouse data in combination with postharvest trials in order to develop a better logistic management system for ‘Orri’ mandarins

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'Orri' mandarin is the main citrus variety grown in Israel, and in 2023, it accounted for 64% of all citrus exports. After harvest and packaging, the fruit can be directed to the local market (1-2 weeks storage), exported to Europe (3-4 weeks storage) or to farther destinations, such as to North America or East Asia (6-8 weeks storage). In preliminary studies, we encountered major variabilities in postharvest storage performances among batches of 'Orri' mandarins from different orchards and harvest times. In the current study, we collaborated with Mehadrin Tnuport Export L.P. (MTEX), the largest citrus grower and Export Company in Israel, in order to evaluate whether we may utilize large-scale pre-harvest and commercial packinghouse data provided by the exporting company in order to predict the postharvest storage performance of different sets of 'Orri' mandarins. For that purpose, we collected during 3 years (2022-2024), from the MTEX packinghouse nearly 100 sets of 'Orri' mandarins per year, and examined their quality after 2, 4 and 8 weeks storage at 4°C and an additional week at shelf life at 22°C. The pre-harvest data consisted of tree age, yield, soil type, amounts of rain, harvest time, and other complementary data. The packinghouse data consisted ripening parameters (TSS, acidity), packing line checks (harvest, nature and pest damage, decay, and colour, shape and size abnormalities), and quality categories packaging rates. Consolidating these large-scale data using machine learning algorithms, revealed that the observed pre-harvest data and the packing line data allowed the prediction of fruit quality by an R^2 of 0.74 and RMSE of 0.5 on a quality scale of 1 (very bad) till 5 (excellent). Overall, the development of fruit quality prediction models based on commercial packinghouse data should assist in conducting better marketing decisions based on quality predictions, thus assuring quality and reducing losses.

Logistic management, mandarin, postharvest, quality prediction models

Simulating supply chain handling scenarios to determine suitability of ‘R2E2’ mango fruit for seafreight

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Australian mango exporters are exploring options to move away from a reliance on airfreight to lower cost sea freight. However, recent supply chain disruption has resulted in increased pack shed consolidation times and sea freight duration that reduced fruit shelf life for consumers. The present study simulated variations in 'R2E2' mango fruit consolidation time and sea freight duration at 12-13ºC under a controlled atmosphere that mimicked monitored sea shipments. The research was conducted with early- and late-season mangoes over two years. Impacts on fruit quality such as skin colour, firmness, weight loss, skin defects and marketable shelf life was assessed at different stages during the simulation. The results from year 1 showed that average shelf life for early-season fruit was generally about 2 days greater than late-season fruit, even though they were picked only 14 days earlier from the same farm block. In year 2, under the best scenario of 0 day consolidation plus 15 days sea freight, early-season fruit exhibited a shelf life of 8.4 days while it was 4.4 days for late-season fruit. When shipment duration was increased from 15 to 20 days, early-season fruit lost 1-2 days of shelf life. A similar trend was observed with late-season fruit. When consolidation time was increased from 0 to 2, 4 and 6 days, early-season fruit lost 1.5, 2.5, 3 and 4.8 days of shelf life, respectively. Fruit that were consolidated for 4 and 6 days did not have sufficient shelf life for consumers. Consolidation time did not significantly influence shelf life for late-season fruit. Taken collectively, it is recommended that 'R2E2' mango export consignments should not be consolidated at the pack shed for more than 2 to 4 days to maximise residual shelf life. Only early-season fruit of lower dry matter content should be sea freighted as they ripen slower and have a longer inherent shelf life.

Mango, shelf life, export, simulation, sea freight

Postharvest interventions to facilitate sea freight of melons from Australia to export markets

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Sea freight is the cost-effective and sustainable method for exporting fruits from Australia to markets in Asia and New Zealand. However, the susceptibility of melons to chilling injury and their short postharvest life pose challenges for refrigerated sea freight, which typically takes 2-3 weeks to reach nearby export markets. The bulkiness of melons and the associated transportation costs make airfreight commercially unviable for the industry. To address these issues and enable the industry to export melons, we examined the integration of modified atmosphere and humidity packaging (MAP) into postharvest handling and shipping protocols for rock melons (cantaloupes) and mini watermelons. These protocols encompassed postharvest cooling, washing, sanitisation, fungicide treatment and packaging in different types of commercial plastic liners, followed by storage for 2 to 4 weeks at temperatures of 5 or 10°C. These trials, conducted at a semi-commercial scale, aimed to simulate export supply chain conditions, and were evaluated based on parameters such as in-package gas composition and humidity, weight loss, decay, fruit quality and microbial safety. It was observed that different types of MAP liners showed a wide range of O_2 (7.6 -15.1%) and CO_2 (5.8 - 16.0%) concentrations in the package headspace after 2 weeks of cold storage. High levels of CO_2 (> 10%) were associated with the development of cavities in the flesh and slight off-odours in both types of melons. The data indicated that, amongst other factors, fungicide treatment is crucial for achieving extended storage and shelf-life of both rock melons and mini watermelons under simulated conditions for up to 3 weeks. The suppression of stem-end mould growth was also observed in high CO_2 MA bags during the first two weeks of cold storage. In conclusion, implementing the proposed postharvest protocols, including MAP packaging with suitable liners, can enable the export of rock melons and mini watermelons to target export markets via sea freight.

Cantaloupes, watermelons, fruit quality, modified atmosphere packaging

Examination of dendrometers to determine apple lenticel susceptibility to bull's eye rot in the orchard

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Apple bull's eye rot, caused by the fungus *Phlyctema vagabunda* syn. *Neofabraea alba*, expresses during long-term fruit cool storage. Infections take place in the orchard through lenticels. Previously, it was shown that fruit susceptibility is moderated by hydration, and that hydration is affected by windrun and rainfall. Rather than rely on secondary weather data, our hypothesis is that tools such as dendrometers could be used to directly measure fruit hydration, and thus lenticel susceptibility to infection by *P. vagabunda*. To understand the interactions between dendrometers and lenticel susceptibility to infection by *P. vagabunda*, wind speed, relative humidity, rainfall and temperature were monitored on two orchard blocks on the Hawke's Bay Research Centre of Plant and Food Research. Anemometers were placed at three heights above the ground, within the canopy (1 m above ground level), at canopy height (2 m) and above the canopy (4 m). Dendrometers were placed on fruit and shoots, and lenticels on the North, South, East and West sides of apple fruit a few weeks before harvest were photographed and measured at two or three different times during the day. Results of these analyses will be presented and discussed.

apple, Malus domestica, Phlyctema vagabunda

Major and emerging postharvest diseases impacting berry crops in Canada

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Blueberry, red raspberry, and strawberry are major berry crops in Canada. Highbush blueberry and red raspberry are mainly cultivated in coastal region of British Columbia (BC), whereas strawberry are cultivated in several provinces including BC, Ontario, Quebec and eastern Canada. Botrytis fruit rot (BFR) caused by *Botrytis cinerea* is the most common disease of raspberry, blueberry, and strawberry occurred at harvest postharvest stages. BFR is more damaging in red raspberry than in the highbush blueberry in the coastal region of BC. Anthracnose fruit rot (AFR) caused by *Colletotrichum* spp. is also a major disease of strawberry and more problematic in eastern Canada than in BC. We will discuss on major impact of these fruit rot diseases on three berry crops in Canada and efforts to mitigate these fruit diseases. We will also present the epidemiology of BFR of red raspberry and highbush blueberry during 2020 to 2022. The variability among cultivars of red raspberry and highbush blueberry on BFR incidence in multiple years will be discussed. Finally, we will present the update on emerging foliar and fruit disease of strawberry caused by *Neopestalotiopsis* in Canada.

highbush blueberry, postharvest diseases, Botrytis, Colletotrichum

Anticipating an incursion by the grape pathogen, *Guignardia bidwellii*

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The fungus *Guignardia bidwellii* (black rot) causes a pre- and postharvest disease of grapes (*Vitis vinifera*). When infected berries are inadvertently mixed with healthy berries, the resultant wine develops unpleasant off-flavours. Black rot is native to North America, and from there has spread to Europe, Central and South America, Asia, Africa and Australasia (New South Wales and Christmas Island). Black rot has probably been spread around the world in grape cuttings and rootstocks, but can also contaminate micropropagated plants and fresh grape berries. Alternate hosts produced as *nursery plants could also provide entry points, such as Asplenium nidus (bird's nest fern) and Pathenocissus tricuspidate* (Boston ivy). An integrated biosecurity risk assessment model (IBRAM) has been developed to evaluate the risk of establishment and dispersal of invasive species along trade pathways. This model has previously been used for insect pests, and has now been adapted to model risk for plant pathogens (IBRAM-path). An example of how IBRAM-path can be used for evaluating the risk of incursion of a postharvest pathogen, *G. bidwellii*, through different pathways into Aotearoa New Zealand, will be presented and discussed.

Vitis vinifera, pathways, biosecurity, incursion, risk, model, Bayesian networks

Postharvest decay and spoilage of tomato from small scale farmers at harvest and storage

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Tomato is the second most important vegetable crop in South Africa, contributing over 24% of the gross vegetable production. Despite the importance of tomato, reports demonstrate that farmers lose approximately 76% of the crop after harvest. This study therefore aimed to evaluate postharvest decay and spoilage losses of tomatoes in small-scale production in Gauteng Province. To achieve this, six kilograms of tomato boxes were collected in triplicates from eight farms across three regions in Gauteng Province. A total of 216 kg of tomato (36 boxes) were collected during the 2022/2023 growing season for loss identification and quantification at harvest (day 1) and storage (day 7 and 14). In addition, the tomatoes were analysed for changes in quality parameters (firmness, pH, weight and TSS). The overall results show that firmness is negatively corelated to pH and TSS during storage. The analysis indicated that losses due to spoilage and decay contributed 11% of the average postharvest losses on day one. Decay losses were significantly higher after storage (day 7 and 14) ($p = 0.000$) with an average of 40%. The fungi associated with postharvest decay were identified as *Fusarium* spp. *Alternaria* spp. and *Colletotrichum* spp. In addition, bacteria such as *Bacillus* spp. *Enterobacter* spp. *Pseudomonas* spp. *Serratia* spp. *Pantoea agglomerans* and *Erwinia percicina*, were also associated with spoilage of tomatoes in storage. Contamination of the fruit can occur pre-harvest and/or through improper handling at postharvest. The study therefore recommends farmers training on good production practices to prevent contamination of tomato with potential plant and human pathogens thereby improving the shelf life and food safety in storage.

Postharvest loss, decay and spoilage pathogens, postharvest storage, food security

An overview of the influential developments and stakeholders within the food composition program of the Pacific Islands: Current and future directions

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There are over 11 million people living in small islands scattered across the vast ocean of the Pacific Island Region. The region consists of three island groups: Micronesia, the Melanesia and the Polynesia. The region has a notable increase in population moving from rural to urban areas in the Pacific Islands. Over time such rural to urban drift has led to wide ranging dietary changes from the more traditional or indigenous root crop-based cuisines to a higher reliance on imported food. It is also noteworthy that across most of the Pacific Islands, incidence non-communicable disease is also on the rise and the region has among the highest per capital of diabetes in the world. One of the reasons for high NCDs may be a result of individuals' not consuming sufficiently diverse or nutritious food. Hence it is important that Pacific Island Communities and Stakeholders understand the nutritional value of food consumed by Pacific Islanders. This requires an understanding of the composition of food consumed. Food composition initiatives in the Pacific Islands began in the late 1940s and early 1950s by the South Pacific Commission (now Pacific Community) with a focus on commonly consumed Pacific Island Foods. In the 1970s much of the food composition work focused on the issues relating to the rise of non-communicable diseases e.g. diabetes and heart diseases. Subsequent work by the SPC focused on reviewing data on the nutrient composition of Pacific foods and to make recommendations concerning the need for additional food composition data in the region. One of the key initiatives in the development of food composition tables for the Pacific Islands was setting up of a working group which comprised of key stakeholders in the Pacific Islands, including SPC and the University of the South Pacific among others. Some of the gaps and limitations towards the development and printing of the Pacific Islands Food Composition Tables were identified. A strong collaborative effort between the SPC nutrition programme and the New Zealand Institute for Crop and Food Research during 1993 - 94 resulted in the publication of the first edition of the tables. However, there were still important gaps in the data. Funding for the second edition, including the necessary analytical work, laboratory accreditation and publication, was provided by the Food and Agriculture Organization of the United Nations (FAO). The work was undertaken primarily at the Institute of Applied Sciences at the University of the South Pacific and the second edition was published in 2004. In 2019, the FAO together with the Institute of Applied Sciences of the University of the South Pacific and other stakeholders in the Pacific Island Region initiated the "Feasibility study to update the Pacific Islands Food Composition tables" to its third edition. In 2023, the Periodic Table of the Food Initiative (PTFI) set up a Centre of Excellence at the University of the South Pacific to support food composition data analysis in Oceania. An overview of influential developments and stakeholders within the food composition program of the Pacific Islands as the current and future direction are presented in this talk.

Diets, nutrients, health, non-communicable diseases, data

The power of Pacific cuisine

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Pacific Island Food Revolution is a transformative initiative dedicated to revitalizing and preserving the rich culinary traditions of the South Pacific. The project seeks to celebrate the diverse food cultures of the Pacific Islands, which include Fiji, Samoa, Vanuatu, the Kingdom of Tonga, and Papua New Guinea. At its core, the initiative addresses the dual challenge of maintaining traditional food practices in the face of modernization, climate change and to improving public health through diet. It's anchor product is an MKR style cooking competition series that has run for 3 seasons, designed to educate both local populations and international audiences about the nutritional benefits and cultural significance of Pacific Island cuisine and an associated social media and radio campaign. There are local spin offs including a Pacific Kids Revolution with UNICEF and Sanma Food Revolution, a grass roots community cooking food show created by 2 of the cook teams from season 2. Pacific Island Food Revolution is now partnering with the Periodic Table Food Initiative (USA), a food and nutrition science organization to add a quantifiable nutrition science underpinning to our work, and the University of the South Pacific to create student led food revolution. We will partner with Professor Steven Ratuva and the climate team at the University of Canterbury to add a climate lens to our messaging. Simply put, local food is both health positive, climate positive and biodiversity positive. In its next phase, Pacific Island Food Revolution, as well as continuing our media, will work within education and tourism to develop local cuisine curricula for hospitality students in an effort to localize the Pacific tourism and thus reduce food imports and provide a richer food experience for visitors. We believe the true emergent change is SOCIAL. It happens with people. Policy and strategies provide a framework, but real change happens in people. Through its comprehensive approach, the initiative not only honours the past but also shapes a healthier and more sustainable future for Pacific Island people. Our aim is to create a population level fleet of local food warriors who can cook take health and climate actions in their kitchens. The revolution begins at home.

Food, health, sustainable diets, nutrition, dietary change

Artificial intelligence as a tool for optimization of postharvest protocols

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Postharvest losses reach up to 25-40% of the agricultural production, causing economic and food security damages. A wide range of treatments are applied to improve the postharvest potential for better maintenance of the global food chain. The current common experimental method is to examine one by one the preservation effect of different treatments on a given agricultural product. Using artificial intelligence (AI) we suggest an innovative approach in which an ensemble of treatments is examined simultaneously, hypothesizing that a synergistic effect between the treatments will provide an enhanced preservation effect. This approach is challenging since some of the treatments can be examined at numerous activation levels providing a vast search space. As a case study, cucumbers were chosen due to their high postharvest losses and their availability all year round so that repeated experimental iterations could be examined. The optimization algorithm suggested 11 combinations per iteration comprising 2 postharvest treatments selected from a pool of 10 treatments, along their activation levels and a package selected from 3 possible types. This combinatorial search space consists of about 10^6 possible combinations. The experiment was conducted at 2 temperatures: 10°C for the simulation of refrigerated fruit, and 20°C for the simulation of marketed fruit. Fruit quality parameters were assessed at the beginning of the experiment and after 4 weeks of storage. The quality of each cucumber was scored according to the summarized change of parameters including peel colour, stiffness, weight, and visual quality. A minimal change of the different parameters represents a successful treatment indicating quality preservation. According to the results of each iteration, the algorithm produced a new set of combinations for the next iteration. After 7 experimental iterations some new protocols were found that significantly improved the quality of cucumbers at both temperatures. For example, one of the new protocols enabled cucumbers with good marketing quality after 9 weeks in cold storage, far more than the current storage ability. This innovative approach demonstrates the potential of integrating AI into the development of postharvest protocols for agricultural produce, reducing waste and improving food security.

Artificial intelligence, cucumbers, protocol

Non-destructive codling moth detection in pear fruit using X-ray imaging and deep learning

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The codling moth (*Cydia pomonella*, *Lepidoptera: Tortricidae*) is one of the most devasting internal feeding pests in pears. The insect feeding often occurs within the fruit during growth without showing obvious external symptoms, which fail to be detected by current commercial quality grading systems based on external properties of fruits. Manual inspection is subjective and unable to inspect every sample. A non-destructive, rapid and reliable inline system is needed for this quarantine organism. X-ray imaging has been proposed as a non-destructive imaging method that allows to inspect the volume of fruit. However, more futile defects are more difficult to identify, especially by conventional image processing. Deep learning utilizes its deeply nested neural network architectures to automatically learn most relevant features to fulfil tasks such as image classification, which imitates the mechanism of the human brain. The method has shown promising capability in X-ray image processing compared with traditional machine learning, which requires hand-crafted feature extraction that often proves difficult. In this contribution, we tested the performance of different deep learning algorithms using convolutional neural networks for detecting fruit moth infestations at different developmental stages. Thereto, 360 fruit were infested to obtain a control and 3 different infestation groups. X-ray imaging with an inline line scanner was performed to obtain 2D scans of each fruit from 2 angles. EfficientNet models were trained and tested to predict multiclass labels. The effects of image resolution and number of images per fruit on classification success were analysed. The detection method was also tested on a batch of naturally infested fruit. The highest classification accuracy is currently above 87% but is expected to be improved considering taking into account data augmentation, multiple view angles and/or 3D imaging using X-ray computed tomography (CT).

Internal defects, inline sorting, quarantine measures, machine learning, X-ray radiography

Melon colour analysis for smarter harvest decisions and quality evaluations

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Fruit colour is a crucial feature that undergoes complex changes throughout maturity and ripening, significantly impacting marketability and consumer acceptance. In the past, melon growers used skin colour as a maturity index to ensure uniform quality at harvest and consumer acceptance. However, modern long shelf life (LSL) cantaloupe varieties do not exhibit common colour changes through ripening, making it difficult for growers to decide when to harvest the fruit. In this research, we examined the different external colorations of LSL cantaloupe varieties during harvest and postharvest, including some newly bred varieties that aim to bring back the colour changes related to ripening. First, we overcame various challenges when conducting image-based colour analysis on melon fruits. One of these was the need to digitally eliminate the fruit netting from the images since the colour of this protective tissue is not always linked to maturity. We then evaluated the cantaloupe skin colour patterns and how they change across time and postharvest storage. We used customized Python scripts and the R package "recolourise" to extract the three main colours in the skin of each melon (n= 180-196) per variety. We then performed a k-mean cluster analysis to group the cantaloupes based on their primary colours. We selected standard melon images representing a ripening progression within our analysis to help assign the fruit to a specific maturity stage. This quantitative colour-based approach for assigning maturity has been validated in five distinct melon varieties, and we are continuing with the evaluations in additional materials. Our ultimate goal is to create a tool that can assist breeders and growers in determining cantaloupe maturity using photographs. Moreover, this colour-analysis pipeline could be applied to other fruits whose colour patterns are complex and not easily predicted.

Shelf life, marketability, postharvest, maturity, image analysis, cantaloupe

Development of a vase life prediction system for cut roses based on a cultivar-specific scoring system

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With the increase of e-commerce purchase, the longevity of cut flowers significantly influences consumer purchasing decisions, thus it necessitates establishing an accurate quality guarantee system to ensure the vase life of cut flowers. However, existing vase life guarantee methods often rely on subjective assessments, overlooking critical factors such as senescence characteristics and susceptibility of cut flowers to diseases. The vase life of cut flowers is influenced by a variety of senescence characteristics, distribution environment, and disease susceptibility, devising a single prediction model that accurately predicts the vase life of cut flowers remains challenging. In this study, we developed an artificial intelligence prediction system for the potential vase life of various rose cultivars using deep learning and hyperspectral imaging systems. To improve the accuracy of the prediction system, we analysed the contribution rates of the physiological and disease factors that affecting the longevity of cut roses. The results showed that the primary factors determining the vase life of cut roses were different according to the flower susceptibility to ethylene, water stress, *Botrytis cinerea* (Bc), and both ethylene and Bc in regardless of the cultivars. Thus, we separated the rose cultivars into eight groups based on the four susceptibility natures and two types (standard and spray) and developed a cultivar-specific scoring system (CSSS). The CSSS was able to apply different weight values of the longevity factors for the each rose cultivar during the model learning and development. The model constructed based on the CSSS showed higher performance in predicting vase life of various cut rose cultivars compared to the models based on the comprehensive scoring system which we developed previously. Our results revealed that the vase life prediction model based on CSSS is a reliable method for evaluating the vase life of cut roses.

Artificial intelligence, Botrytis cinerea, deep learning, hyperspectral camera, prediction, vase life

Food safety of fresh produce: striking a balance between compliance, sustainability and profitability

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Food safety stands at the crossroads of scientific research, regulatory standards, operational practices and economic viability. It plays a pivotal role in safeguarding the consumers, industries and market access. At its essence, scientific research drives our understanding of microbial pathogens, contamination pathways, and strategies for mitigation, laying the groundwork upon which food safety standards are developed. Regulatory frameworks, grounded in scientific evidence, establish benchmarks aimed at safeguarding public health and preserving consumer trust. Conversely, growers and packers/processors endeavour to uphold these standards while maintaining their economic viability. Challenges to adherence may arise due to various factors such as limited resources, economic constraints, or external variables like weather conditions and wildlife. This presentation aims to illuminate these challenges and showcase the success of industry's food safety initiatives towards achieving a harmonious balance between regulatory compliance, sustainability and profitability. Drawing from real-world examples in the leafy vegetable and melon sectors, we will illustrate how this balance is being achieved through initiatives like the 'Safe Leafy Veg' and 'Safe Melons' programs led by the New South Wales Department of Primary Industries and supported by industry, government and regulators in Australia. These programs are industry-led but driven by world-class science and data-based food risk management. In a nutshell, we will demonstrate the translation of scientific research into the adoption of best practice, leading to food safety outcomes desired by all supply chain participants.

Foodborne illness, best practice, whole-genome sequencing, supply chain, consumers

Kiwifruit softening: A cell wall study

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Success of a new kiwifruit cultivar requires not only good taste, but also a storage life that allows it to remain firm during storage and transport to distant markets, and the subsequent ability to soften and ripen once it reaches the consumer. During the ripening process it is changes in the cell wall composition and in the structure of the cell walls that enable fruit to soften and become edible. Within kiwifruit (*Actinidia spp.*) there are closely related genotypes that show large differences in softening rates. We compared two such cultivars with different softening rates to investigate the biochemical, structural and molecular bases of fruit softening, with a view to identifying key softening regulators. Compositional analysis of cell walls during softening showed differences in monosaccharide composition between the cultivars at the same developmental stage. This indicates that the rate of softening may not be just an effect of increased enzyme activity, but that there may be fundamental differences in the cell wall composition. Immunolocalisation studies using monoclonal antibodies showed differences in the distribution of specific epitopes, particularly in the hemicellulose domain of the cell wall. The activity of key cell wall enzymes, such as xyloglucan endotransglycosylase, also differed. Collectively this information suggests that softening rate is influenced by the modification of specific cell wall polysaccharides. This idea is supported by expression analysis of xyloglucan transglycosylase/hydrolase (XTH) genes, which suggests that genes coding for different XTH isozymes may play key roles in controlling softening rates in kiwifruit. Extending the knowledge of the cell wall components, structural properties and genes expressed during softening can be applied to identify chemical and genetic markers for breeding kiwifruit to enable early-stage selection of genotypes with a preferred softening rate.

Actinidia, cell wall, enzymes, gene expression, immunolabelling, sugar composition

New insights on the regulatory biology of the ripening block in avocado

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'Hass' avocado fruit (*Persea americana Mill.*) have the remarkable ability to hang on the tree in a physiologically mature but unripe state for over twelve months. Previous research suggests that ethylene regulation is involved, because ethylene is critical for ripening of the fruit off-tree. Those studies showed that avocados vary widely in their sensitivity to ethylene at harvest, and that ripening/softening occurs two days after climacteric ethylene production has peaked in the fruit. We hypothesized that at-harvest fruit response variability to ethylene reflects differences in the loss of their residual on-tree ripening-block strengths. By taking small tissue samples from fruit still on the tree, we directly paired ethylene sensitivity differences of individual fruit once picked back to their on-tree transcriptomes and identified gene expression associated with the on-tree ripening block. Physiologically mature fruit (based on size and dry matter content) that were insensitive to a 24-h ethylene treatment administered at harvest had on-tree transcriptome profiles usually associated with very young immature fruit. More specifically, the fruit were enriched in transcripts related to gibberellin biosynthesis and auxin signalling. The on-tree relative transcript abundances of three genes associated with these pathways were subsequently shown to predict how fruit would immediately respond to an ethylene challenge at harvest: either by producing autocatalytic ethylene production and ripening earlier, or by being insensitive to the hormone. Relatively high or low transcript abundances of these three genes in fruit could be used to predict whether the fruit will ripen earlier or later after harvest in the absence of an ethylene challenge. We conclude that avocado fruit on-tree have different strengths of ripening inhibition, which is caused by the differential retention of gibberellin and auxin-related biology that affects their ethylene sensitivity.

Avocado; ripening block; ethylene sensitivity

A new role for gibberellin A metabolism in modulating the pre-climacteric phase of avocado (*Persea americana* Mill. 'Hass') fruit postharvest

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The heterogeneity of avocado fruit (*Persea americana Mill*. 'Hass') ripening postharvest causes logistical challenges in delivering fruit with consistent quality to consumers. Despite numerous studies on the ripening-associated increase in ethylene production, the plant hormonal signals coordinating the onset of the climacteric phase are poorly understood. In this study, the accumulation patterns of seven major plant growth regulator (PGR) classes, and their associated metabolites, were monitored from individual 'Hass' fruit using biopsy samples throughout the pre-climacteric phase (PCP): at harvest, the three days thereafter when fruit develop ethylene sensitivity, and when fruit started producing ethylene, marking the end of the PCP. Through this approach, changes were revealed in metabolism and content of abscisic acid (ABA), auxin (IAA), gibberellins (GAs), salicylic acid (SA), jasmonic acid (JA) derivatives, cytokinins (CKs) and for the first time in avocadombrassinosteroids (BRs). Across fruit, increased ABA was associated with the climacteric rise in ethylene, whereas bioactive GAs, SA-biosynthesis, JA-isoleucine, BR and major cytokinins (CKs) decreased significantly. Variation in PCP-duration segregated fruit from the same harvest into 'Short'-PCP fruit, which entered the climacteric phase 5 days after harvest with a strong burst of ethylene (80.1 ±16.9 µL/kg/h) and 'Long'-PCP fruit that entered the climacteric 8 days after harvest with a lower burst of ethylene (32.8 ±7.6 µL/kg/h). Pronounced differences in PGR composition at harvest discriminated 'Short'-PCP fruit by reduced bioactive GA contents and higher amounts of the catabolite GA51, whereas 'Long'-PCP fruit contained elevated concentrations of IAA, hydroxylated ABA-catabolites, SA-glucoside and the CK dihydrozeatin riboside. The at-harvest differences were maintained through to the climacteric stage. Together these results indicate that GA-metabolism may coordinate ethylene sensitivity during the early PCP in interaction with ABA, while additional PGRs that are negatively associated with the climacteric rise in ethylene production, modulate the length of the PCP.

Avocado, plant growth regulator, metabolism, ripening, gibberellin A, ethylene, abscisic acid, brassinosteroid

The effect of storage temperature on post-harvest transcriptomic dynamics in ‘Red Aroma’ apple fruit

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With about 30% of the total volume, 'Red Aroma' is the main apple cultivar in Norway, appreciated for its mild aromatic taste and suitability for the short growing season. However, the cultivar has numerous challenges in storage and relatively quickly reaches an unacceptable fruit quality. To provide a base for postharvest improvements, transcriptomic changes in cold-stored fruit were investigated. Fruit was picked at two distinct maturities, with a three-week gap between the harvests. After harvest, the fruit were stored in regular atmosphere cold storage at either 4°C or -0.5°C. Fruit quality was analysed both at harvest and after the cold storage period of up to 13 weeks. Fruit peel samples for RNA isolation and subsequent RNA sequencing were taken at harvest and after the cold storage period. The interplay of two storage temperatures and harvest maturities resulted in diverse transcriptomic changes. Differences in gene expression and transcription factors related to ethylene biosynthesis and cell wall modifications were apparent between the two harvest maturities and storage temperatures. The link between transcriptional changes and fruit quality will be discussed.

Malus domestica var. Borkh, firmness, post-harvest physiology, harvest timing optimization, fruit ripening process, senescence

1-MCP treatment in combination with DCA storage: The potential for loss of aroma in apple

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Dynamic controlled atmosphere (DCA) storage used to subject apple fruit to the lowest O_2 levels that can be sustained, without damage to the product, to maximally inhibit the action of ethylene. Further, DCA-stored fruit are often treated with the ethylene action inhibitor 1-methylcyclopropene (1-MCP), the effects of which can persist long after storage is completed. We were concerned that there may be a substantial loss in aroma as DCA storage duration increased, especially when DCA is applied in combination with 1-MCP. A critical concern about 1-MCP is that apple flavour is compromised in treated fruit because aroma volatiles are so closely linked with ethylene response. We evaluated the recovery of aroma-related ester emanations from six different apple cultivars over a period of two years. Storage durations were approximately 4, 7, and 10 months. Following removal of fruit from DCA, the volatile profile and fruit quality traits were measured for up to 5 weeks while being held at room temperature. Generally, aroma formation was severely compromised immediately after DCA storage with and without 1-MCP treatment. Recovery of aroma formation took several weeks at room temperature. While individual cultivars differed in their responses somewhat, typically the rapidity and extent of recovery diminished as the duration of DCA storage increased and this phenomenon was exacerbated by 1-MCP application.

Fruit, aroma, ester, DCA, dynamic, CA

Effect of 1-Methylcyclopropene (1-MCP) on disorder development in ‘Scifresh’ apples stored under regular and controlled atmosphere conditions

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Storage temperature and storage atmosphere are factors that can be controlled to extend the storage life of apples. These factors are important in maintaining fruit quality, reducing post-harvest losses and supplying the year-round demand of apples. 'Scifresh' (marketed as Jazz trade), used in this study, is a relatively new cultivar in the international market. However, it is susceptible to a range of post-harvest disorders. The aim of the study was to evaluate the effects of different storage conditions and storage times as well as 1-methylcyclopropene (1-MCP) on fruit quality, disorder development and biochemical indicators of 'Scifresh' apples. In season 1, fruit was stepwise cooled after harvest. In season 2, apples were immediately stored at 0.5°C to increase the risk of chilling injury related disorders to observe the differences between treatments better. 'Scifresh' apples were subjected to four storage protocols: regular atmosphere (RA) (0.5°C) with and without 1-MCP for 2 and 4 months; controlled atmosphere (CA) (2 kPa O_2 and 2 kPa CO_2) with and without 1-MCP for 2, 4, 6, and 8 months at 0.5°C. Bitter pit incidence was significantly higher in season 1 when fruit was stepwise cooled compared to the immediate cooled fruit after harvest in season 2. Therefore, 'Scifresh' apples need to be immediately room cooled after harvest to reduce the risk of bitter pit development. It is recommended to do immediate room cooling of 'Scifresh' apples intended for RA-storage after harvest at 0.5°C and to store the fruit for longer than 2 months. If fruit is to be stored for less than 4 months in RA, fruit needs to be treated with 1-MCP as it will aid in reducing the incidence of bitter pit. The fruit was more prone to develop bitter pit with increased internal ethylene concentration (IEC) during storage, peel background colour, and decreased flesh firmness. The effects of 1-MCP on 'Scifresh' apples fruit quality was less effective when stored under CA conditions. Therefore, due to the risk of bitter pit development under CA conditions, the recommendation for long-term CA storage is that fruit should be harvested at optimum maturity and not be treated with 1-MCP.

Antioxidant capacity, apple quality, bitter pit, cooling, Jazz, pome, post-harvest defects, reactive oxygen species, total phenolics

Pre- and postharvest ethylene combined with 1-methylcyclopropene differentially affects sprout growth in red and yellow onion (*Allium cepa* L.) bulbs

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Sprouting is a common problem in onion bulbs during long term storage and this can be influenced by several factors including varietal differences. Postharvest application of ethylene in conjunction with 1-methylcyclopropene (1-MCP) before or after curing has been found to reduce sprouting in onion during storage. To determine whether preharvest ethylene combined with postharvest 1-MCP treatment can also suppress sprouting in two different onion varieties, Juni F1hybrid red onion and the yellow type Superex F1 were subjected to either a preharvest ethephon (3000 µl L^{-1}) treatment 2 weeks before harvest followed by a post-curing 1-MCP treatment (preharvest ethephon + 1-MCP), or postharvest ethylene (10 µl L^{-1}) treatment combined with 1-MCP (1 µl L^{-1}) (postharvest ethylene + 1-MCP). The onions, including untreated control, were stored at 5 C without humidity control for 90 days. All treatments incurred minimal weight loss (less than 8%) after 90 days. Preharvest ethephon + 1-MCP and postharvest ethylene + 1-MCP prevented sprouting for up to 30 days in red and yellow onions, respectively and both treatments reduced sprout growth after 60 days compared to the control. While both treatments significantly reduced sprout growth in red onion after 90 days, preharvest ethephon + 1-MCP treatment led to higher sprouting incidence and sprout length in yellow onion compared to the control. Dry matter content decreased after 90 days of storage for both red and yellow onions regardless of treatment. Preharvest ethephon + 1-MCP treatment resulted in lower total soluble solids (TSS) in yellow but not in red onion. The characteristics which relate to pungency and relative storability such as pyruvate content, dry matter, and total soluble solids are higher in the red compared to yellow variety.

Onion, sprouting, 1-MCP, ethylene, ethephon, pyruvate, low temperature storage

Physiological changes in Grand Naine banana fruits as influenced by 1-methylcyclopropene (1-MCP) under different storage environments

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Bananas, being climacteric in their ripening behaviour, are sensitive to the factors that influence the shelf life and quality of fruits. Considering long-distance transport and market potential, ripening is manipulated through physical and physiological approaches. 1-methyl cyclopropene (1-MCP) is widely used in different forms in many countries to delay the ripening of fruits and vegetables by blocking the ethylene action. An experiment was conducted to study the influence of 1-MCP vaporization at different concentrations on postharvest changes in Grand Naine banana fruits at ripening stage 2 (25% ripening) under ambient storage, AS (27 ± 2°C), and cold storage, CS (17°C) conditions. Fruits treated with 1-MCP at 600 ppb resulted in greater firmness retention even after 13 days, considering both storage conditions. 1-MCP vaporization impaired the ethylene release and delayed the peak of ethylene evolution, with significantly lower ethylene evolution (0.65 µL kg^{-1} h^{-1}), compared to the untreated fruits. A decline in CO_2 evolution (12.34 µL CO_2 µL kg^{-1} h^{-1}) was also observed due to 1-MCP at 600 ppb while the control fruits had the highest respiration (25.76). The maximum CO_2 evolution of 1-MCP-treated fruits was very low (35.31) compared to the climacteric level (60.24) in control fruits, indicating a suppression in respiration rate and ethylene production. Under both storage conditions, Pectin Methyl Esterase activity was low (8.04, 8.22 meq of COOH g^{-1} min^{-1}) in fruits treated with 1-MCP at 600 ppb, causing higher fruit firmness. The total antioxidant activity as a percentage of DPPH inhibition was also observed to be higher in 1-MCP 600 ppb-treated fruits (63.92) than untreated control (36.53). A relatively higher fruit K content (350.8 mg $100g^{-1}$) was observed due to 1-MCP when compared to the control (295.9). The shelf life of banana fruits was significantly enhanced to 18 days by 1-MCP at 600 ppb under CS, while the untreated fruits had only four days under AS conditions.

Banana,1-MCP, physiology, shelf-life, fruit quality

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

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Pathogenic fungi are a main cause of postharvest loss. The most effective treatment against postharvest diseases is chemical 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. After characterization of the mode of action of dsRNA penetration to the fungi, we developed new technique, 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 specifically inhibited 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. Storage conditions as high humidity and CO_2 accelerated the release of the dsRNA from the LDH. Overall, this study advances the use of dsRNA one step closer to an applicative eco-friendly alternative to the conventional postharvest fungicides.

dsRNA, antifungal, postharvest

Dual role of (E)-2-hexenal in modulating postharvest interaction between fruit and *Botrytis cinerea*

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The exploration of interaction mechanisms between fruits and fungal pathogens holds significant promise for controlling post-harvest diseases. Plant volatile organic compounds (VOCs), particularly reactive electrophile species such as (E)-2-hexenal, play uncertain roles in defending fruits against fungal invasion. Our study reveals that (E)-2-hexenal constitutes 20-50% of the total VOCs in strawberries and its concentration increases by 42% upon grey mould infection, underscoring its critical role in plant-pathogen interactions. *In vitro* antifungal assays showed that high concentrations of (E)-2-hexenal can inhibit *Botrytis cinerea* infection, reducing the diameter of strawberry lesions. At the cellular level, (E)-2-hexenal was found to increase both reactive oxygen species and mitochondrial membrane potential in *B. cinerea*. LC-MS/MS and FTIR analyses confirmed a Michael addition reaction between (E)-2-hexenal and glutathione (GSH), resulting in the formation of a GSH-H adduct. Moreover, our research uncovered that low concentrations of (E)-2-hexenal activate *B. cinerea* nutritional assimilation capability by inducing the expression of Bcmet3 and Bcmet16, thereby enhancing sulphate assimilation to increase internal GSH content. This process boosts oxidative tolerance and infection potency during the invasion. This study elucidates the bidirectional regulatory role of fruit VOC (E)-2-hexenal based on GSH addition in post-harvest pathogen infection, expanding our scientific understanding of sulphur assimilation in post-harvest disease regulation. Our findings provide a more systematic theoretical basis for selecting appropriate dosages of plant VOCs for post-harvest disease control.

Fruit, Volatile organic compound, Botrytis cinerea, glutathione

ZIF-8 nanoporous material for thymol release: a novel strategy to control ‘Cavendish’ banana fruit crown rot

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Crown rot is a significant postharvest fungal disease that affects the export of 'Cavendish' banana fruit. The utilization of bioactive compounds with antifungal properties as vapours, in particular thymol, is found to be an effective solution for disease control. Zeolitic Imidazolate Framework-8 (ZIF-8) is a highly hydrophobic metal-organic framework (MOF) nanoporous material that can be produced at an industrial scale. ZIF-8 has been selected as a potential solution for thymol sustained delivery because the diffusion of volatile organic compounds in ZIF-8 is known to be particularly slow. This study investigated the impact of thymol vapor released from ZIF-8 on the reduction of internal crown rot in banana fruit packed in carton boxes after 11-d storage at 14°C. Hyperspectral images revealed that thymol released from ZIF-8 resulted in less advanced internal necrosis of crown tissues compared to untreated fruits. In contrast to the direct application of thymol in its crystal form, the controlled release allowed the prevention of phytotoxicity when fruits were packed in carton boxes. The CO_2 and O_2 levels did not alter the release concentrations. This study demonstrated the potential utility of thymol released from nanoporous material as a novel strategy for postharvest disease control.

'Cavendish' banana fruit, hyperspectral image, internal crown rot, thymol vapor, phytotoxicity, ZIF-8

Induced resistance as a tool to manage postharvest decay of fresh fruit and vegetables

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Harvested fresh fruit and vegetables are perishable, subject to desiccation, show increased respiration during ripening, and can be infected colonized by postharvest fungal pathogens. Induced resistance is a strategy to control diseases by eliciting biochemical processes in fruits and vegetables. This occurs by modulating the progress of ripening and senescence, which maintains the fresh produce in a state of heightened resistance to decay-causing fungi. Application of induced resistance to protect fruit and vegetables has been improved thanks to increased knowledge and scientific tools that better characterize physiological changes in plants. Induced resistance slows the decline of innate immunity after harvest, and increases the production of defensive responses that directly inhibit plant pathogens. This increase in defence response in fruits and vegetables contributes to higher amounts of phenols and antioxidant compounds, including nutraceutical compounds, improving both the quality and appearance of the produce. This will summarize mechanisms and treatments that induce resistance in harvested fresh fruit and vegetables to suppress fungal colonization. Moreover, it highlights the importance of timing of application, host maturity and stage of ripening as limiting conditions for the improved expression of induced-resistance processes. The work was developed within the framework of the FoodWaStop COST CA22134 Action.

basic substances, chitosan, postharvest, ripening delay, shelf life

Impact of domestic storage on bioactive phytochemicals and sugars in red-fleshed cultivars, ‘Rubycot’ plumcot and ‘Queen Garnet’ plum

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Domestic storage can significantly affect the phytochemical composition and sugars in stone fruits. The present study evaluated the effect of two common domestic storage temperatures (4°C and 23°C) on the main phytochemicals and sugars found in 'Rubycot' (RC) plumcot, a novel stone fruit variety, and 'Queen Garnet' (QG) plum, an anthocyanin-rich Japanese plum. Furthermore, the total phenolic content (TPC), was also determined as a measure of the reducing capacity of the samples. Phytochemicals (anthocyanins, quercetins and carotenoids) and sugars were analysed by UHPLC and TPC was determined using a spectrophotometer. The total anthocyanin concentration (TAC) in RC increased during storage at both temperatures and was highest after 7 days of storage at 23°C (+95%), whereas QG had the highest TAC after 14 days of storage at 23°C (+60%). At 4°C, TAC in QG and RC increased until the last storage day (day 14), but only by 27% (QG) and 30% (RC), respectively. A 40% increase in total quercetin concentration (TQC) was observed in QG during storage at 23°C. Similar to TAC, TPC increased at both storage temperatures in both cultivars. In contrast, there were no significant changes in the carotenoid profiles during storage. Both RC and QG had similar sugar profiles (sucrose, glucose, fructose and sorbitol) and the total sugar content decreased gradually with time at both storage temperatures. Results from this study clearly showed that ambient storage (23°C) can improve the nutritional quality of RC and QG by significantly increasing bioactive anthocyanins and quercetins. However, it is important to evaluate the textural and sensory properties of stored RC and QG to confirm consumer acceptability following ambient storage.

Plumcot, plum, phytochemicals, domestic storage, stability, nutritional quality

Exploring the nutritional value of native Australian citrus fruit

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Citrus fruit play an important role in human nutrition, providing high levels of vitamin C, carotenoids, flavonoids, dietary fibre and some B vitamins. Additionally, the fruit provide anti-inflammatory, anti-diabetic and anti-obesity activity, believed to primarily result from the unique flavonoids and polymethoxyflavones present. Australia has six endemic *Citrus* species; however, there is very limited data on the nutritional composition of their fruit. Nevertheless, this information is essential to support the commercialisation of these species and/or the use of their germplasm in citrus breeding programs. This study focuses on one of the native Australian species: *Citrus garrawayi* (Mount White Lime), with fruit sourced from three distinct geographic locations. Compared to commercial Persian lime (*C. x latifolia*), *C. garrawayi* generally showed comparable titratable acidity, Brix, and protein content. It typically displayed lower levels of moisture, ash, vitamin C, total antioxidants and flavonoids, total alkaloids, most minerals, and major sugars (glucose, fructose, sucrose). The levels of phytate, tannin, molybdenum, lead and boron were higher in *C. garrawayi* than Persian lime. *Citrus garrawayi* contained a higher total pectin content, with a greater degree of esterification and equivalent mass, but lower methoxy content than Persian lime. This indicates that while the overall (proximate) nutritional value of *C. garrawayi* fruit may be similar to commercial Persian lime, it may contain lower levels of specific micronutrients and phytochemicals. Nevertheless, the unique flavour, pearl texture and fruit shape may support its commercial uptake in the future. Further investigation into the specific flavonoids present and potential bioactive properties of C. *garrawayi* is ongoing, along with investigations into fruit from the other native Australian Citrus species.

Indigenous fruit, ascorbic acid, sugars

Unlocking the nutritional potential of Australian indigenous edible halophytes

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Edible halophytes are receiving significant interest due to their high salinity tolerance, a crucial trait in times of climate change, growing world population and loss of arable land. Although they are widely distributed and popular for their diverse "applications" among Indigenous communities in Australia, studies on their nutritional and sensory profiles are very limited. Therefore, the nutritional composition including anti-nutrients and sensory profiles of four important Australian indigenous edible halophytes (AIEH), Saltbush (*Atriplex* sp.), Samphire (*Tecticornia* sp.), Seablite (*Suaeda* sp.) and Seapurslane (*Sesuvium* sp.), were determined in the present study. Overall, considerable amounts of fibre, essential minerals and trace elements (especially Ca and Fe), protein, polyunsaturated fatty acids and vitamin C could be determined in the halophyte samples, whereas folate (vitamin B9) and betalains were found in lower concentrations. Anti-nutrients were generally lower than in Spinach, a "popular relative" of Saltbush and Seablite (Amaranthaceae family). Results of the sensory study clearly showed that the growing location can significantly affect the sensory attributes of AIEH and subsequently their potential food applications. The present study generated critical and novel data on the nutritional and sensory properties of AIEH. However, potential applications of these underutilised native plants as a healthy and tasty side dish or (functional) food ingredient should be explored further.

Halophytes, underutilized, composition, sensory, nutrition

Ethylene as a contaminant at the retail end of the cool chain

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Ethylene is well known to have physiological effects on fresh produce. In particular ethylene is used commercially to stimulate ripening in many (climacteric) products. Alternatively, 1-methylcyclopropoene is used as a treatment to inhibit ethylene perception and subsequent ripening and senescence effects. Beyond these deliberate treatments ethylene may still exist in the cool chain as a contaminant from ripening and rotting produce or combustion, including from exhaust fumes. Effects of contaminant ethylene on produce quality will be a function of exposure concentration, time and temperature within the cool chain environment. Until recently concentrations of ethylene in the environment have been challenging to measure below the μL L^{-1} (ppm) range and as a result little quantification of contaminant ethylene levels have been documented. However, technology advances over the last decade have resulted in commercialisation of technologies that enable μL L^{-1} (ppb) ethylene detection by relatively portable equipment. This equipment has subsequently been trialled and utilised by Massey University to take a series of surveys and unique ethylene measurement in the New Zealand and international supply chains. This talk will review (1) the technologies available to assess ethylene concentrations in the μL L^{-1} (ppb) range and (2) example results of the potential ethylene contamination (concentrations) that may exist in retail environments.

MacView, ETD-300, supply chain, refrigeration, ambient ethylene, industrial survey

Influence of low temperature storage and exogenous ethylene treatment on physico-chemical fruit quality of ‘Sindhri’ and ‘Samar Bahisht Chaunsa’ mangoes

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Sindhri and Samar Bahisht Chaunsa are the two major mango cultivars of Pakistan. Investigations were made to determine the optimum temperature for sea-shipment and post-shipment ripening of these two cultivars for export markets. Physiologically mature fruit were harvested and subjected to different storage temperatures (8, 10, 12 or 14°C; ± 1°C; 80-85%RH) for different periods (7, 14, 21 or 28 days). The quality of both cultivars was significantly affected by the storage temperature and duration. Both cultivars were negatively affected at 8°C and 14°C with significantly severe chilling injury and more physiological weight loss respectively. Sindhri mangoes stored at 11 ± 1°C; 80-85%RH for 28 days indicated the potential for successful shipment to distant offshore markets with uniform post-storage peel colour development and a post-storage saleable life of 6-7 days at 24 ± 1°C. The exogenous ethylene treatment (100 ppm for 24-48h) helped attain better post-storage peel colour development and other physico-chemical fruit quality attributes. The response of cv. S.B. Chaunsa was complicated, and its sea-shipment potential was limited by significant chilling injury, higher titratable acidity and poor peel colour development under prolonged low temperature storage (> 21 days) at the tested storage temperatures. Disease management is very critical in sea-frights for better post-storage/post-shipment out-turn in terms of fruit quality and marketability. This paper provides detailed account of the investigations regarding refrigerated shipment potential of both commercial mango cultivars.

Mangifera indica, chilling injury, sea-freight, ripening, marketability

Integrated quality control of Indian jujube (*Ziziphus mauritiana)* exportation by collaborating forced-air cooling and 1-Methylcyclopropene treatment

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Jujube (*Ziziphus jujuba Mill.* cv. TN13) has attracted a large number of consumers because its rich in nutrients, such as carbohydrates, organic acids, amino acids and high medicinal value with anti-obesity, antioxidant and anti-hepatoma activities. Jujube fruit could be eaten not only dried but fresh for a healthy juicy fruit, contains sugars, acids and volatile aroma compounds for providing favour, and antioxidant compounds that can ameliorate the oxidative damage caused by free radicals. Fresh jujube fruit appearance phenotypes are an important factor for consumers, including fruit size, shape, colours, and firmness quite different between fresh and dried ones. For demands of shelf-life and export, postharvest handling strategies would be integrated. Maturation and ripening stage should be chosen with lower maturity. 1-MCP(1-Methylcyclopropene) applied for 2 hours fumigation from field to packing house. Vertical forced-air cooling was be operated following 1-MCP treatment at packing house, decreased core temperature lower than 10°C. Cold chain management was managed during exportation to Europe. Compared to normal packing protocol without 1-MCP treatment, the quality of both applied 1-MCP and precooling treatment arrived retailer after 8 days is tremendous well than control (Control: Integrated quality control (ITQ) - 9 score: 1.6% : 60%; 7 score: 25% : 31.7%; 5 score: 59.4% : 8.3%; 9 score is the best quality ,1 is overripe browning bad quality and above 5 score is the quality for selling).Hue angle of ITQ is 111.1 compare to control is 104.2 more fresh green than control respectively. These data showed that ITQ is a profitable protocol for maintaining fresh jujube well quality for export.

Indian jujube, Ziziphus mauritiana, forced-air cooling, 1-MCP

Postharvest ethanol treatment promotes ripening of kiwifruit through stimulation of ethylene production

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Postharvest ethanol treatment affects ripening and senescence in horticultural crops. In this study, to clarify fruit ripening and its mechanism by ethanol, ethanol vapor treatment with ethanol pads, a continuous treatment, was applied to kiwifruit fruit to investigate ethylene production, respiration rate and internal quality during ripening. Kiwifruit "Hayward" (*Actinidia deliciosa)* were used as materials. The fruit was enclosed in a perforated polyethylene bag with and without (control) an ethanol pad and stored at 20°C in the darkness. Ethylene and carbon dioxide were measured with gas chromatography. Only 20% of the untreated fruit produced ethylene and ethylene production was trace throughout the storage period. In ethanol treated fruit, ethylene production increased markedly on 10 days in storage (DIS), and 100% of the fruit produced ethylene on 13 DIS. Respiratory rates increased after the ethylene production increased. The results of hardness, sugar content, and titratable acidity measurements indicated that the ethanol treated fruit became edible on 13 DIS. When 1-MCP treatment was applied prior to ethanol treatment, ethylene production was delayed, and the increase in respiration rate and changes in hardness, sugar content, and acidity were also delayed. These results indicated that postharvest ethanol treatment promotes ripening of kiwifruit through stimulation of ethylene production.

Ethanol, ethylene, kiwifruit quality, ripening

The effect of modified atmosphere packaging on postharvest quality of green eat-all almond during cold storage

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Green "eat-all" almonds, a traditional snack in the Middle East, boast a fuzzy green hull and a tender, jelly-like endosperm. Often sold at room temperature, they are susceptible to water loss, colour changes, lignification, and decay. Objective of this study was to investigate the effect of modified atmosphere on the overall quality and storability of the almonds. To this end, the green almonds (var. Filippo Cea) were packaged in PP-PET bags with different levels of perforations to modulate the gas conditions at the equilibrium, resulting in the following treatments: non-microperforated (0 holes; T0), low-microperforated (2 holes; T1), medium-microperforated (4 holes; T2), high-microperforated bags (8 holes; T3) and control treatment (CTRL) in air. Samples were stored at 5°C, while CTRL samples were stored in open clamshells at 0°C and 5°C. Data related to headspace gas concentration, fruit weight loss, decay incidence, firmness, colour, pH, titratable acidity (TA), total soluble solid content (SSC), antioxidant capacity, chlorophyll, fibre, total phenols, condensed tannins, crude fibre, lignin, and sensory analysis were collected. Fruit quality was assessed at harvest and after 13, 22, and 43 days of storage. The results show that about 27% of the fruit stored in air at 0°C showed superficial stains attributed to chilling injury. On the other hand, fruit stored in T1 and T2 perforation packaging showed the best quality attributes reaching gas equilibrium after 13 days (T1: 19% CO_2 and 7% O_2; T2: 12% CO_2 and 12% O_2) compared to those in T3 and T0 perforations and to control, as indicated by slower colour changes during storage (in line with change in chlorophyll), lower degradation of bioactive compounds and firmness attributes. Finally, samples stored in air, without MAP conditions, showed the worst quality, and the occurrence of some decay at the end of cold storage.

MAP, microperforated bag, shelf-life, firmness, weight loss

Improving storability and shelf-life of red dragon fruit using O_2 absorbent-based modified atmosphere packaging

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Dragon fruit has great economic potential for Indonesia, but it is highly perishable during a commercial distribution and market display typically signed with shrivelling, bract discoloration and decay. This study was conducted to extend the storage and shelf-life of dragon fruit using oxygen (O_2) absorbent-based modified atmosphere packaging (MAP) at low temperature storage. Dragon fruit were packaged in 0.03 mm-thick commercial polyethylene (PE) and polypropylene (PP) films with the addition of O_2 absorbents to lower respiration process. The packaged fruit were then stored at 8°C for 21 and 35 days, before being transferred to 20°C for shelf-life quality assessments. As a control treatment, the fruit was stored at the same storage temperature. We found that extension of storage period, for all packaging treatment, shortened the dragon fruit shelf-life at 20°C. It lasted 7 days after 21 day-storage while it was only 3 days after 35 day-storage. The fruit without packaging underwent severe shrivelling and decay. Dragon fruit packed in the PE film were associated with less colour change, weight loss, softening and pH change, and higher total soluble solid for 35 + 3 days of the storage and post-storage. The use of PE film and O_2 absorbent in MAP, protecting the fruit from shrivelling, bract discoloration and decay, is a practical and easy packaging method improvement for the dragon fruit.

Postharvest handling, packaging, tropical fruit, respiration, oxygen

Effects of storage temperature and packaging on the shelf life of peeled garlic cloves

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This study aims to investigate the use of different storage temperature and packaging technique in maintaining the quality of fresh peeled garlic cloves. Garlic samples were sorted and peeled off prior to packing in 4 packaging types (150 grams/pack), namely, normal sealed low-density polyethylene (LDPE) bag, vacuum-sealed LDPE bag, normal sealed modified atmosphere (MA) LDPE bag and normal sealed LDPE bag with desiccant pack. All packaging treatments were stored at 5 and 10°C, 90-95% RH. The result showed that peeled garlic cloves could be stored for up 50 days at 5°C and 30 days at 10°C with acceptable quality, except for the garlics in MA bag which lasted for only 30 and 15 days, respectively. The samples had abnormal symptoms, i.e. flesh browning, flesh dries out, and fungal infestation, causing the garlic cloves became unacceptable.

Ready-to-eat garlic, storage quality, package

Optimum packaging system for export transportation of strawberries and grapes by air

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The optimum modified atmosphere packaging (MAP) conditions were determined based on microbiological quality for 'Tochiotome' strawberries and 'Shine Muscat' grapes intended for air transportation from Japan to Asian countries. Storage temperature of strawberries and grapes was employed according to real temperature fluctuations ranging from 10-15°C for 72 hours to Hong Kong and 10-27°C for 76.5 hours to Taiwan, respectively. The fruits were packaged in OPP films with a low water transmission rate (WTR) or ONY films with a high WTR, and non-packaged samples were used as controls. With strawberries, the CO_2 concentration in both packaging films increased similarly to 23-24% by the end of storage. Notably, condensation occurred inside the OPP films but not in the ONY films. Bacterial counts of strawberries increased to 2.7-3.2 log CFU/g in OPP films and non-packaging during storage, while they remained below the detection level (2.3 log CFU/g) in ONY films. Fungal counts tended to be higher in OPP films than in ONY films. Most of fungi isolated from strawberries were yeasts, and the diversity of yeast flora was less in the ONY films than in the OPP films. With grapes, OPP films and ONY films approached an equilibrium of 6-10% CO_2 after 24 hours, and water vapor condensed into water droplets only in the OPP films. Bacterial counts of berries remained below the limit of detection in ONY films, whereas counts increased to 2.7-3.5 log CFU/g in samples in OPP films and non-packaging. No differences were found in fungal counts of berries and diversity of fungi (mostly mould) flora among the treatments. These results indicate that MAP using a low WTR film such as ONY is recommended for practical air transportation of strawberries and grapes by inhibiting condensation inside the films, thus preventing microbial proliferation.

Strawberries, grapes, air transportation, modified atmosphere packaging, microbiological quality

Inhibition of branched-chain ester synthesis by ALS inhibitors provides evidence for the origins of ester precursors

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Branched-chain esters are important contributors to the Flavors of many fruits. In most fleshy fruits, they contribute to the 'fruitiness' of the aroma and in banana fruit they are responsible for the fruit's characteristic aroma. The biochemical origins of these compounds have long been assumed to be from protein-sourced, catabolized branched-chain amino acids, a passive, senescent process. In contrast with this perspective, fruit ripening is a dynamic, largely uni-directional developmental process under the control of numerous, highly regulated processes. We proposed that aroma synthesis, oftentimes a terminal developmental process in ripening, is primarily an anabolic process that relies upon the de novo synthesis of the precursors to branched-chain esters. To test this hypothesis, we applied various acetolactate synthase (ALS) inhibitors to ripening or ripened apple, quince, and banana fruits. These inhibitors arrest synthesis of the branched-chain amino acids and are widely employed as herbicides in commercial agriculture. The fact that these are lethal compounds infers that there is only a single route for the synthesis of the branched-chain amino acids. Following herbicide treatment, 2-methylpropyl and 2-methylbutyl esters were significantly (90 to 100%) reduced in apple, and ornamental quince fruits and 2-methylpropyl and 3-methylbutyl esters were likewise suppressed in banana. Simultaneously, valine, leucine, and isoleucine were also reduced, but only in fruits that produce the corresponding branched-chain esters. This finding suggests that esters are, in fact, largely derived from newly synthesized substrates and not of proteinogenic (catabolic) sources. Straight chain esters were partially reduced (30 to 50%) in some cases, which was taken to indicate a general herbicidal impact was also in effect. In a sensory test of the treated apples, we demonstrated the humans could readily recognize the absence of branched-chain esters in fruits, despite the retention of a still highly complex aroma profile. We believe our ability to sense these esters may be responsible for the tendency of human-facilitated breeding to select for apple fruit that produce said esters, highlighting the importance of these compounds even in fruits with highly complex aroma profiles.

Apple, banana, ester, aroma, herbicide

The transition to peat-free cultivation: transplantation medium effects on mature crop phytochemistry and flavour compounds

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Peat has historically been an essential constituent of the growing media (GM) used in the production of Brassica crops. However, due to environmental concerns surrounding peat extraction, horticulture is facing immediate legislative pressure to find replacement materials. While alternative GMs are available, the long-term impact of early-stage peat-free cultivation on the yield, sensory and health qualities of post-transplant Brassica crops at harvest is not known. In an ongoing series of research trials, the impacts of pre-transplant GM selection on the nutritional and sensory quality in Brassica oleracea var. acephala cultivars and accessions are being explored. Initially, 80 accessions obtained from the Warwick Genetic Resource Unit were cultivated to transplant stage in four peat-free treatments and a peat-based control. The results indicate genotype x environment effects for transplant stage biomass, root to shoot ratios and glucosinolate (GSL) profiles. A further field trial investigating the potential impact of peat-free nursery cultivation on post-transplant kale crops was conducted. Harvest-ready kale crops were analysed for GSL contents by LCMS, as well as volatile compounds using GCxGC-TOF-MS. Our results showed that 4-methoxyglucobrassicin and neoglucobrassicin contents were 33% and 53% lower, respectively, in cv. Reflex F1 crops cultivated pre-transplant in peat free compared with peat. Furthermore, preliminary chemometrics analysis of field grown kale indicates differences in volatile compounds between those raised to transplant in peat and peat-free GM. These results provide the first evidence that early-stage GM selection could have potential long-term impacts on Brassica biochemistry and flavour at maturity. In this presentation, the most recent research outcomes of the project will be discussed, showcasing novel insights into the long-term effect of pre-transplant cultivation conditions on post-harvest quality.

Peat-free, growing media, Brassica oleracea, glucosinolate, genotype environment interactions, nursery, volatile organic compounds, GCxGC-TOF-MS, LCMS, sensory, nutrition

Quantitative changes of volatile compounds in ‘Honeycrisp’ apple during cold storage in association with soft scald disorder and delayed cooling treatment

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Soft scald is a physiological disorder in 'Honeycrisp' apple fruit that develops during cold storage and can significantly reduce fruit quality and marketability. Delayed cooling prior to fruit storage has been adopted by the fruit industry to mitigate the development of this disorder. Fundamental knowledge about the biochemistry associated with disorder expression and the effects of delayed cooling to reduce disorder development is still required. Therefore, a quantitative volatile analysis employing solid phase micro-extraction and 2-dimisional gas chromatography-mass spectrometry (2D-GC-MS) was conducted to investigate changes in the volatile composition of 'Honeycrisp' apples associated with soft scald development and delayed cooling treatment. The study was conducted over two seasons and over 100 volatile compounds were detected. The data were subjected to ANOVA and volatile compounds that changed significantly in association with soft scald development after 1.5- and 3-month storage were identified. In addition, an overall increase in volatile compounds during storage and as a result of the delayed cooling treatment was found. Volatiles associated with fruit ripeness (i.e. esters and ethanol) were greater in fruit that did not develop soft scald compared to those that developed the disorder. Delayed cooling also increased the content of these volatiles, suggesting that fruit maturity may be an important factor determining whether fruit will develop soft scald during storage. The association of volatile metabolism with soft scald development has the potential to be used as potential biomarkers of soft scald development. Results on volatile also suggest that the positive effect of delayed cooling treatment not only can reduce soft scald, but also improve volatile production associated with flavour quality in 'Honeycrisp' apples.

Malus x domestica, metabolomics, soft scald, volatiles, 2D-GC-MS, fruit quality

Comparative analysis on flesh texture and aroma components of different pear varieties

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In order to explore the evaluation methods and indicators for the flesh texture and aroma of soft -flesh pear and crisp -flesh pear fruits, pear varieties were selected from the National Pea r Germplasm Resources Repository , and the relevant indicators of the flesh for comparative analysis were determine d by using the texture analyser and headspace solid-phase microextraction (HS-SPME) combined with gas chromatography-mass spectrometry (GC-MS). Pear fruits of 8 pear varieties and 86 pear varieties were selected for TPA analysis of fruit flesh quality during development, post-harvest at room temperature without refrigeration and after refrigeration at different shelf periods. Pear fruits of 8 pear varieties and 3 pear varieties were s elected to conduct volatile substance determination and analysis at different storage periods at room temperature and after refrigeration, respectively. Correlation analysis were performed on TPA parameters and volatile compounds of fruit flesh, as well as single fruit weight and soluble solids content (SSC), measured at different stages of fruit flesh quality. The results showed that there was a significant difference in the changes between melting pear and crispy pear, and there was a significant correlation between the measured related indicators; PCA principal components were extract ed as reference indicators for evaluation and analysis. The relevant texture parameter indicators obtained by the TPA method could accurately reflect the changes in texture of pear fruits with different maturities during the shelf life and the differences in texture characteristics between different pear varieties. The changes in flesh texture parameters could provide reference for judging fruit maturity and quantifying fruit flesh quality evaluation standards. There was a relation between changes in flesh texture and changes in volatile compounds. The differences in volatile compounds formed unique aroma characteristics of different flesh textures. This study used HS-SPME and GC-MS techniques to screen for different volatile compounds related to the quality of crispy flesh pears and soft flesh pears, providing reference for elucidating the aroma characteristics of pear fruits with different flesh textures.

Pear, flesh texture, shelf life, texture profile analysis, HS-SPME/GC-MS

Postharvest treatments with biocontrol agents and essential oils strongly modify the fruit microbiome

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Postharvest disease management of fruits is crucial for global food security amid a growing population. Innovative strategies utilizing natural compounds, such as essential oils and biocontrol agents, are promising alternatives to pesticides to control storage rots of fruit. Biofumigation with slow-release diffusers of essential oils (EOs) was effective in the control of grey mould of apples and of brown rot of nectarines. Metabarcoding analysis showed a significant impact of tissue, treatment, and sampling time on the fruit microbiome composition. Epiphytic microbiome had higher richness and evenness compared to their endophytic counterpart. On apples, treatments with thyme EO reduced *B. cinerea* abundance, while favouring a significant increase in *Penicillium* species. Similarly, on nectarines, basil EO was able to reduce the abundance of *Monilinia* spp. but it favoured a significant increase of *Penicillium* spp. Application of different biocontrol agents (BCAs) to control postharvest rots of apples, nectarines and grapes significantly affected both the epiphytic and endophytic microbiome. The BCAs were recovered as epiphytes and as endophytes, demonstrating an internalization in the fruit pulp. On nectarines, the microbiome analysis showed a good proliferation of the yeasts on the treated fruit, together with a reduction of *Monilinia* spp. On apples, the addition of *Aureobasidium pullulans* did not correlate with a decreased abundance of white haze genera, though the disorder occurrence was reduced on the fruit, which might suggest a more complex activity. On grapes, the species of BCAs applied were among the most abundant taxa recovered, with a consequent reduction of *Botrytis* spp. Fruit surfaces harbour resilient microbial communities, which make challenging the establishment of BCAs. Integrating microbial communities to create a conducive environment for biocontrol agents shows promise in real-world conditions. These findings provide new insights for the development of sustainable strategies for the management of postharvest diseases of fruit.

Biofumigation, metabarcoding, apples, nectarines, grapes, biological control, microbiota, Botrytis, Penicillium, Monilinia

Yeast species associated with postharvest rots in sugarbeets

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Sugarbeet is a major source of consumable sugar in domestic and industrial applications in the U.S. Due to high tonnage of the crop that exceeds immediate sugar factory processing capabilities, storage of sugarbeet roots is required in most of the sugar production areas in the U.S. including the red river valley of Minnesota (MN) and North Dakota (ND). Postharvest storage pathogens including yeast species can develop postharvest decays and cause sucrose loss in sugarbeets during storage. To date, limited information is available on the spectrum of yeast species associated with storage rots in sugarbeet piles in MN and ND. The aim of this study was to identify and characterize yeast species associated with postharvest rots in sugarbeets from MN and ND. Symptomatic sugarbeet roots with microbial infestation or suspected roots in the vicinity of symptomatic roots were collected from factory yards and storage piles during the 2022 processing campaign. Pure cultures of yeast isolates were recovered from symptomatic roots and yeast species were identified by sequencing of internal transcribed spacer region and D1/D2 regions of 26S ribosomal DNA. A total of 17 yeasts species were identified from the 108 isolates obtained from the symptomatic root samples. *Pichia membranifaciens* was the most repeated yeast species out of the 17. Other major yeast species include *Hansespora valbyensis* and *Kurtzmaniella quercitrusa*. Several *Candida* species were also isolated from sugarbeet root samples. This study provides important information on yeast isolates from sugarbeet storage which can be foundational in developing management strategies to minimize storage rots and sucrose loss.

Sugarbeets, storage diseases, sucrose loss, Pichia membranifaciens

Deciphering the effects of agronomical practices on *Aspergillus* incidence and carposphere's microbial communities of grapevine

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Going through the new transitioning era of the "European Green Deal", the search for alternative, non-chemical, disease control methods is essential. Aspergillus bunch rot is considered one of the most important diseases of grapevines resulting in severe yield losses and, major qualitative deterioration of grape products due to the production of mycotoxins. We investigated, in a two-year field study, the impact of agronomic practices like defoliation to enhance grape microclimate (DF), pruning method to reduce grape bunch density (LBD), and irrigation cut-off (NIR), at three developmental stages of grapevine (Pea size berry, Veraison, and Harvest), on (i) grape composition (titratable acidity, pH, and total soluble solids), (ii) on the frequency of occurrence of *Aspergillus* on grape berries and (iii) on the overall composition of grape carposphere microbiome. The density of *Aspergillus* on grape berries was significantly reduced by the applied management practices (DF, LBD, NIR). Amplicon sequencing analysis showed that both the phenological stage and the agronomic practices employed (particularly NIR and DF) imposed significant changes in the α-diversity and β-diversity of the grape carposphere bacterial and fungal communities. The NIR, LBD, and DF treatments which supported lower *Aspergillus* populations, network analysis revealed negative co-occurrence patterns between *Aspergillus* and several bacterial genera (*Streptococcus*, *Rhodococcus*, *Melitangium*) reported to have antifungal properties suggesting potential natural attenuation mechanisms for the control of *Aspergillus*. Overall, our study (i) showed that the application of halting of irrigation and thinning of leaves and grape bunches, reduce the occurrence of *Aspergillus* and hence the incidence of Aspergillus bunch rot disease and (ii) identified preliminary evidence for interactions of *Aspergillus* with members of the epiphytic grape bacterial communities that might be involved in the suppression of Aspergilli, an observation which will be further pursued in following studies in the quest for the discovery of novel biological control agents.

Bunch rot disease, microbiome, viticultural practices, amplicon sequencing analysis, bunch density, leaf removal, irrigation, disease management

CRISPR/Cas9 editing of MLO genes to improve powdery mildew resistance in Strawberry

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Strawberry (*Fragaria* x *ananassa*) is a highly valued fruit crop known for its unique flavor, nutritional benefits, and potential health advantages. However, the presence of powdery mildew (PM) caused by *Podosphaera aphanis* poses a significant threat to strawberry production. The conventional method of controlling PM through fungicide application has been hindered by the development of resistance. Previous studies have shown that loss-of-function mutations in Mildew Resistance Locus O (MLO) genes can confer broad and durable resistance to PM in various plant species. However, traditional breeding methods face challenges due to the complex genetic makeup of *F.* × *ananassa*. In this study, we utilized the CRISPR/Cas9 system to knockout three MLO genes (MLO1, MLO2, and MLO3) separately in strawberry. A total of 60 independent lines for each gene were generated, with 90% of them exhibiting successful editing as confirmed by PCR amplification and High Resolution Melting assay. Phenotypic analysis using *in vitro* detached leaves PM disease assay revealed that approximately 60% of the edited lines displayed increased resistance to PM. These findings demonstrate the potential of CRISPR/Cas9-mediated editing of MLO genes as an efficient approach for enhancing PM resistance in strawberry.

Strawberry, powdery mildew, MLO genes, genetic editing