V^th International Symposium on Postharvest Pathology

Book of abstracts

www.postharvest2019.be

LIÈGE université Gembloux Agro-Bio Tech

ISPP International Society for Plant Pathology

ISHS

Contents

Organization

Venue

Université de Liège,
Academic Hall
7, Place du 20 Août,
4000 Liège

Date

19th to 24th May 2019

Website

https://events.uliege.be/postharvest2019/

Scientific Committee

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Hanène Badri – Gembloux Agro-biotech, University of Liège, Belgium
Abdoul Razack Sare – Gembloux Agro-biotech, University of Liège, Belgium

Welcome note

Dear Colleagues,

It is our great pleasure to welcome you to the Vth International Symposium on Postharvest Pathology hosted by the International Society for Horticultural Sciences (ISHS) and the International Society for Plant Pathology (ISPP) that will be held in Liège, Belgium from 19 to 24 May 2019.

It is the first time that Belgium will host this prestige symposium. The meeting will address the questions related to postharvest supply chain management. The last symposium held in South Africa in 2017 addressed the next generation innovation and commercial solutions for postharvest pathology to reduce losses. The present conference in Liège, will tackle the postharvest pathology issues from another corner. The meeting will highlight the postharvest chain management, and this will include all the process from pathology detection, prevention and protection till processing and distribution in an attempt to satisfy consumer demands.

To this regard, specialists in the field of plant protection industry and postharvest technologies are invited to address the problems encountered during this process, they will bring a real mirror for problems encountered during the value chain activity (Protection products, Storage, Packaging, Distribution). Innovative technologies of detection and protection will be presented. The symposium will offer the opportunity to exchange advanced technologies, methods, and knowledge towards postharvest disease management of fruits and vegetable. This International Conference will be a forum to bring researchers, academics and industry professionals to share knowledge and research contribution in the evolving technologies related postharvest pathology. Ten renowned speakers are invited to cover the main sessions of the symposium.

Besides the science, we are organizing three social evening events and one guided technical tour. They are used to strengthen and develop collaborations.

We look forward to see your presence with active contribution to make this event successful.

Sincerely,

Prof. Haïssam Jijakli

Convenor of the symposium

Program

Sunday, 19 May 2019

19:00 - 20:00: Arrival and registration with welcome reception and cocktail: beer, wine and chocolate testing event at Congress palace

Monday, 20 May 2019

08:00	Arrival, registration and posters I, II III and IV hanging	
09:00	Welcome and Opening	Haïssam Jijakli; Samir Droby; Antonio Ippolito
	Opening session	
09:30	Postharvest treatments today and in the future: perspectives from the plant protection industry	Geoffroy de Chabot-Tramecourt
10:15	Physiology and pathology: the intersection between postharvest technologies	Christopher B. Watkins
11:00	Round table: discussion on industry demands	Geoffroy de Chabot-Tramecourt, Christopher B. Watkins, Benito Orihuel leaded by Antonio Ippolito
11:30	COFFEE BREAK	
12:00	**Poster viewing Sessions I, II, III and IV**	
13:00	LUNCH	
SESSION I: Smart innovative technologies for detection of postharvest pathogens and toxic metabolites		Chair: Baric Sanja and co-chair: Antonio Ipollito
14:00	Smart innovative technologies for detection of postharvest fungal pathogens and their toxic metabolites	Simona Marianna Sanzani
14:30	The application of information technology for diagnosing postharvest diseases of apple	Sanja Baric

14:45	Phenotypic characterization of Bull's eye rot and bitter rot pathogens in South Tyrol isolated from apple fruits after storage	Greice Amaral Carneiro
15:00	High Resolution Melting (HRM) as a tool to characterize *Aspergillus* and *Penicillium* populations of pomegranate fruit	Annamaria Mincuzzi
15:15	Volatiles as biomarker for *Erwinia* infection in Potato	Gabriels Suzan
15:30	COFFEE BREAK	
SESSION II Innovation in Postharvest Disease Control		Chair: Haissam Jijakli and co-chair: Samir Droby
16:00	The next thirty years: Envisioning the future of postharvest disease research	Michael Wisniewski
16:30	Extension of shelf 'life of *Penicillium digitatum* infected sweet oranges by vapor heat treatment	Abiola Aborisade
16:45	Round table discussion: Are the market needs in accordance with actual innovative research	Simona Marianna Sanzani, Michael Wisniewski, Geoffroy de Chabot-Tramecourt, Christopher B. Watkins, Benito Orihuel leaded by Haïssam Jijakli
17:30	End of the DAY 1 - Free evening	

Tuesday, 21 May 2019

SESSION III Elucidation of host pathogen interactions/Molecular exploration of host-pathogen interactions		Chair: Davide Spadaro and co-chair: Laura Vilanova Torren
08:00	Arrival	
08:30	From gene expression to the packinghouse: can metal chelation be a possible alternative treatment to control fruit postharvest diseases?	Luis González-Candelas
09:00	Scanning genomes to identify secondary metabolite production by postharvest pathogens	Davide Spadaro
09:15	Whole-genome sequence of the brown rot fungal pathogen *Monilinia fructigena* Mfrg269 strain isolated in Italy	Lucia Landi
09:30	Exploiting the effector repertoire of *Monilinia fructicola* as a breeding strategy targeting disease resistance	Laura Vilanova Torren
09:45	A walk-through method for identifying brown rot resistance in stone fruit: methodology development, validation, and application on an interspecific almond × peach population	Núria Baró-Montel
10:00	COFFEE BREAK	
10:30	Understanding the potential of *Colletotrichum* spp. to cause bitter rot on apple during preharvest and postharvest in the Mid-Atlantic United States	Kari Peter
10:45	Apple Lenticel Rots: State of knowledge about the epidemiology of *Neofabraea vagabunda*	Michel Giraud
11:00	Role of anthocyanin and flavonoids in resistance of mango fruit to fungal pathogens and chilling injury	Noam Alkan
11:15	General discussion Session III	
12:00	**Poster Flash Presentations**	Chair : Abdoul Razack Sare
13:00	LUNCH	
14:00	**Poster viewing Sessions I, II, III and IV**	

SESSION IV Integrated approaches and new chemistries to reduce postharvest waste		Chair: Neus Teixido and co-chair: Cherryl Lenox
15:00	Antifungal edible coatings for postharvest preservation of fresh fruit	Lluis Palou
15:30	Brown rot disease management of peach in Italy (Emilia Romagna Region)	Gianni Ceredi
15:45	Management of citrus sour rot and green mold in South African pack-houses	Cheryl Lennox
16:00	COFFEE BREAK	
16:30	Mechanism responsible for the alleviation of chilling injury of peach fruit by hot water and glycine betaine treatments as determined by transcriptomic and physiological analysis	Li Wang
16:45	Biological and chemical applications against *Botryosphaeria* during flowering of mango increase fruit count and yield and reduce postharvest decay	Noam Alkan
17:00	The effect of post- harvest treatments on long term storage of Acorn squash	Carmit Ziv
17:15	Role of Strbohs in the promotion of wound healing of potato tubers by BTH	Yang Bi
17:30	Biosecurity risk management of postharvest pathogens on international fruit trade	Niranjani Saverimuttu
17:45	Study of biological control efficacy of *Yarrowia lipolyti*ca against postharvest decay of table grape caused by *Penicillium rubens* and its possible mechanisms of action	Hongyin Zhang
18:00	General discussion Session IV	
18:30	End of DAY 2	
20:00	**Liégeoise speciality Diner at Congress Palace**	

Wednesday, 22 May 2019

TECHNICAL TOUR

08:00	Departure from Congress Center
09:00 11:00	Visit of PCFruit, Sint-Truiden
12:00	LUNCH
13:00 16:00	Visit of Gembloux AGRO BIO-TECH, Gembloux
16:00	Return to Liege
17:30	Free evening

Thursday, 23 May 2019

SESSION V Alternative Postharvest Disease Control Technologies		Chair: Samir Droby and co-chair: Gianfranco Romanazzi
08:00	Arrival	
08:30	Alternative means for the management of postharvest pathogens on fruits	Neus Teixido
09:00	Isolation and in vivo screening of yeast antagonists for the control of *Botrytis cinerea* and *Penicillium expansum* of pome fruit	Nokwazi Carol Mbili
09:15	Characterization of Volatiles Organics compounds of two biocontrol agents: *Pichia anomala* strain K and *Candida oelophila* strain O	Hanene Badri

09:30	Volatile organic compounds produced by *Aureobasidium pullulans* inhibit the growth of *Botrytis cinerea* and *Alternaria alternata*	Madhupani Yalage Don
09:45	Strawberry fruit decay is affected by plant volatiles	Toktam Taghavi
10:00	Alternative postharvest treatment of mango: Potential use of essential oil with thymol to control anthracnose development caused by *Colletotrichum gloeosporioides*	Marc Chillet
10:15	COFFEE BREAK	
10:45	Effects of chitosan coatings on avocado postharvest diseases and expression of phenylalanine ammonia-lyase, chitinase and lipoxygenase genes	Chinelo Obianom
11:00	Alternative methods for controlling banana crown rot in an organic production context	Olivier Hubert
11:15	Hot water dipping of apple - Not living up to its promise?	Matthias Naets
11:30	Development of hot water treatment to control postharvest diseases of carrots	Justyna Wieczynska
11:45	Semi-commercial hot water treatments to control apple bull's eye rot (*Neofabraea alba* syn. P*hlyctema vagabunda*)	Kerry Everett
12:00	General discussion Session V	
12:30	LUNCH	
13:30	**Poster viewing session V, VI, VII and VIII**	

SESSION VI Microbiota community in postharvest		Chair Leonardo Schena and co-chair Michael Wisniewski
14:30	Engineering the fruit microbiome for biological control of postharvest diseases	Samir Droby
15:00	Impact of primers on metabarcoding analyses of phyllosphere fungal communities	Leonardo Schena
15:15	The apple fruit microbiome: influence of orchard management, variety, storage time and storage atmosphere	Andreas Bühlmann
15:30	The effect of waxing and low-temperature storage on the microbiota of different tissues of apple and the survival of foodborne pathogens	Michael Wisniewski
15:45	Cultivars and geographic location influence the epiphytic microbiota associated with mangoes	Ahmed Taibi
16:00	COFFEE BREAK	
16:30	Exploration of microbial communities associated to fruitlet core rot (FCR) disease in 'Queen' pineapple from Reunion island	Jean-Christophe Meile
16:45	Postharvest and on-field microbial community changes caused by root rot in sugar beet	Peter Kusstatscher
17:00	Functional characterization of apple fruit epiphytic microbiome in Belgium	Abdoul Razack Sare
17:15	Probiotic bacteria and yeasts as novel biocontrol agents of postharvest pathogens	Samir Droby
17:30 18:30	Business meeting	
20:00	**Congress Palace Gala Dinner**	

Friday, 24 May 2019

SESSION VII Postharvest Food safety		Chair: Roboson Machado and co-chair: Lise Korsten
09:15	*Listeria monocytogenes* in fresh fruits: The occurrence and potential mechanisms of contamination	Dumitru Macarisin
09:45	Behavior of *Listeria innocua* on cut cantaloupe during sanitization and refrigerated storage	Jennifer Perry
10:00	COFFEE BREAK	
SESSION VIII Advances and applied research in handling, packaging, transport, and distribution to reduce postharvest losses		Chair Dumitru Macarisin and co-chair Mette Goul Thomsen
10:30	Advances in applied research in handling, packing, transport and distribution to reduce postharvest losses - embracing the 4th industrial revolution	Lise Korsten
11:00	Comparison of the shelf life and surface mold population of Hungarian *Prunus cerasus* cultivars following different pre- and postharvest treatments	Ferenc Takács
11:15	Salicylic acid and chitosan retained strawberry fruit quality and phytochemical contents and decreased decay extension during cold storage	Mohammadreza Asghari
11:30	Pre -and post-harvest factors determining carrot storability	Mette Goul Thomsen
11:45	General Discussion and closure of the Vth ISPP	
12:30	LUNCH	

Poster sessions

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P001	Early detection of fungal storage pathogens on pome fruits	Ulrike Persen
P002	Storage spoilage in Swedish apple production and novel ways of predicting storability	Joakim Sjöstrand
P003	Volatile fingerprinting of potato rots during cold storage	Maria Gutiérrez Pozo
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P004	Use of clean technologies to control postharvest diseases and anthracnose incidence in papaya	Carmen Villalobos Rivera
P005	Insights into molecular events controlling LED Blue light-induced resistance against *Penicillium digitatum* in citrus fruits	Teresa Lafuente
P006	Effect of hyperbaric pressures treatments on cashew peduncle postharvest diseases	Ben-Hur Mattiuz
P007	Preliminary investigations on the effect of low-pressure treatment on in vitro and vivo growth of *Penicillium* sp. in oranges	John Archer
P008	Dynamic Controlled Atmosphere (DCA): a chance for sustainable storage of fruit, maintaining quality and better volatile profile	Daniel Neuwald
P009	Antioxidant of bamboo leaves controls surface browning in fresh-cut apples	Chen Chen
P010	Organic oils fumigation and ozonated cold storage influence superficial scald disorder and fruit quality in Granny Smith apples	Rahil Malekipoor
P011	Effect of hydrocooling in electrolyzed water on reducing fruit rot diseases and maintaining postharvest quality of rambutan	Pongphen Jitareerat

SESSION III (20-21 May)

P012	Analysis of changes in the expression of genes belonging to two pectinase families as a potential virulence mechanism of *Monilinia laxa*	Núria Baró-Montel
P013	PpWRKY33, a key transcription factor, is associated with the host response to *Rhizopus stolonifer* infection in peach fruit	Nana Ji
P014	cAMP signaling regulates appressorium formation and virulence of *Alternatia alternata* induced by cuticular wax of pear fruit	Yongcai Li
P015	New insights into griseofulvin biosynthesis by *Penicillium griseofulvum*, an agent of blue mould on apples	Silvia Valente
P016	Development of *Neofabraea vagabunda* infection during apple storage: interplay between the pathogen and fruit volatile metabolism	Fiorella Neri
P017	Changes in prevalence of postharvest fungal pathogens after a single orchard incursion by *Pseudomonas syringae* pv. actinidiae	Kerry Everett
P018	Identification and characterization of *Botrytis* isolates obtained from blossom blighted flowers and fruits with calyx-end rot in Chile	Enrique Ferrada
P019	*Phacidiopycnis washingtonensis*, a newly discovered pathogen on apple in Norway	Jorunn Borve
P020	Bull´s Eye Rot Development in Stored Apple Fruit in Chile is Related to the Timing of Infection in the Orchard by *Neofabraea vagabunda*	Mauricio Lolas
P021	Postharvest fungal pathogens of pomegranate fruit in southern Italy	Antonio Ippolito
P022	Survey on *Moniliniae* affecting stone fruits in the Marche region, Central-eastern Italy	Gianfranco Romanazzi
P023	Quince fruit susceptibility to postharvest fungal pathogens	Natasa Duduk
P024	Incidence of postharvest diseases of *Brassica napus* var. *napobrassica*	Belachew Asalf
P025	Black mold of stored onion bulbs caused by *Aspergillus welwitschiae*	Ivana Vico

P026	Evaluation of pink spots on rose petals and their relationship to *Botrytis cinerea*	Melissa Munoz

SESSION IV (20-21 May)

P027	Latent postharvest pathogens and their management: from single measures to a systems intervention approach	Marcel Wenneker
P028	Exploring the effects of gaseous ozone (O3) and 1-Methylcyclopropene (1-MCP) treatments on the development of *Penicillium expansum* and patulin production on apple fruits (cv. Granny Smith) using `omics´' approaches	Georgios Karaoglanidis
P029	Traditional and alternative strategies to protect apple fruits against scald	Vladimir Gudkovski
P030	Promising technology to control bitter pit and other postharvest physiological diseases	Vladimir Gudkovski
P031	Efficacy of postharvest fungicides against Bull's eye rot of apple	Cheryl Lennox
P032	Selecting an isolate of *Penicillium digitatum* resistant to Imazalil from ‘W. Murcott’ and ‘Nova’ mandarin fruits	Liliana Aragon
P033	Salicylic acid enhances the positive effects of a chitosan-based edible coating in extending the postharvest life of harvested grapes	Mohammadreza Asghari
P034	Preharvest and postharvest fungicide applications for the control of gray mold on postharvest decay of strawberries, and fungicide residues on the fruit	Gianfranco Romanazzi
P035	Effect of precooling with sodium carbonate on fruit rot and physiological changes in organic netted melon	Pongphen Jitareerat
P036	Acetylsalicylic Acid treatment reduces Fusarium rot development and neosolaniol accumulation in muskmelon fruit	Huali Xue
P037	Pomegranate decay fungi occurring in South Africa and their control	Elrita Venter
P038	Fludioxonil: a potential alternative for postharvest disease control in mango fruit	Noam Alkan

P039	Combined efficacy of hot vapor, sodium chlorite, and PVC film on postharvest decay and browning of trimmed aromatic coconut	Pongphen Jitareerat
P040	Control of postharvest anthracnose in papayas (*Carica papaya* L.) by hot water and chitosan	Silvia Valencia Chamorro
P041	Effect of ascorbic acid and modified atmosphere packaging on browning of fresh-cut eggplant	Wenzhong Hu

SESSION V (23-24 May)

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P043	Screening of biological control agents against *Alternaria alternata* causing postharvest black spot of persimmon	Neus Teixidó
P044	Biocontrol of mango anthracnose: isolation of new bacterial antagonists of *Colletotrichum* from mango surface	Ahmed Taibi
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P046	Efficacy of *Bacillus amyloliquefaciens* cyclic lipopeptide supernatant to control pomegranate blue mould fungi in vitro	Cheryl Lennox
P047	Lipopeptides, fengycin and iturin A, from *Bacillus amyloliquefaciens* as postharvest fungicides on pome	Cheryl Lennox
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P049	Investigating the protein expression profile and transcriprome characterization of *Penicillium expansum* induced by *Meyerozyma guilliermondii*	Qiya Yang
P050	*Aureobasidium pullulans* strain Ach1-1 : a potential biocontrol agent of postharvest diseases of apples	Hanene Badri
P051	Verifying the potential of novel film-forming formulations of the biocontrol agent *Candida sake* CPA-1: influence of abiotic factors and efficacy on different hosts	Rosario Torres
P052	Ecological niches and environmental resilience of different formulations of the biocontrol agent *Candida sake* CPA-1 using the Bioscreen C	Neus Teixidó
P053	Strategies to enhance the efficacy of biological control organisms against wound pathogens causing storage diseases on apples	Wendy Van Hemelrijck

P054	Antifungal activity of sage (*Salvia triloba* L.) essential oil against key postharvest pathogens	Nikolaos Tzortzakis
P055	Screening of essential oil as potential postharvest biofungicide	Simon Dal Maso
P056	Exposure to volatiles of essential oils to control gray mold disease of strawberry	Claudia Mattiuz
P057	Improved quality of washed carrots by use of essential oils	Justyna Wieczynska
P058	Antifungal activity of essential oils and their combinations against postharvest fruit pathogen	Josemar G. de Oliveira Filho
P059	Antifungal activity of *Zingiber officinale* Roscoe (ginger) extracts on postharvest pathogen	Marcela Miranda
P060	In vitro antifungal activity of lemon (*Citrus limon* L.) waste extracts against *Alternaria alternata* and *Alternaria citri*	John Golding
P061	Transcriptomic response of orange fruit to a pomegranate peel extract	Imen Belgacem
P062	Physical and antifungal characterization of starch-based-edible film containing Fennel oil	Hai-tao Long
P063	Effect of carnauba wax nanoemulsion coating on postharvest papaya quality	Marcos David Ferreira
P064	Effects of carnauba wax and chitosan bilayer edible coating on the shelf life of fresh-cut apple	Marcos David Ferreira
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P067	Preharvest chitosan sprays promote epidermal lignification of harvested potato tubers	Yan Zhu
P068	Salicylic acid dipping promotes wound healing of potato tubers	Yi Wang
P069	Effect of wound-healing strategies on postharvest disease development in carrot (*Daucus carota* subsp. *Sativus*)	Pia Heltoft
P070	Foliage sprays of calcium during cultivation to control postharvest gray mold rot of bell peppers	Carmit Ziv

P071	Preliminary evaluations of postharvest organic treatments against *Monilinia* and *Botrytis* cherry decay	John Golding
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P079	Application of Ultraviolet C light as alternative sanitation technology for keeping safety of fresh raspberries	Carmen Villalobos Rivera
P080	Antioxidant capacity of fermentation broth of fresh-cut fruits and vegetables scraps and its application as a detoxifying agent	Aili Jiang

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P082	Hot water treatment and modified atmosphere packaging reduce decay of 'tainung no.2' papaya (*Carica papaya* L.) fruits during low temperature Storage	Jeng-Jung Shyr
P083	Comparison of sanitation systems on air and fruit quality during cold storage of white currant, red currant and blueberry	Dario Angeli
P084	Aqueous ozone treatment decreased degradation of cell-wall polysaccharides in fresh-cut apple during cold storage	Chenghui Liu
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Abstracts

Opening Session

Postharvest treatments today and in the future: perspectives from the plant protection industry

Ir. Geoffrroy de Chabot-Tramecourt, Turnhoutseweg 30, 2340 Beerse, Belgium; gdchabot@its.jnj.com

Abstract body text:

Postharvest processing is a critical step in the preservation and shelf life extension of fruit. In particular, this presentation will describe the actual use of plant protection products in postharvest processing, their advantages and disadvantages. It's critical to understand why active substances like Imazalil or Thiabendazole have been on the market for decades. The postharvest market is driven by "technic" and not by "marketing". Above all, efficacy, in all its aspects (including antifungal spectrum, compatibility with common practices or resistance management), is the driver in the postharvest industry. New active substances or technologies applied on fruits once harvested need to have a significant number of additional features, including price positioning or regulatory compliances, to be used by packers. These features and the future state of the postharvest market will be addressed in this presentation.

Is there still a future for chemicals, or will products of natural origin replace the existing solutions for controlling decay and reducing physiological disorders? This presentation will focus on some natural origin products (plants extracts or fermentation products) and will describe why these products may be used in postharvest. The presentation will also insist on the existing and future unmet needs. With the non-renewal of Guazatine and the future ban of Propiconazole, a disease like sour rot (*Geotrichum candidum*) will become a major problem for the citrus industry but also an opportunity for plant protection companies. The number of comparable examples is increasing, and some will be addressed here.

If we assume that the increasing world population will consume more and more fresh produce, research institutes, universities and start-ups should be clearly aware of the current and future unmet needs of this industry. Consumers should still be supplied in the future with abundant, diversified, safe and quality fresh produce. This connexion between the reality of the market at global level and the scientific world is pivotal for providing innovations that will address the existing and future technical challenges in postharvest.

Keywords: Pesticides, alternative technologies, innovation, research, regulatory

Physiology and pathology: the intersection between postharvest technologies

Prof. Dr. Christopher B. Watkins, Cornell University, School of Integrative Plant Science, Ithaca, NY 14853-5908, United States of America; chris.watkins@cornell.edu

Abstract body text:

Postharvest physiology and pathology and closely intertwined, but often appear to operate as parallel but separate research endeavors. An example, is the research efforts in edible coatings such as chitosan but relatively little effort on physiological effects on quality of horticultural products and their consumer acceptance. In addition, there can often be a separation between availability of postharvest technologies and their adoption. Temperature and relative humidity control, sometimes supplemented with controlled atmosphere (CA) storage and modified atmosphere packaging (MAP) storage, are the primary technologies that are used around the world to maintain quality of horticultural products. In the last decade or so, 1-methylcyclopropene (1-MCP) has been tested extensively for fruits and vegetable but application is primarily limited to apples for a number of reasons including the challenges of ripening recovery of some treated products and cost benefit ratios. Another new technology, known as dynamic controlled atmosphere (DCA), has also been developed and is sometime used in conjunction with 1-MCP. Other technologies such as heat treatments, edible coatings and irradiation meet specific needs that can make them economically viable, although application can be limited by consumer preferences. A whole range of potential technologies such as nitric oxide have also been extensively tested, along with other chemicals such as salicylic acid, polyamines and ɣ-aminobutyric acid. However, the potential for commercial development remains less clear as factors such as patent control can be critical to their successful commercialization. In this overview, research approaches that are being actively explored for use in disease control will be discussed in terms of commercialization within existing and new postharvest technologies.

Keywords: Physiology; fruit; vegetables; postharvest technologies

Session I - Smart Innovative Technololologies for Detection of Postharvest Pathogens and toxic metabolites

KEYNOTE SPEECH Smart innovative technologies for detection of postharvest fungal pathogens and their toxic metabolites

Author: Dr. Simona Marianna Sanzani, DISSPA, University of Bari Aldo Moro, Bari, Italy; simonamarianna.sanzani@uniba.it

Abstract body text:

A substantial portion of fruits and vegetables is lost after harvest mainly because of fungi-induced rots. Moreover, several genera and species produce toxic metabolites. Specifically, species of the genera *Aspergillus*, *Penicillium*, and *Alternaria*, causing postharvest rots, produce mycotoxins that are harmful to human and animal health, so that regulatory limits for harvested commodities and by-products have been set by national and international legislation. Recently, the role of mycotoxins as pathogenicity factors has been supported, and thus reduced contamination might have disease control significance. The use of conventional fungicides on harvested commodities is often not allowed or ineffective because of the development of fungicide-resistant strains which is also enhanced by their use at suboptimal concentration to maintain low residue levels. Thus, the use of alternative control means (e.g. microbial antagonists, natural compounds, physical means, etc.) is becoming increasingly popular. However, alternatives have a better chance of success if applied at optimum timing, and thus the early and rapid detection of pathogens of fundamental importance. Traditional diagnostic tools require large quantity of target tissue and multiple steps to accurately identify pathogens and as such they are time-consuming and not sensitive. Consequently, innovative tools are needed to improve the accuracy and promptness in diagnosing plant pathogens and their toxic metabolites. They in turn will facilitate high-throughput analysis, and might be used for efficient monitoring and crop protection. Such accurate technology might help in designing an integrated disease management strategy for controlling postharvest pathogens.

Keywords: Detection, fungi, mycotoxins, molecular tools

S-I-O1 The application of information technology for diagnosing postharvest diseases of apple

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Abstract body text:

South Tyrol (northern Italy) produces around one million metric tons of apple fruit annually and contributes approximately 10% of the European apple production. Despite the availability of advanced storage technologies, postharvest diseases of apple may lead to the deterioration of quality and losses of fruit not only during storage but also in the course of packing, shipment and shelf-life. In order to decide on a strategy for damage containment or to implement plant protection programs, a reliable determination of the disease is crucial. Apart from the observation of macroscopic symptoms and the application of laboratory-dependent microscopic, microbiological and molecular methods, a variety of novel approaches for the detection of plant diseases and pathogens are being developed. The present study focuses on the potential of information technology that could bring the diagnosis finding process closer to the practitioners. Particular attention is on the use of images in combination with decision support systems or the application of computer vision techniques. A review about the implementation of existing informatics-based tools to diagnose plant diseases is provided and an assessment of potential applications for the detection of postharvest pathogens is discussed. Finally, the outline of the research project DSSApple that focuses on the development of a decision support system for the determination of postharvest diseases of apples is presented.

Keywords: Postharvest pathogens; *Malus domestica*; disease diagnosis; information technology

S-I-O2 Phenotypic characterization of Bull's eye rot and bitter rot pathogens in South Tyrol isolated from apple fruits after storage

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Abstract body text:

South Tyrol (northern Italy) is the largest continuous apple producing area in Europe. Apples can be stored for prolonged periods, due to advanced conservation technologies. Nevertheless, pathogenic fungi can cause post-harvest diseases during and after storage and lead to significant losses. Bull's eye rot and bitter rot, which comprise several species of the genera *Neofabraea* and *Colletotrichum*, represent important diseases of apple fruit both during production as well as during storage. These diseases are difficult to be distinguished based merely on symptoms on the fruit and usually require expert phytopathological support, including molecular analysis. Reliable identification of specific pathogens, however, is the basic requirement for studying various aspects post-harvest diseases, as well as for the development of effective strategies for disease management. The aim of the present research was to provide a description of the morphological characteristics of *Neofabraea spp*. and *Colletotrichum spp*., isolated from symptomatic apple fruit after storage. In order to obtain apple fruit infected with different species of Bull's eye rot and bitter rot pathogens, several cooperatives representing different cultivation areas of South Tyrol were sampled. The pathogens were isolated on nutrient media from apples with characteristic symptoms and subsequently an optimized procedure for obtaining single-spore cultures was set up. The cultures obtained by the improved procedure, which identity was confirmed by molecular means, provided the basis for the assessment of morphological characteristics of various pathogenic species, considering the morphology of colonies, hyphae and spores. Single-spore isolates furthermore represent the starting point for the development of novel diagnostic procedures of postharvest disease pathogens such as image-based determination or rapid molecular fingerprinting that are further discussed.

Keywords: *Neofabraea spp*., *Colletotrichum spp*., diagnosis

S-I-O3 High Resolution Melting (HRM) as a tool to characterize *Aspergillus* and *Penicillium* populations of pomegranate fruit

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Abstract body text:

Because of its nutraceutical and cosmeceutical properties, production and consumption of pomegranate fruit is increasing worldwide. Postharvest fruit losses caused by fungal pathogens are one of the main issues, due to the risk of contamination by mycotoxins of both fresh and processed products. As an example, within *Penicillium* and *Aspergillus* genera there are species producing mycotoxins, such as ochratoxin A (OTA) and fumonisins, that are hazardous to human health, so that the European Commission regulates their thresholds in food and feed. In this investigation, two collections, one of *Penicillium spp*. and one of *Aspergillus spp*. belonging to section Nigri, from symptomatic pomegranate fruit of various cultivars were characterized. Since their morphological identification at species level was not easy, and to avoid the misidentification between *Talaromyces* and *Penicillium sensu stricto (s.s.)* genera, which are both included in *Penicillium sensu lato (s.l.)*, a *Talaromyces*-specific PCR assay and two genus-specific and species-discriminating HRM assays were set up. Moreover, the presence of OTA and fumonisin genes was evaluated. Ninety percent of the collection of *Penicillium s.l.* proved to be made up of *Penicillium s.s.* strains, within which *P. glabrum* proved to be the most represented species. None of the tested strains possessed a key biosynthetic gene of OTA. Whereas, within *Aspergillus* section Nigri, *A. tubingensis* and *A. welwitschiaewere* were the most represented species, and several strains of this last species were able to produce fumonisins.

Keywords: HRM, *Penicillium*, *Aspergillus*, pomegranate, fruit rot

S-I-O4 Volatiles as biomarker for *Erwinia* infection in potato

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Abstract body text:

In Northern Europe, potatoes are harvested at the end of the summer period and kept in large storage facilities for many months. Depending on the agreed delivery time, the demand on the market and/or the quality during storage, potatoes are sold. Higher quality potatoes, delivered at agreed delivery time, or at a time of high market demand, will lead to a higher price and thus more profit for the potato grower. One of the important quality issues during storage is the development of rot, often caused by infection with bacteria belonging to the family of *Pectobacteriaceae* causing soft rot (*Pectobacterium* and *Dickeya* species). Initial infection can spread to neighbouring tubers and therefore trigger a wide infection. Such infections can start anywhere in a potato pile and are thus not always immediately visible, leading to extensive product losses. Respiration and volatile production of healthy, wounded and soft rot-infected potatoes was measured over time using GC and PTR-ToF-MS. We observed that both the respiration, as well as the production of specific volatiles increases significantly in potatoes infected by *Pectobacterium polaris*. This indicates that there is a potential to use the respiration and volatile-profile as biomarkers for early and remote detection of rot in potato. This would allow growers to take action by adjusting the storage regime to prevent further spread of infection and extend storage of the healthy potatoes. Depending on the demand on the market, growers could also decide to bring batches showing no signs of infection to the market while the quality is still acceptable, thereby increasing profit for the grower.

Keywords: Potato, bacteria, volatiles, respiration, quality prediction, physiology, industry implications

P001 Early detection of fungal storage pathogens on pome fruit

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Fungal storage pathogens on pome fruits cause economic losses in all European countries. They may also be considered a risk for the export of fruit as a commodity from Europe to third countries due to the quarantine status of some fungal diseases for the importing countries. For most postharvest diseases, infection of the fruit may already have inflicted in the field. The risk of infections increases with suitable weather conditions, susceptible cultivars, insufficient orchard sanitation or other plant protection measures and timing of harvest. A main challenge is to know the status of infection of potential postharvest pathogens before fruit are transferred into cold storage due to absence of symptoms at that time. A research project (coordinated under ERA-NET EUPHRESCO frame network) has been initiated to establish tools for the detection of these fungi during their latent period. The overall goal is to provide qualitative and quantitative early detection systems for pathogenic storage fungi, which in the future would possibly allow preventive measures during fruit production, harvest and further processing to diminish losses caused by pathogens in long term storage of pome fruit. The consortium consists of four additional partners (InHort - PL, FGBU VNIIKR - RU, WUR - NL, USAMV – RO). In a first step, the causal agents of storage rots will be identified and the relevant pathogens will be selected for further studies. The main focus will be on molecular tools, supplemented by morphological studies. In parallel this project will provide data on fungal diversity on apple and pear fruits using NGS technology before storage. The aim is to link the detection results to the pathogens identified from symptomatic fruits after storage. For the most important fungi, detection and identification protocols will be established. With emphasis on early quantitative detection, the best timing and location (in the field, in the packing house…) for sampling should be identified. A correlation of the incidence of selected diseases with duration of storage, cultivar susceptibility and storage conditions will be established. First results will be presented.

Keywords: Post-harvest disease, isolation, identification, decay, qPCR, diversity, NGS, latent infection, *Malus, Pyrus*

P002 Storage spoilage in Swedish apple production and novel ways of predicting storability

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Abstract body text:

Swedish apple industry faces many challenges when it comes to storage of apples. Pathogens such as *Colleotrichum spp*., *Neofabrea spp*., *Botrytis cinerea* and *Penicillium expansum* cause substantial losses during storage. Also physiological disorders like soft scald and senescent breakdown contribute to fruit losses. Many of these storage diseases and disorders are aggravated by either a too early or too late harvest time. To estimate optimal harvest time is, however, difficult and at the moment reliant on destructive maturity tests using a small number of arbitrarily selected fruit. These tests may therefore not give the full picture of the ripeness across the orchard. To get a better prediction of optimal harvest time, a so called DA-meter is used in an investigation to compare this non-destructive method with traditional maturity indices. By emitting wavelengths of light around chlorophyll's absorbance spectra, a value is calculated which correlates well with fruit maturity. The DA-meter is a hand-held device that is easy to use and does not harm the fruit. It might be used in the orchard by the growers to get a more accurate measure of ripeness as more fruits can be tested. The method has been used in both Europe and Australia but optimal values for storage of Swedish apple varieties are unknown. Storage trials are conducted for nine of the most commercially interesting Swedish apple cultivars with different DA-values and the aim is to find the optimal values for harvest time and also for when to take the fruit out of storage. Quality indices such as soluble solids and firmness are recorded. Storage diseases as well as storage disorders are monitored during the trials. By using DA-meters to get more accurate maturity indices a better quality of fruit can be obtained as well as less fruit damaged by pathogens during storage.

Keywords: DA-meter, Storage diseases, Maturity indices, Storability, Apple, DA-value

P003 Volatile fingerprinting of potato rots during cold storage

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Abstract body text:

Potato crop can be divided into two different categories depending on the destination of potato tubers, they can be sell as a fresh or a processed product. Almost half of potato crop is sold as a fresh product for immediate use, while the rest is stored at cold temperatures (4-10^{o}C) for up to 10 months. Storage is a dynamic situation where all environmental factors, mainly temperature (4-10^{o}C) and relative humidity (95-98%), need to be optimized. Otherwise, an optimal condition for fungal and bacterial growth can emerge. Potato storage diseases have a significant impact on the potato market by increasing potato spoilage and consequently, the generation of loss and waste. The aim of this work is to utilize the Volatile Organic Compound (VOC) as biomarkers for identification of potato rots, as a quick, non-destructive and real time detection tool of potato storage diseases. The work focused on two main diseases affecting potato tubers; soft rot (*Pectobacterium carotovorum atrosepticum*) and dry rot (*Fusarium sambucinum*). Potato tubers (Casablanca and Record variety) were inoculated with these pathogens and stored at 8.5^{o}C. VOCs were sampled using a pre-concentration method, and were analyzed using Thermal Desorption-Gas Chromatography-Time of Flight-Mass Spectrometry. Identification of possible biomarkers of each of the pathogens studied is underway. The results will be used for the development of an interactive storage sensor system which will be a low-cost, compact and sensitive multi-species trace gas sensor that monitors emitted gases from fresh agro products under commercial storage conditions.

Keywords: VOC, *Pectobacterium carotovorum atrosepticum*, *Fusarium sambucinum*, potato tubers, soft rot, dry rot, post-harvest diseases, postharvest, spoilage

Session II - Innovation in Postharvest Disease Control

KEYNOTE SPEECH The next thirty years: Envisioning the future of postharvest disease research

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The concept of postharvest biological control was literally conceived about 30 – 40 years ago through the early work of Tronsmo on strawberries, Pusey and Wilson on peach and later apple, and Chalutz and Droby on citrus. The field rapidly grew and many antagonists and products (commercial and potential) were developed through the excellent research conducted in many labs throughout the world (especially in Europe, South America, ad South Africa). The science of postharvest biological control has also grown tremendously and we know more than ever before about the antagonists, their mechanisms of action, and their interactions with their hosts and pathogens. Other alternatives have also arisen as stand-alone approaches or as part of an "integrated postharvest disease management system," that may or may not include the use of biocontrol agents. These alternatives include the use of many different "naturally-ocurring" bioactive substances (e.g., essential oils, GRAS compounds, microbially-produced compounds), and physical applications (e.g., heat, UV, ozone, ROS-activated water). As many of these alternatives have been only rudimentarily accepted or explored by industry, it may be a good time to raise the question of why and ask where the field is heading and what will be the new innovations that drive this field forward in the future? What will the new approaches and products look-like in the future? Importantly, the central driving force for this research must always be kept in mind, namely, the need to find safe and effective alternatives to the use of synthetic chemicals that pose a risk to human health, other organisms, and the environment. This central premise has also been greatly enlarged by the challenges of this and coming generations, climate change, exponential growth in population, food security, cultural conflicts, and the need for appropriate technologies for developing countries. All these factors will increase the challenge of maintaining an adequate, high-quality, food supply. Innovation is often driven by two major forces: paradigm shifts and advances in technology. Both have provided and will provide the fuel for future advances in postharvest disease management. Advances in genetics (fueled by NGS, and other -omic technologies) have allowed researchers to discover a wealth of knowledge about the pathogens, hosts, and antagonists we work with. These advances are also fostering new paradigms about how an organism is defined, how it has evolved, and how its well-being is dependent on the state of the metaorganism (organism plus its associated microbiota). These concepts are relatively new but are slowly and dramatically changing how we think about organisms and disease prevention, including preharvest and postharvest fruit biology. This new paradigm is encompassed in microbiome research, and synthetic biology. We are learning more and more about the diversity and function of the fruit microbiome. Identifying "core" microbiomes, elucidating the genetic control of the microbiome, and how to manipulate the

fruit microbiome in a beneficial and controlled manner are topics that will be the driving-forces of future innovation. Lastly, the field of bioinformatics and artificial intelligence (AI) also represents a driving force for future innovation. The ability of computers to "make-visible" the information encompassed in millions of data points, and reveal the interactions that occur in numerous interacting entities will dramatically enhance our understanding of biological systems. For those of us who have been involved in postharvest disease research for 30-40 years we can only stand in awe of what is yet to come and do our best to foster the development of young scientists. Be humble, be open and ethical, care about the world at large, and look to the arts for inspiration, everything starts as a "wild-idea" born in one's imagination.

Keywords: Innovative technologies, synthetic biology, core microbiome, apple

S-II-O1 Extension of shelf life of *Penicillium digitatum* infected sweet oranges by vapor heat treatment

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Heat treatment protocols making use of hot water for postharvest decay control on oranges has the disadvantage of the water serving as source of inoculum for wounded fruits. Vapor heat has the potential of eliminating this problem. Orange fruits inoculated with *P. digitatum,* exposed to heat as steam at 55° and 60°C, stored at tropical ambient temperature (28-30°C) had extended shelf-life. Exposure at 55°C for 25, 30 and 35 minutes and 60°C for 30, 35 and 40 minutes were observed to preserve fruits for a minimum of 40 days when the control fruits had started showing decay symptoms on day 6 post treatment. Inoculated fruits exposed to vapor heat at 60°C for 30 minutes remained disease free for 100 days. In vitro studies indicated that exposure to vapor heat did not significantly affect germination of spores of *P. digitatum* but significantly reduced germ tube extension, showing that the treatment was effective because it prevented the fungal mycelium from growing into and colonizing the host despite spore germination. The method, at indicated protocols is recommended for routine postharvest treatment of sweet oranges for significant extension of storage life at tropical ambient storage.

Keywords: Vapor heat, sweet orange, decay, *Penicillium* infection, ambient storage

P004 Use of clean technologies to control postharvest diseases and anthracnose incidence in papaya

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Abstract body text:

The susceptibility of papaya to postharvest diseases is high. Fungal growth and anthracnose are considered one of the most significant. Synthetic fungicides are the most used for postharvest disease control. Nevertheless, these products have been turning out to have a restricted application due to its negative effects on health. The aim of this work was to study the effect of clean technologies as alternative for postharvest quality and pathology control. Papaya fruits were selected and subsequently treated with several clean technologies: Mild Heat Treatment at 45°C for 5 minutes (MHT45), Mild Heat Treatment at 70°C for 1 minute (MHT70), Ultrasounds at ambient temperature for 10 minutes (USTA) and Ultrasounds at 50 °C for 1 minute (US50). Additionally, non-treated fruits were used as control. After treatments, fruits were dried and stored at 8°C. Weight loss, respiration rates, firmness, aerobic mesophilic bacteria, moulds, yeast counts and anthracnose incidence were monitored after 0, 5, 14 and 21 days of storage. The fruit treated with ultrasounds had an increase in the respiration rate and in weight loss, whilst the application of MHT lead to a lower respiration rate and weight loss. Conversely, the treatments assessed, especially US50 and MHT70, resulted in fruit with higher firmness compared to the control. In US50, MHT45 and MHT70 treatments bacterial counts of 6.45, 5.79 and 7.21 cfu g-1, respectively versus counts of 9,95 cfu g-1 for control fruit after 21 days. These treatments also resulted in lower fungal counts of 4.95, 2.00 and 3.30 cfu g-1 versus counts of 6.93 cfu g-1 detected for control fruit after 21 days of storage. Consequently, the anthracnose visual incidence was reduced up to 80% following the application of MHT treatments. Thus, the application of treatments such as MHT at 70°C might be a suitable alternative for the control of pathogens and enhancing postharvest quality.

Keywords: Clean technologies, anthranose, postharvest quality, papaya

P005 Insights into molecular events controlling LED Blue light-induced resistance against *Penicillium digitatum* in citrus fruits

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Abstract body text:

Green mold rot, caused by *Penicillium digitatum* (Pers.:Fr.) Sacc., is the most important postharvest disease of citrus fruit grown under Mediterranean climate conditions. The potential of LED Blue Light (LBL) for controlling the growth of different *P. digitatum* strains and for inducing resistance against this pathogen in citrus fruits has been proven. The objective of this study was to get an overview of the molecular events associated with the LBL-elicited resistance. We examined changes in the transcriptome of the flavedo (outer colored part of the peel) of mature Lane Late oranges (*Citrus sinensis* (L.) Osbeck) when they were treated for 2 days with 60 µmol m-2s-1 LBL (0 day post-treatment, 0 dpt) and when they were transferred to darkness for 3 days (3 dpt). Fruits were infected with *P. digitatum* only to determine the efficacy of the light treatments to elicit resistance. Elicitation of resistance was higher at 3 than at 0 dpt. The transcriptomic analysis of flavedo of non-inoculated fruit samples taken at 0 and 3 dpt showed that major gene expression changes occur at 0 dpt; and that LBL has an important impact favoring xenobiotics and starch degradation and repressing processes related to cell wall degradation. Likewise, transcriptomic analysis revealed that LBL-elicited resistance may be related to the induction of processes related to light reactions, including Calvin cycle and photorespiration processes, to lipid metabolism, and also to the induction of oxidative stress-related proteins. LBL also induced the expression of genes involved in the secondary metabolism, which were mainly related to the phenylpropanoid metabolism, the synthesis of lignin and lignans, coumarins, and also of alkaloids-like compounds, in the peel of citrus fruits.

Keywords: Transcriptomic, induced resistance, infection, light emitting diodes, *Penicillium digitatum*

P006 Effect of hyperbaric pressure treatments on cashew peduncle postharvest diseases

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Abstract body text:
Cashew apple is a fleshy and juicy pseudofruit native of Brazil. It presents great aroma, high levels of ascorbic acid and bioactive compounds. Despite the nutritional condition, the shelf life and in natura commercialization of the peduncle is limited mainly due to its high perishability and susceptibility to the attack of pathogenic microorganisms, especially the fungi of the genera *Colletotrichum*, *Cladosporium*, *Rhizopus*, *Alternaria*. The objective of this work was to evaluate the effect of hyperbaric pressure treatments in the control of diseases in cashew peduncles. Cashew peduncles of cultivar Anão Precoce CCP 076 were used. The cashew peduncles were treated with the hyperbaric pressures of 100 (control), 200, 400, 600 and 800 kPa for 1, 2 and 4 days (t1, t2, t4) at 22 °C and 95% RH, followed by another 2 days to simulate the commercialization period. The incidence of diseases was evaluated, with grades attributed to the percentage of affected area of the pseudofruit: [0] without diseases; [1] low (1 to 10%); [2] medium (11 to 20%); [3] severe (21 to 30%); and [4] very severe (≥ 31%). Cashew peduncles of the control (100 kPa) presented the highest percentage of diseases, reaching the area considered as commercial discard (31%) at 4 days of storage. It was verified the occurrence of lower incidence of diseases with the increase of the applied pressure among the treatments. Cashew peduncles submitted to 800 kPa pressure presented little or no disease incidence and maintained commercial quality (appearance, color, firmness) until the end of storage (t4 + 2d). In addition to extending the postharvest quality of the cashew peduncles for 6 days at a temperature of 22 °C, the hyperbaric pressure of 800 kPa was efficient in the control of cashew peduncle diseases.

Keywords: *Anacardium occidentalis* L., hyperbaric atmosphere, postharvest pathology, cashew peduncle rot, postharvest quality

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P007 Preliminary investigations on the effect of low-pressure treatment on *in vitro* and *in vivo* growth of *Penicillium sp*. in oranges

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Abstract body text:

Green mould (*Penicillium digitatum*) is the major postharvest decay in citrus. *Penicillum* decay is currently controlled with synthetic fungicides but there is a growing need to reduce the reliance on synthetic fungicides and find alternative treatments. Low-pressure treatments may offer a potential solution for the storage and transport of citrus, as it is a physical treatment and does not leave any chemical residues. To test the effectiveness of low pressure storage treatments on *Penicillium* growth, small-scale laboratory experiments were conducted with specialist low pressure chambers. *P. digitatum* was grown on PDA agar plates and treated with low pressure (4 kPa) for either 3 or 6 days before growth assessments in air at regular atmospheres. The results showed that low pressure treatments slowed the growth of *P. digitatum*. In a further experiment on oranges, *P. digitatum* infected fruit were treated with low pressure (4 kPa) at 5^{o}C for up to 22 days. This experiment also showed a reduced growth of *Penicillium* in vivo. These results show there is a potential to control the growth of *P. digitatum* at low pressure treatments. More work is continuing.

Keywords: Low pressure, *Penicillium*, citrus

P008 Dynamic Controlled Atmosphere (DCA): a chance for sustainable storage of fruit, maintaining quality and better volatile profile

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Abstract body text:

The development of modern storage systems went from cool storage to CA-storage, to ULO-storage. Since a few years DCA-storage is more and more examined. The threshold for oxygen partial pressure was undercut every time a new method applied. Three different possibilities to control “oxygen stress” exist. Measurement of chlorophyll fluorescence (DCA-CF), anaerobic metabolism products (DCA-Eth) or respiratory quotient (DCA-RQ) are based on dynamical variation of oxygen levels, depending on stress signal occurring in case of anaerobic metabolism. By low oxygen concentrations in storage, respiration is running at a minimum. Therefore, the ripening process is slowed down, which is required for a long storability and maintenance of fruit quality. The lowest oxygen limit (LOL) is the level that apples can be stored without damage, changes according to the cultivar, storage period, temperature, maturity stage, etc., ranging between 0.05 and 0.8kPa O_2. If, for example RQ is higher 1.0 the LOL is below the anaerobic compensation point, oxygen is exhausted and anaerobic metabolism occurs. This might result in off-flavor by production of alcoholic compounds like ethanol, acetaldehyde and ethyl acetate. Due to inhibition of ripening, either DCA-storage based on chlorophyll fluorescence (DCA-CF) or respiratory quotient (DCA-RQ) maintained the firmness as well as green ground color in ‘Elstar’ and ‘Nicoter’ apples. Incidence of physiological disorders like superficial scald is reduced in ‘Nicoter’ apples as well as fungal diseases in ‘Elstar’ apples, by the storage under DCA. The storage of ‘Elstar’ and ‘Nicoter’ apples under DCA-RQ resulted in a rise of compounds related to off-flavors, like acetaldehyde, ethanol and ethyl acetate, but its concentrations were below the odor thresholds. However, the storage under DCA-RQ resulted in higher concentration of butyl acetate, 2-methylbutyl acetate and hexyl acetate, which contribute positively to the apple aroma. The storage of ‘Elstar’ and ‘Nicoter’ apples in DCA-RQ maintain better overall quality and volatile profile as compared to CA storage. Thus, the adoption of DCA technologies in commercial rooms would be beneficial for both suppliers and consumers.

Keywords: Anaerobic metabolism, aroma, chlorophyll fluorescence (DCA-CF), fungal diseases, oxygen stress, physiological disorders, respiratory quotient (DCA-RQ),

P009 Antioxidant of bamboo leaves controls surface browning in fresh-cut apples

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Abstract body text:

The shelf-life and acceptability of fresh-cut apples is limited due to a surface browning during storage. The antioxidant of bamboo leaves (AOB) is a kind of polyphenols-rich extract from bamboo leaves and it has been certified as a natural antioxidant by the Ministry of Health of the People's Republic of China. Since browning-inhibitor formulations generally contain a reducing agent and/or possess antioxidant activity. We hypothesize that AOB can inhibit the surface browning of fresh-cut apples. Therefore, herein, the effect of AOB treatment (0.1 g L-1, 1 min) on inhibiting surface browning of fresh-cut apples stored for 12 d at 4 °C was studied. Browning index, H_2O_2 and malondialdehyde (MDA) contents, total phenolic content (TPC), the activity of polyphenol oxidase (PPO), peroxidase (POD), superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), glutathione reductase (GR), lipoxygenase (LOX) and non-enzymatic antioxidant activities (DPPH and ABTS assays) were measured. The results showed that AOB treatment effectively controlled the surface browning of fresh-cut apples during storage, accompanied by a reduction in LOX and PPO activities, H2O2 and MDA accumulation. Furthermore, AOB treatment enhanced the antioxidant enzymes (SOD, CAT, APX, GR and POD) and non-enzymatic antioxidant activities, thereby alleviating oxidative damage and membrane lipid peroxidation. The results indicated that AOB treatment controls the surface browning of fresh-cut apples by lowering the PPO activity, as well as enhancing enzymatic and non-enzymatic antioxidant activities. Therefore, treatment with AOB is a safe and promising strategy to control the surface browning and extend the shelf-life of fresh-cut apples.

Keywords: Antioxidant of bamboo leaves, fresh-cut apples, browning, antioxidant activity

P010 Organic oils fumigation and ozonated cold storage influence superficial scald disorder and fruit quality in Granny Smith apples

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Abstract body text:

Ethylene management during storage is challenging in organically grown apples due to limited available options. The objective of this investigation was to examine the effects of lemon and cinnamon oils fumigation on storage life, incidence of superficial scald and quality of *Malus pumila* 'Granny Smith' apple which were kept in cold storage with and without ozone. The fruit were fumigated with 3µl L-1 lemon or cinnamon oil for 24 h and untreated fruit were kept as a control. Following the treatments, the fruit were stored at (0.5 to -1°C) with and without ozone for 100 and 150 days. After each storage period, ethylene production and respiration rate, superficial scald and various fruit quality parameters were estimated. Lemon oil fumigated fruit showed significantly reduced mean climacteric peak ethylene production rate in 100 and 150 days stored fruit. Mean climacteric peak ethylene production rate was significantly reduced in the apples which were kept in an ozonated as compared to cold stored without ozone for 100 days. The climacteric ethylene peak was delayed only in 100 days cold stored fruit with ozone (8.78 d) as compared to without ozone (3.89 d). Firmness was significantly higher in the fruit fumigated with lemon or cinnamon oil compared to control for both storage time. Lemon or cinnamon oil fumigation significantly reduced superficial scald in cold stored fruit with or without ozone. The fruit fumigated with lemon oil or cinnamon oil following 150 days cold storage resulted in significantly higher levels of ascorbic acid and antioxidant capacity as compared to the control fruit. In conclusion, lemon oil fumigation was more effective in suppressing ethylene production in 100 -150 days cold stored fruit than cinnamon oil. Whilst, fumigation of lemon or cinnamon oil were effective in reducing superficial scald and maintaining quality in 100-150 days cold stored fruit.

Keywords: Apple, limonene oil, cinnamon oil, superficial scald, ozone, cold storage

P011 Effect of hydrocooling in electrolyzed water on reducing fruit rot diseases and maintaining postharvest quality of rambutan

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Abstract body text:

Rambutan (*Nephelium lappaeum* Linn.) is one of Thailand's major fresh fruit exports. The main problems of rambutan export are postharvest decay and rapid physiological changes during storage and transportation. Thus, the objective of this research was to investigate the effect of hydrocooling in electrolyzed water on fruit rot diseases and the quality of rambutan. Rambutan cv. 'Rong-rein' at color stage 4-5 (light red peel and green spinterns) were used in this study. The fruit were selected and washed in tap water. Then they were precooled in 200, 400 and 600 ppm electrolyzed water at 10°C for 3 min. Untreated fruit were served as the control. All fruit were packed in polyethylene bag and kept at 13°C (90-95% RH) for 15 days. The result revealed that the fruit hydrocooled in 400 ppm electrolyzed water showed the best effectiveness to reduce the incidence and severity of fruit rot diseases, followed by fruit hydrocooled in 600 ppm and 200 ppm electrolyzed water, whereas the control fruit showed the highest of fruit rot diseases. The decrease of disease correlated well with the increase of key plant defense-related enzyme activities such as phenylalanine ammonia lyase (PAL) and chitinase. Additionally, hydrocooling also maintained better quality by reducing weight loss and respiration rate. However, hydrocooling in electrolyzed water did not affect to total soluble solids (TSS) and peel color of rambutan in comparison with the control fruit.

Keywords: Electrolyzed water, fruit rot disease, hydrocooling, quality changes, rambutan

Session III - Elucidation of host pathogen interactions/ Molecular exploration

KEYNOTE SPEECH From gene expression to the packinghouse: can metal chelation be a possible alternative treatment to control fruit postharvest diseases?

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Abstract body text:

Previous transcriptomic studies conducted in our group have revealed that the synthesis of extracellular proteases and ion homeostasis are two processes highly induced during the infection process of citrus fruit by *P. digitatum*. The objective of the present study was to gain increased knowledge on the relevance of these processes for the virulence of *P. digitatum* and to determine if they have the potential for the development of new alternative control treatments. As proteases represent a large family of proteins, we attemptedto downregulate many of them by deleting the gene, *prtT*, which codes for a protein transcription factor that regulates the expression of secreted proteases. ΔprtT knockout mutants were obtained that exhibited a decrease in extracellular protease activity when grown *in vitro* compared to the wild-type. The mutants, however, were not impaired in their virulence towards citrus fruit. Gene expression analysis of the two major secreted proteases showed that the coding genes were still expressed during the infection process in the knockout mutant. This result precludes the ability to reach any conclusion regarding the potential role of proteases in virulence. A pharmacological approach was then used by inoculating fruits with the pathogen in the presence of a cocktail of protease inhibitors. This treatment drastically reduced the development of green mold on citrus fruit. The analysis of individual inhibitors indicated that an inhibitor of metalloproteases was responsible for the reduction in *P. digitatum* growth. The inhibitory effect was reversed by the addition of transition metals. Further *in vivo* studies confirmed that metal chelation was able to reduce green mold development even as a curative treatment. Metal chelation therapy was shown to be effective in controlling blue mold development in both citrus and apple fruits.

Keywords: Apple, blue mold, citrus, green mold, *Penicillium digitatum*, *Penicillium expansum*

S-III-O1 Scanning genomes to identify secondary metabolite production by postharvest pathogens

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Abstract body text:

Postharvest pathogens of fruits and nuts are characterized by their ability to produce a plethora of secondary metabolites, including harmful mycotoxins. For instance, *P. expansum*, the causal agent of blue mould, is the primary postharvest pathogen of stored apples and is able to produce patulin in different fruits. In addition to *P. expansum*, *P. crustosum* and *P. griseofulvum* can also cause postharvest decay on apples and are potential producers of patulin, roquefortine C, meleagrin, griseofulvin, and penitrem A. Other *Penicillium* spp. have been isolated from chestnuts and are virulent on both chestnuts and apples and are able to produce a wide range of secondary metabolites in infected fruit. Many biotic and abiotic factors are involved in the biosynthesis of secondary metabolites, which can be absent in laboratory conditions. As a consequence, the mycotoxigenic potential of *Penicillium* species can be underestimated. Due to the availability of data from fungal genome sequencing projects, however, many biosynthetic genes have been found to be arranged in gene clusters. Therefore, the evaluation and identification of potential mycotoxin gene clusters should be a component of the analysis of genomes. The mycotoxigenic potential of eight *Penicillium* species isolated from chestnuts was explored by both HPLC/MS-MS *in vitro* in culture and by Illumina high throughput sequencing. The comparative genomic approach identified a huge number of secondary metabolite clusters, which have the potential to be activated under favorable conditions. Combining genomic approaches with chemical and biological analyses provides the ability to identify favorable conditions for mycotoxin biosynthesis and to evaluate the relationship between secondary metabolite production and pathogenicity in postharvest storage of fruits.

Keywords: Apple, blue mould, chestnut, genome, mycotoxins, *Penicilium* spp.

S-III-O2 Whole-genome sequence of the brown rot fungal pathogen *Monilinia fructigena* Mfrg269 strain isolated in Italy

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Abstract body text:

The most important diseases of stone fruit and pome fruit trees are brown rot and blossom blight caused by *Monilinia* spp. Three apothecial ascomycetes species are considered to be economically significant: *Monilinia fructigena*, Honey ex Whetzel, *Monilinia laxa* (Aderhold & Ruhland) Honey, and *Monilinia fructicola* (G. Winter) Honey. Among these, *M. fructigena* is the primary cause of fruit rot, before and after storage and marketing. The aim of the present study was to provide a high-quality sequence of the *M. fructigena* genome, *de novo* assembly, and annotation of protein-coding genes. In this work, we provide a draft genome obtained from a monoconidial strain of *M. fructigena*, Mfrg269, isolated from plum in southern Italy (Tursi, Basilicata). A hybrid assembly strategy was applied to produce scaffolds using both, short 2 × 92-bp paired-end reads (Illumina Sequencing Technology; HiScanSQ platform; SELGE Network Sequencing Service, Bari, Italy) and long 20-kb reads (PacBio Sequencing Technology; RSII platform; Macrogen Inc., Next Generation Sequencing Service, Geumcheon-gu, Seoul, South Korea). Sequencing data were assembled into 131 scaffolds with a G+C content of 42.05% and a total assembly size of 43.125 Mb. The N50 length was 767,732 bp, the largest scaffold was 1,863,841 bp, with a scaffold L50 of 20. About 83% of the RNA-Seq reads mapped on to the draft version of the final genome. A total of 10,511 genes, with 10,811 transcripts that coded for 9,970 proteins were functionally annotated, using Augustus implemented in the BLAST2GO PRO package (v.4.1.9), utilizing *Botrytis cinerea* as the model species and the RNA-Seq reads as a guide. Our genome assembly can be used to develop a better understanding of the epidemiology of the pathogen and its interactions with the host(s) and thus improve brown rot management. The Whole Genome Shotgun project generated and analyzed in the current study (BioProject PRJNA470675) are available at the NCBI repository, under the Accession Number QKRW0 00000 00.

Keywords: Brown rot, de-novo assembly, *Monilinia fructigena*, next generation sequencing, pome fruit, postharvest disease, stone fruit, third-generation sequencing

S-III-O3 Exploiting the effector repertoire of *Monilinia fructicola* as a breeding strategy targeting disease resistance

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Abstract body text:

Monilinia fructicola, *M. laxa*, and *M. fructigena* are the fungal pathogens responsible for brown rot disease on stone fruits and can cause severe preharvest and postharvest losses. These *Monilinia* species can infect multiple plant structures, including blossoms, twigs, and immature and mature fruits. The genus *Monilinia* belongs to the Sclerotinaceae family which comprises a large number of plant pathogenic species with a necrotrophic lifestyle. Necrotrophic fungal pathogens kill host cells and subsequently colonize the dead tissue. Cell death can be achieved by releasing metabolites or proteins with phytotoxic activity into the host plants. Such molecules are referred to as 'necrotrophic effectors'. Sensitivity to necrotrophic effectors (i.e. cell death response upon effector application) has been demonstrated to be correlated with susceptibility to the pathogen in several pathosystems. The application of purified effectors can have an important impact on breeding strategies since it allows one to screen germplasm to detect susceptible cultivars in a more reliable way, independent of pathogen infection tests. The objective of the present study is to exploit the genome sequences of *M. fructicola* to identify effectors that cause necrosis in host plants. The genome was sequenced with PacBio and the *de novo* assembly resulted in a genome size of 42.95 Mb. After a manual curation, supported by RNA-Seq libraries, 10.086 predicted genes were annotated. The genome was examined for the presence of genes that encode secreted proteins and more specifically for effector proteins. A total of 134 putative effectors were identified, which are presently the subject of functional studies. A reproducible infection assay for *M. fructicola* in nectarine leaves was developed and different time points following inoculation were selected for gene expression analysis. Several candidate effector genes were cloned into Agrobacterium tumefaciens for transient expression in *Nicotiana benthamiana* plants and some of the tested candidates triggered necrotic lesions. The contribution of necrotrophic effectors in pathogen virulence can in the future be exploited in effector-based selection of (partially) resistant germplasm. Our findings may eventually result in the development of alternative methods to control brown rot disease and open new perspectives in this field of research.

Keywords: Genome, annotation, necrosis, genes

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S-III-O4 A walk-through method for identifying brown rot resistance in stone fruit: methodology development, validation, and application on an interspecific almond × peach population

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Abstract body text:

An ecological approach for brown rot management is to plant cultivars that are resistant to *Monilinia* spp., the causal agents of brown rot worldwide. Little information is available, however, on the identification of genomic regions involved in brown rot resistance. Clearly, taking into account both the scarce information on the *Monilinia* spp.-stone fruit pathosystem, and benefits of using environmentally friendly alternatives to synthetic fungicides, further studies are needed. The objective of the present study was to investigate possible sources of resistance in a breeding program. To achieve this objective, the following plant was instituted: i) development of a phenotyping methodology, ii) validation of the developed methodology, and iii) application of the developed methodology in an interspecific almond ('Texas') × peach ('Earlygold') population named T1E. The first step encompassed determining the effect of different factors (wounding, incubation time, inoculum concentration, strain aggressiveness and fruit disinfection) on screening for fruit resistance to brown rot. Based on these results, a methodology to establish levels of susceptibility to *M. fructicola* was developed and applied to a set of commercial peaches and nectarines. Then, it was applied to fruit from the T1E population over two consecutive harvest seasons (2016 and 2017). Phenotypic data revealed differences in fruit response and provided complementary information (flesh and epidermal resistance). Interestingly, several genotypes that were non-wounded exhibited resistance to brown rot. Finally, data obtained using the developed methodology, combined with QTL analysis, provided the ability to identify several QTLs associated with brown rot resistance, including a stable region on G4 of the T1E map. This knowledge can provide guidance for researchers assessing resistance to *Monilinia* spp. in different germplasm worldwide and supports the development of ecofriendlystrategies of

crop protection, such as marker-assisted selection (MAS). These findings also contribute to a better understanding of the mechanisms underlying host resistance factors that are important for the selection of seedlings with enhanced brown rot resistance.

Keywords: *Monilinia* spp., disease resistance, *Prunus persica, Prunus dulcis*, QTL analysis.

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S-III-O5 Understanding the potential of *Colletotrichum* spp. to cause bitter rot on apple during preharvest and postharvest in the Mid-Atlantic United States

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Abstract body text:

In years past, bitter rot on apple was a minor disease in apple orchards in the Mid-Atlantic region of the United States. Consequently, little research was conducted on understanding the causal pathogen, its epidemiology, and appropriate management strategies for this region. Growers have observed an increase in incidence over the last several years, with 2018 being the most challenging. In 2018, many growers abandoned the apple crop in some orchard blocks due to overwhelming bitter rot incidence. The increase in incidence has been hypothesized to be attributed to increased tolerance of the pathogen to widely used fungicides, fungicide use restrictions, planting of susceptible apple cultivars, climate change, and changes in orchard management. In 2017 and 2018, >700 bitter rot symptomatic fruit were collected from both conventional and organic orchards to determine the infecting *Colletrotrichum* species commonly found in Pennsylvania. Fungi from infected fruit were identified as members of either *Colletotrichum acutatum* or *Colletotrichum gleosporiodes* species complexes, with the predominant species being *C. fiorinie*. A subset of isolates was tested for tolerance to commonly used fungicides using mycelial growth and conidial germination assays. To date, an increase in tolerance to trifloxystrobin has been observed. Culturing and PCR based methods were used to detect *Colletotrichum* in the orchard environment to elucidate overwintering sites and spore dispersal periods. *C. fiorinae* spores were detected as early as bloom, as well as having significant endophytic colonization of weeds growing in orchards. These results will be discussed in regards to bitter rot management and the risk incidence during postharvest storage.

Keywords: Apple, bitter rot, *Colletotrichum*, fungicide resistance

S-III-O6 Apple lenticel rots: state of knowledge about the epidemiology of *Neofabraea vagabunda*

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Abstract body text:

Lenticel Rots represent one of the main post-harvest diseases affecting apples in long storage. Bull's-eye Rot (BER) and *Colletotrichum*, cause economic losses and require pre-harvest preventative treatments. *Neofabraea vagabunda* is the primary causal agent of BER in France, Italy, and in many other western European countries. Infection occurs on fruits prior to harvest through lenticels and the fungus remains latent until the appearance of symptoms after several months of cold storage. Although the biology o BER is receiving more attentiona, information on the epidemiology of *N. vagabunda* is lacking. The source of inoculum has been recently examined and found to be present in the orchard, as well as the general environment (Kohl et al., 2018). In contrast to *N. perennans, N. vagabunda* does not typically cause cankers on bark tissues. Utilizing artificial inoculation, however, we have found that the fungus can survive and produce conidia in cracks of the bark. Incidence of climatic parameters on the infection level has also been investigated in the orchard over the past several years by picking fruits at different dates or by window trials. The role of rain has now been confirmed and the minimal wetness required for fruit infection has been shown to be related to temperature. Conidia germination in free water occurs after 5 hours, but the infection of fruits requires lenticels at a minimum stage of development. It is possible to determine the potential of infection by *N. vagabunda* for each rain event and analyze the most correlated parameters with the level of infection. This could serve as a starting point for modeling the disease. Assessment of risk for a given variety harvested at a given date was conducted at three locations in France by analyzing pre-harvest climatic data.

Keywords: Epidemiology, post-harvest disease, apple, Bull's-eye rot

S-III-O7 Role of anthocyanin and flavonoids in resistance of mango fruit to fungal pathogens and chilling injury

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Abstract body text:

Fruits of red mango cultivars that accumulate anthocyanin were more resistant to both biotic (anthracnose) and abiotic (chilling) stress. To validate that anthocyanin is correlated with biotic and abiotic resistance, red and the green 'Shelly' mango fruit from the exterior and interior of the tree canopy were evaluated. Red mango fruits accumulated more anthocyanin, flavonoids and antioxidants, although the ripening parameters of both red and green mango fruit were similar. In response to storage at suboptimal temperature, 'green fruit' exhibited ROS and lipid peroxidation, and also developed significantly more chilling injury symptoms than 'red fruit'. Furthermore, 'red fruit' had a more diverse stem-end microbiome and had less postharvest decay. Red fruits were also more resistant to *C. gloeosporioides* inoculation on both the red and green side of the red fruit, suggesting the involvement of induced resistance. Induced resistance was further evaluated by transcriptome analysis. Interestingly, the resistance of red mango fruit involves both induced resistance and direct antifungal activity. The direct antifungal activity was evaluated by organic extraction of red fruit peel which had higher levels of inhibition of conidia germination and hyphal growth relative to extract obtained from green fruit. During the characterization of flavonoids and anthocyanins, un-glycosylated flavonoids from mango were found to be more active against pathogenic fungi. In summary, red mango fruit that accumulate high amount of anthocyanin exhibit increased resistance to chilling and fungal pathogens by direct antifungal activity and the activation of induced resistance. Through the use of pruning and preharvest application of phytohormones, greater red color and higher fruit quality could be induced in several mango cultivars.

Keywords: Induced resistance, anthocyanin, flavonoids

This abstract contain five different sub-sections, which three of them were recently published:

1. Sivankalyani S, Feygenberg O, Diskin S, Alkan, N. 2016. Increased anthocyanin and flavonoids in mango fruit peel are associated with cold and pathogen resistance. Postharv. Biol. Technol. 111: 132–139) and the other two are in writing process.
2. Sudheeran P, Feygenberg O, Maurer D, Alkan N. 2018. Improved cold tolerance of mango fruit with enhanced anthocyanin and flavonoid contents. Molecules, 23(7), 1832.
3. Sudheeran PK, Love C, Feygenberg O, Maurer D, Ovadia R, Oren-Shamir M, Alkan N. 2018. Induction of red skin and improvement of fruit quality in 'Kent', 'Shelly' and 'Maya' mangoes by preharvest spraying of prohydrojasmon at the orchard. Postharv. Biol. Technol. In press.

P012 Analysis of changes in the expression of genes belonging to two pectinase families as a potential virulence mechanism of *Monilinia laxa*

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Abstract body text:

The secretion of cell wall-degrading enzymes is one of the virulence mechanisms of necrotrophic fungi that enables them to colonise host tissues. Information about virulence factors in *Monilinia* spp., one of the causal agents of brown rot in stone fruit, however, is scarce. Plant cell walls are composed of three main components: cellulose, hemicellulose, and pectin that fungal enzymes can degrade. In order to identify *M. laxa* candidate proteins involved in pectin hydrolysis, two *in vitro* approaches were utilized: a) a phenotypic and ecophysiological characterisation of strain ML8L (CECT 21100) growth at different pH in glucose- and pectin-containing solid media for 7 days of incubation, and b) gene expression analysis of pectin methyl esterases (PMEs) and RG-hydrolases (HYDs) genes after 0.5, 2, 6, 24 and 48 h of incubation in glucose- and pectin-containing liquid media. Phenotypic tests provided information on the role of carbon sources on the growth rate and aggressiveness of *M. laxa*, indicating that the activity of pectinases were greatly affected by pH. Regarding the analysis of gene expression, different patterns of expression were observed among the members of each family (3 PMEs and 5 HYDs) and between both families, indicating that some of the members were activated at earlier phases while others were activated later (at 48 h). Results also revealed that the up-or down-regulation of the examined genes was carbon source-dependent. Based on these results, we hypothesize that PMEs and HYDs may represent potential virulence factors of *M. laxa* during the process of infection and colonization of stone fruit. To confirm the role that these genes play in the *Monilinia* spp.-stone fruit pathosystem, however, further complementary *in vivo* studies are required.

Keywords: Host-pathogen interaction, brown rot, cell wall-degrading enzymes, carbon sources, pectin methyl esterases, hydrolases

Authors are grateful to Spanish Government for their financial support by national projects AGL2014-55287-C02-02 and AGL2017-84389-C2-1-R from Ministry of Economy, Industry and Competitiveness (MINECO) and to the Catalan Government (Generalitat de Catalunya) for the PhD grant 2018FI_B2_00184 (Baró-Montel, N.) and for the funding received from CERCA Programme / Generalitat de Catalunya.

P013 PpWRKY33, a key transcription factor, is associated with the host response to *Rhizopus stolonifer* infection in peach fruit

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Abstract body text:

Plant-specific WRKY transcription factors (TFs) have been reported to play an essential role in pathogen resistance, however, their role in disease resistance in peach (*Prunus persica*) fruit remains to be elucidated. In the present study, the expression of PpWRKY33, a WRKY TF that responds to *Rhizopus stolonifer* infection in peaches, is characterized. PpWRKY33 expression gradually increased in response to an increase in disease incidence and lesion diameter after inoculation. Subcellular localization and transcriptional activation assays indicated that PpWRKY33 is a nuclear-localized protein with activation ability, and shares the highest identity with AtWRKY33. An electrophoretic mobility shift assay (EMSA) revealed that PpWRKY33 activates the expression of pathogen defense related (PR) genes such as PR1, PR4, CHI1, and NPR1 by binding to the W-box motif of their promoters. Collectively, the data indicate that PpWRKY33 is associated with the response of peach fruit to postharvest pathogen infection. This finding provides new insight into the role of WRKY33 as a transcriptional regulator in pathogen response in peach fruit.

Keywords: WRKY, transcription factor, disease resistance, peach

P014 cAMP signaling regulates appressorium formation and virulence of *Alternatia alternata* induced by cuticular wax of pear fruit

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Abstract body text:

A study was conducted on the regulatory role of the cAMP signaling pathway on the response of *A. alternata* to physicochemical signals of the pear fruit surface. Atropine was used as a cAMP signal pathway inhibitor to study the role of the cAMP signal pathway on virulence of *A. alternata* on pear fruit. The regulatory role of the cAMP signal pathway on appressorium formation of *A. alternata* in was also evaluated *in vitro* in response to the hydrophobicity and chemical composition of pear cuticular wax. Results indicated that the higher hydrophobic surface and pear wax extract-coated surface significantly promoted spore germination and appressorium formation. Atropine treatment, however, significantly inhibited the spore germination and appressorium formation that was induced by the higher hydrophobicity and pear wax. The rate of appressorium formation on the hydrophobic and fruit wax coating surface was reduced by 75.3% and 63.7% after 4 hours of exposure to the atropine inhibitor. Atropine also decreased the incidence of black spot on inoculated fruit and exogenous cAMP partially restored the inhibitory effect of atropine. The rate of appressorium formation on the higher hydrophobic and pear wax coated surface treated with cAMP+Atropine was 2.4 times and 1.6 times higher than in the same surfaces treated with atropine alone after 4 hours of incubation. These findings suggest that the cAMP signal cascade pathway affects the recognition and response of *A. alternata* to the cuticular wax of pear fruit through regulating the formation of infection structures.

Keywords: *Alternaria alternata*, pear fruit, cuticular wax, cAMP signaling pathway, hydrophobicity, appressorium formation

P015 New insights into griseofulvin biosynthesis by *Penicillium griseofulvum,* an agent of blue mould on apples

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Abstract body text:

Penicillium griseofulvum is a plant pathogen, and one of the causal agents of apple blue mould, the most important postharvest diseases of apples. This species, as with other *Penicillium* spp., can produce an impressive array of secondary metabolites, including mycotoxins. Griseofulvin is one of the most characteristic compounds produced by *P. griseofulvum*, and is an antifungal metabolite classified as a potential carcinogen for humans by the International Agency on Research on Cancer (IARC). The genome of *P. griseofulvum* was previously sequenced and the griseofulvin biosynthetic genes were identified and partially characterized, but the role of the putative transcription factors, gsfR1 and gsfR2, remain unknown. By producing deletion mutants, the role of gsfR1 and gsfR2 was investigated. Results indicate that the gsfR2 gene is not involved in griseofulvin biosynthesis, while gsfR1 encodes for a negative regulator. In the promoter sequence of gsfR1, binding sites for a number of different regulators, including AreA, CreA, StuA, and FacB, were observed. This suggests that griseofulvin production is regulated mainly by the level of nutrients, with greater production induced by the availability of easily assimilated carbon sources, such as glucose. Griseofulvin production in the two deletion mutants was verified *in vitro* and *in vivo* and compared with the wild-type strain and knockout mutants for the polyketide synthase gene. A higher level of griseofulvin and a higher virulence on apples were observed in the mutants. The current findings provde a better comprehension of griseofulvin biosynthesis and the role of this compound in the growth of *P. griseofulvum*.

Keywords: *Penicillium griseofulvum*, blue mould, griseofulvin, gene cluster, transcription factor, apple

P016 Development of *Neofabraea vagabunda* infection during apple storage: interplay between the pathogen and fruit volatile metabolism

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Abstract body text:

Neofabraea vagabunda, a typical latent fungal pathogen, is the cause of Bull's eye rot, an important postharvest disease of apples. The pathogen infects fruits in the orchard and develops decay symptoms during cold storage, after a long period of quiescence (generally 2-4 months after harvest). The transition from a quiescent to an active infection is influenced by fruit ripening, however, the specific factors involved in this process are still to be determined Here, we present *in vivo* and *in vitro* studies showing that apple extracts and typical fruit volatile compounds stimulate the growth of *N. vagabunda in vitro*. Increased emission of volatile organic compounds typically produced in ripe apples was also observed in 'Cripps Pink' apples infected with *N. vagabunda*, suggesting that the development of Bull's eye rot involvesan acceleration of the ripening process in apples tissue that is induced by the pathogen.

Keywords: Bull's eye rot; enzymes; fungal quiescence; light microscopy; PTR-ToF-MS analysis; SPME/GC-MS analysis; volatile organic compounds

P017 Changes in prevalence of postharvest fungal pathogens after a single orchard incursion by *Pseudomonas syringae* pv. *actinidiae*

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Abstract body text:

Pseudomonas syringae pv. *actinidiae* (Psa) was first detected in New Zealand in November 2010. By 19 August 2014 it had spread to 30 orchards in the Kerikeri district, and was first found on the Kerikeri Research Orchard of The New Zealand Institute for Plant & Food Research Limited (PFR) on 19 September 2014. Kiwifruit leaves were collected from Actinidia chinensis var. chinensis 'Hort16A' vines on two blocks at the PFR Kerikeri Research Orchard on 7 December 2012 before Psa infected the orchard, and again from the same two blocks on 25 November 2014. The fungal populations changed on the kiwifruit phylloplane after Psa occurred at the Kerikeri Research Orchard. There was a large decrease in the numbers of ascomycete fungi, and a large increase in the numbers of basidiomycetes. Two ascomycete fungi were not present before Psa was detected; *Colletotrichum* sp. and *Pestalotiopsis* sp. Both *Colletotrichum* sp. and *Pestalotiopsis* sp. cause fruit rots on kiwifruit, and recently there has been a noticeable increase in the number of fruit rots caused by these species. Weather parameters examined (rainfall and temperature) were not able to explain the increase in populations of these fungi. More available infection sites around Psa leaf spots may enable more extensive colonisation and an increase in populations of these two fungal genera. Factors such as changes in the fungicide programme may also have contributed to these differences.

Keywords: Kiwifruit, canker, microbiome, whole genome sequencing, ITS, inter-transcribed spacer

P018 Identification and characterization of *Botrytis* isolates obtained from blossom blighted flowers and fruits with calyx-end rot in Chile

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Abstract body text:

Calyx-end rot, caused by *Botrytis cinerea*, attacks the apple fruit during harvest and post-harvest, reducing the production and quality of apples. Reports of this disease in the cultivar 'Cripps Pink' indicate a incidence at harvest of 0.1 to 0.2%, increasing to 2% after 60 days of cold storage. In this study, isolates of *Botrytis* obtained from blossom blighted flowers and calyx-end rot fruits of different cultivars, were characterized culturally, morphologically, molecularly and pathogenically. Twenty isolates were visually classified based on the morphology of their colonies and if they exhibit low or high sporulation on potato dextrose agar acidulated (APDA) culture medium. The evaluated morphological parameters included the shape and size of conidia and conidiophores in pea agar culture medium and the production of sclerotia on APDA. The same isolates were molecularly characterized by DNA amplification and sequencing of the glyceraldehyde- 3-phosphate dehydrogenase (G3PDH), heat-shock protein 60 (HSP60), and DNA-dependent RNA polymerase subunit II (RPB2) genes. Pathogenicity tests were carried out on 'Cripps Pink', 'Fuji', 'Granny Smith', 'Modi', 'Premium Gala', 'Braeburn', 'Scarlette', and 'Red Chief'. The cultural and morphological data indicate that all the isolates correspond to the genus *Botrytis*. The molecular characterization confirmed the identification of the isolates under study, which clustered together with reference isolates of *B. cinereal,* with the exception of some isolatesthat clustered in a separate group. Pathogenicity tests were positive in all cultivars evaluated, with differences in virulence exhibited among the isolates. This research is the first study to identify and characterize of *Botrytis* causing blosson blightand calyx-end rot in the Maule Region, Chile.

Keywords: Calyx-end rot, fruit apples, *Botrytis*

P019 *Phacidiopycnis washingtonensis*, a newly discovered pathogen on apple in Norway

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Abstract body text:

The fungus *Phacidiopycnis washingtonensis*, causal agent of rubbery rot (also referred to as speck rot) is mostly associated with the long-term storage of apple fruit. Apple production in Norway is only for domestic marketing, and most of the fruit is sold within a period of up to 12 weeks after harvest. Therefore, *P. washingtonensis* was not expected to be found on apple in Norway during short-term postharvest storage. In autumn 2018, a low incidence of typical rubbery rot was found in storage on fruit of cv. Amorosa obtained from one commercial orchard. The first infected fruit was identified after six weeks in cold store and 10 days at 20 ˚C. Rubbery rot was found both on fruit stored at 2 and 4 ˚C in a ventilated storage unit. In addition to storage rot, *P. washingtonensis* may also cause cankers and twig dieback. In summer 2017, cankers were found on ornamental trees of *Malus toringo* var. sargentii 'in a Norwegian nursery in Ås', and the causal agent was identified as *P. washingtonensis*. The pathogen has been subsequently found on pollinator trees of cvs. Evereste and Golden Hornet in apple orchards. Mummified fruit of pollinizer trees has been previously reported in other countries as an important inoculum source. Infected fruit left on pollinator trees may become mummified and produce inoculum the following year. Further investigations are needed to determine the importance of such contaminated fruit in Norwegian apple orchards. The pathogen was also found on Scots pine (*Pinus sylvestris*) in Norway in 2017, indicating that it may be more widespread on other host plants than previously known.

Keywords: Crab apple, *Malus* x *domestica* Borkh

P020 Bull´s eye rot development in stored apple fruit in chile is related to the timing of infection in the orchard by *Neofabraea vagabunda*

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Abstract body text:

Bull's-eye rot caused by *Neofabraea vagabunda* is an important postharvest disease of apple. This species is the only one that is associated with this rot in Chile. Symptoms are slow to develop and progress, requiring at least three months in cold storage to be visible during inspection of the fruit. The disease is initiated from a preharvest latent infection of a fruit lenticel. Epidemiological studies are needed to understand when the apple lenticels are being inoculated and infected in the orchard so effective preharvest fungicide spray programs can be developed. To determine the timing of fruit infection, 'Cripps Pink' apple fruits from three commercial orchards were inoculated with a suspension of *N. vagabunda* mycelia and conidia at 4, 3 and 2 months prior to harvest and then every week until harvest in 2016, 2017, and 2018. Inoculated apples were harvested and stored at 0°C for 150 days, and Bulls' Eye Rot incidence was then recorded. Both, mycelial and conidial inoculations resulted in significant Bull's Eye Rot after storage when apple fruits were inoculated at 70 days or less prior to harvest, with mycelial inoculations resulting in higher levels of incidence. Inoculations made at 40 days to or immediately prior to harvest resulted in a higher level of incidence of Bull's Eye Rot in storage compared to inoculations made at 4 or 3 months prior to harvest. Collectively, results indicated that apple lenticels are susceptible to infection by *N. vagabunda* as early as 3 months prior to harvest in Chile.

Keywords: Lenticel rot, *Neofabraea*, *Phlyctema*, apples, epidemiology, Bull's-eye rot, postharvest, disease

P021 Postharvest fungal pathogens of pomegranate fruit in southern Italy

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Abstract body text:

Pomegranate (*Punica granatum* L.) is an emerging fruit crop in the Mediterranean area due to its organoleptic and nutraceutical properties. Spain and Italy are the main European producers of pomegranates and the most common cultivars are 'Wonderful', 'Akko', 'Mollar de Elche', and their clones. Postharvest pomegranate losses, principally caused by fungi, are a significant economic drawback to producers and consumers due to presence of toxic metabolites produced by the fungi that have potential negative effects on human health. In the present investigation more than 150 symptomatic pomegranate fruit from orchards, markets, and packinghouses located in southern Italy were collected and processed to obtain a collection of about 350 monoconidial isolates of fungal pathogens. The aim was to identify the main postharvest pathogens of pomegranate fruit in Southern Italy, and evaluate their incidence. Isolates were characterized according to micro- and macro-morphological features and molecular approaches. Data provided information on "wound" pathogens, as well as fungi causing "latent" infections; some of which had not been previously recorded on harvested pomegranate fruit in Italy.this included *Talaromyces albobiverticillius*, *Cytospora punicae, Colletotrichum acutatum sensu stricto*, and *Pilidiella granati*. In addition, well-known genera such as *Botrytis* spp., *Penicillium* spp., *Alternaria* spp., and various black Aspergilli, were isolated and identified at a species level. Some of these fungi are potential producers of hazardous mycotoxins or useful pigments.

Keywords: Pomegranate, postharvest, fruit rots, fungi

P022 Survey on *Moniliniae* affecting stone fruits in the Marche region, Central-eastern Italy

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Abstract body text:

Brown rot is the most important disease of stone fruit in warm and humid climates. These conditions can induce blossom blight and brown rot, with the latter developing both in the field and even more so during storage, transport and shelf life. The casual agents are four fungal species of the genus *Monilinia*: *Monilinia fructicola*, *Monilinia laxa*, *Monilinia fructigena*, and *Monilinia polystroma*. Other species such as *Monilinia mumecola* and *Monilinia yunnanensis* have also been reported as pathogens recently. In this study, a survey was carried out during spring of 2018 across several stone-fruit orchards in the Marche region, and in particular in Valdaso and Valle del Foglia, to identify the species responsible for brown rot. Samples were taken from infected fruit and twigs, and total DNA was extracted using the cetyltrimethylammonium bromide method. Molecular identification was performed using the common reverse primer MO368-5 and three forward primers: MO368-8R (specific for *M. fructigena* and *M. polystroma*), MO368-10R (specific for *M. fructicola*), and Laxa-R2 (specific for *M. laxa*). The amplified products were electrophoresed through 1.5% agarose gels in 1× TBE buffer, stained with GelRed dye, and visualized under ultraviolet light. The most common species recorded in this survey on twigs and fruit were *M. laxa* and, to a lower extent, *M. fructicola*. Considering the different virulences of these species, knowledge about the presence of *Moniliniae* is essential for planning appropriate disease management strategies. Further investigations are required to explore the frequency of occurrence of each species and the resistance to the most commonly used fungicides.

Keywords: Blossom blight, brown rot, *Monilinia* spp., postharvest decay

P023 Quince fruit susceptibility to postharvest fungal pathogens

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Abstract body text:

Quince (*Cydonia oblonga* Mill.) is a nutritionally rich and fragrant pome fruit. Quince in Serbia is grown on 1660 ha with a yearly production of ~14000 t. The production of quince is small compared to other pome fruits but is of great traditional value, which is why Serbia is one of the main producers in Europe. Quince is primarily used for brandy but also for marmalade, juice, jam, syrup, compote etc. Quince fruit can be stored for up to seven months but is susceptible to decay while in storage. *Botrytis*, *Penicillium*, *Botryosphaeria,* and *Diplodia* are all genera that are known to cause postharvest rots of different fruits. To evaluate the susceptibility of quince to these postharvest pathogens, quince fruit cv. Leskovacka was artificially inoculated with *Botryosphaeria dothidea, Diplodia seriata, Botrytis cinerea, Penicillium solitum* and *P. glabrum*. Symptom development and lesion size were evaluated at 7 and 11 days after inoculation. Species-dependent differences in the susceptibility of quince fruit to the different postharvest fungal pathogens. Quince fruit was most susceptible to *B. dothidea* and *D. seriata*, moderately susceptible to *B. cinerea*, low susceptible to *P. solitum* and the least susceptible to *P. glabrum*.

Keywords: Fruit rot, pome fruit, *Botrytis, Penicillium, Botryosphaeria, Diplodia*

P024 Incidence of postharvest diseases of *Brassica napus var. napobrassica*

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Abstract body text:

Rutabaga or Swede (*Brassica napus var. napobrassica*) is a root vegetable in the family *Brassicaceae*. Rutabaga is very important in traditional Norwegian cuisine, and is in highdemand. Norwegian root vegetables are typically stored 3 to 8 months before consumption, often resulting in 20-30% postharvest loss. As part of the project OPTIROOT, a two-year survey was conducted to determine the incidence of postharvest diseases in rutabaga. Rutabaga was grown in four regions of Norway. In each region, rutabaga grown in one field was stored in 2 or 3 commercial cold storage units within each region. Disease incidence was assessed by visual inspection of foliage one week before harvest, on roots at harvest, and after long-term storage. At the time of storage, 100 rutabagas were randomly selected, divided into four groups, placed in net bags, and stored in four storage bins in each storage unit. At the end of the storage period, disease incidence was assessed by categorizing the rutabagas into healthy (free of rots) and possessing different diseases. Disease incidence significantly ($p \leq 0.05$) varied from region to region and among the commercial cold storage units. Post-harvest disease incidence ranged from 4 to 53% in 2017 and from 3 to 67% in 2018. Irrespective of year and commercial cold storage type, the most important diseases contributing tor postharvest loss of rutabaga were *Botrytis cinerea*, *Fusarium* spp., *Phoma lingam* (*Leptosphaeria maculans*), *Sclerotium rolfsii* (*Athelia rolfsii*), *Rhizoctonia solani,* and *Gibellulopsis nigrescens* (syn. *Verticillium nigrescens*). No previous reports of*Gibellulopsis nigrescens* as a pathogen of rutabaga in Norway or other countries were found. The identity of *G. nigrescens* was confirmed by DNA amplification and sequencing. The incidence of *G. nigrescens* reached 14% in some commercial cold storage units. Postharvest loss due to fungal diseases is a critical problem in long-term storage of rutabaga.

Keywords: Postharvest loss, Kålrot, fungi,

P025 Black mold of stored onion bulbs caused by *Aspergillus welwitschiae*

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Abstract body text:

Black mold of onion bulbs is a postharvest disease that can cause economic losses when onions are inappropriately stored. Among several species of *Aspergillus* section Nigri reported as causal agents of black mold, recent studies have reported a dominant presence of *Aspergillus welwitschiae* on onion bulbs. In the present study, onion bulbs cv. “Vuelta” were collected in 2015 from a storage facility in Stara Pazova, Serbia. Black sporulation of the pathogen was present on the outer scales of the collected onion bulbs and inside, light brown, soft and watery decay was spreading from the neck of the bulb throughout the fleshy scales. Two fungal isolates were obtained using standard laboratory procedures and pathogenicity of the isolates was tested by wound inoculation of healthy onion bulbs cv. “Stuttgarter riesen”. Three weeks after inoculation lesions developed (average diameter 28 mm) and sporulation was present. The isolates were preliminary identified based on morphological characteristics as members of *Aspergillus* section Nigri. Species level identification was completed by sequence analyses of the partial calmodulin gene. Based on the molecular and morphological properties, the isolates were identified as *A. welwitschiae*. This is the first report of *A. welwitschiae* as the causal agent of black mold of stored onion bulbs in Serbia. Since onion bulbs are widely consumed by humans, the presence of toxigenic *A. welwitschiae* (fumonisin B2 and/or ochratoxin A producers) indicates the need for further investigation and evaluation of the toxigenic potential of *A. welwitschiae* isolates present in Serbia.

Keywords: Identification, *Aspergillus*, onion, black mold

P026 Evaluation of pink spots on rose petals and their relationship to *Botrytis cinerea*

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Abstract body text:

Botrytis cinerea is the causal agent of gray mold disease in cut roses. The infection is detrimental to rose quality in production and pot-harvest environments causing reduction in the yield and economic losses. Although, this disease has been a substantial problem in cut roses for several years, some of the early symptoms associated with the disease are still under discussion. The initial *B. cinerea* symptoms on petal tissues have been described as small flecks of discolored or necrotic tissue that enlarge to form large necrotic areas. 'Pink spots' appearing on rose petals have also been thought to be directly associated with *Botrytis* infection, and shipments are often rejected during inspection at the port-of-entry when pink spots are observed. It is not clear, however, if these symptoms are actually a result of *Botrytis* infection. The objective of this research was to evaluate the relationship between pink spots and *B. cinerea* infection in cut rose petals. Four commercial shipments of 'Vendela' and 'Brighton' roses were evaluated. Each shipment contained 24 asymptomatic roses (no-'pink spots') and 24 symptomatic roses per cultivar. Detached petals and intact rose flowers were evaluated separately in two different experiments. For the detached petal experiments, three non-symptomatic petals, three petals symptomatic for pink spots, and three non-symptomatic petals from flowers symptomatic for pink spots were selected from six roses per shipment and cultivar. The petals were surface sterilized and incubated for 7 days under moist conditions favorable for disease development. For the intact rose experiments, six roses symptomatic for pink spot and six non-symptomatic roses per shipment and cultivar were placed in a humid chamber and incubated for 7 days. Symptom development and *B. cinerea* incidence were evaluated. We distinguished between distinct round pink spots approximately 2,2 mm in diameter and pink discoloration on the edge of petals. Individual pink spots were the predominant symptom on 'Vendela', while the pink edges were predominant on 'Brighton'. No difference was observed in *B. cinerea* incidence between tissues with or without pink spots for either cultivar in the evaluation of detached petals or whole rose flowers. When *Botrytis* did occur on petals or intact rose flowers with pink spots, the infection did not originate from pink spots or the pink edges. Pink spots never enlarged during the evaluations, which would be expected if a fungal pathogen was involved. These results suggest that pink spots or pink edges in cut rose petals are not associated with *B. cinerea*.

Keywords: Cut roses, *Botrytis cinerea*, post-harvest, symptoms

Session IV - Integrated approaches and new chemistries to reduce postharvest waste

KEYNOTE SPEECH Antifungal edible coatings for postharvest preservation of fresh fruit

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Abstract body text:

Postharvest losses of fresh fruit are mainly caused by weight loss, physiological disorders, and decay during storage and commercialization. Currently, postharvest treatments with conventional chemical fungicides and/or synthetic waxes are commonly used in combination with low-temperature storage to reduce such losses and minimize their economic impact. However, their continuous use by the industry for many years has arisen important health and environmental problems related to the production of chemical residues and the proliferation of resistant pathogenic fungal biotypes. Therefore, safe and eco-friendly alternatives should be commercially implemented as part of non-polluting integrated disease management (NPIDM) programs for preservation of fresh fruit. Among them, the development of edible coatings with antifungal activity is a technological challenge and a very active research field worldwide. The main advantage of these coatings is that they could provide a single solution for both physiological and pathological major postharvest issues. While some natural coatings such as chitosan or *Aloe* spp. gels show inherent antifungal activity, specific food-grade antifungal ingredients should be incorporated into composite matrixes of hydrocolloids (polysaccharides such as cellulose derivatives, alginates, pectins, gums, and peptides or proteins) and lipids to form synthetic edible coatings with antifungal properties. These ingredients include natural or low-toxicity compounds, such as inorganic or organic salts (e.g., carbonates, sorbates, benzoates, paraben salts) and essential oils or other plant extracts approved as food additives or generally recognized as safe (GRAS) compounds by competent authorities, and biological control agents such as antagonistic strains of some microorganisms.

Keywords: Fungal postharvest diseases, fungicide-free control, chitosan, composite edible coatings, GRAS compounds, biocontrol agents

S-IV-O1 Brown rot disease management of peach in Italy (Emilia Romagna Region)

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Abstract body text:

Brown rot, caused by *Monilinia* spp., is the primary postharvest disease of stone fruits, worldwide. Pathogen control is challenging due to the high adaptability of the pathogen to climate conditions, high inoculum potential, and its broad host range. The distribution of *Monilinia* species in stone fruit orchards in Emilia Romagna was monitored from 2012 to 2017 and indicated the prevalence of *M. fructicola* during fruit development. In more than 20 years of field trials, the activity of different plant protection products normally applied as pre-harvest treatments has been evaluated using different application schedules. Through this work we were able to determine the effectiveness of each fungicide in guaranteeing protection of peach fruit during storage and subsequent shelf life. Additional postharvest chemical treatments or alternative means (such as thermotherapy) to improve disease control were assayed with encouraging results. Continuous use of a specific chemical can result, however, in the development of pathogen resistance. Therefore, the sensitivity of many isolates of *M. fructicola* to some of the most representative fungicides was also assessed.

Keywords: Fungicides, peaches, postharvest, resistance, efficacy

S-IV-O2 Management of citrus sour rot and green mold in South African pack-houses

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Citrus sour rot caused by *Galactomyces citri-aurantii* and green mold caused by *Penicillium digitatum* are devastating postharvest diseases responsible for major economic losses. Both are orchard pathogens that infect fruit through wounds and during harvest or handling of fruit. Pathogens present during fruit degreening are especially problematic, since the environment is ideal for disease development. Fruit is drenched with fungicides before degreening to manage decay. Several fungicides are available for green mold control, but only guazatine (GZT) has thus far been effectively used for sour rot control. GZT has been banned on citrus fruit exported to the EU. The demethylation inhibitor (DMI) propiconazole (PPZ) is a newly registered postharvest fungicide for sour rot control. PPZ is also effective against green mold. Fungicide resistance has been reported for the DMI class of fungicides and anti-resistance strategies need to be established before intensive commercial use. Fungicide exposed *G. citri-aurantii* and *P. digitatum* from the Eastern and Western Cape were tested at a discriminatory dose (DD) of 0.5 mg/L PPZ. The DD is a chosen fungicide dose used to determine if a fungal isolate is sensitive or resistant. Thirteen resistant isolates (>50% relative growth compared to the unamended control) were detected out of 161 screened *G. citri-aurantii* samples (8.1%). PPZ -resistance frequencies were 5.7% for *G. citri-aurantii* isolates in the Western Cape (N=106) and 12.7% of Eastern Cape isolates (N=51). In the Eastern Cape, 15 *P. digitatum* isolates out of 88 were classified as resistant (17% resistance frequency), and all tested Western Cape green mold isolates (N-23) were PPZ sensitive.

Keywords: DMI-propiconazole, discriminatory dose, fungicide resistance

S-IV-O3 Mechanism responsible for the alleviation of chilling injury of peach fruit by hot water and glycine betaine treatments as determined by transcriptomic and physiological analysis

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Abstract body text:

Glycine betaine (GB) and hot water (HW) treatments are useful for reducing chilling injury (CI) in several kinds of fruits, including peach. The underlying regulatory mechanisms responsible for this effect, however, remain unknown. This study utilized a physiological and transcriptomic analysis to evaluate soluble sugar and membrane fatty acid metabolism in GB and HW-treated peaches. Results showed that both GB and HW reduced CI and maintained high levels of sucrose and unsaturated fatty acid content in treated fruit. The activity of enzymes related to sugar and fatty acid metabolism were significantly enhanced by GB and HW. In addition, transcriptomic evaluation indicated that GB and HW treatments activated the biosynthesis of sugar and suppressed the degradation of membrane fatty acids. Furthermore, GB and HW up-regulated most of the heat shock transcript factors (HSFs), resulting in high levels of heat shock proteins (HSPs). Thus, the physiological and transcriptomic data suggest that GB and HW treatments can enhance chilling tolerance of peaches by regulating sugar and membrane fatty acid metabolism, and by maintaining high levels of sucrose, unsaturated fatty acid, and HSPs in treated fruit.

Keywords: Peach, glycine betaine, hot water, physiological metabolism, heat shock transcript factor, heat shock protein

S-IV-O4 Biological and chemical applications against *Botryosphaeria* during flowering of mango increase fruit count and yield and reduce postharvest decay

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Abstract body text:

During storage, mango fruit develop stem-end rot (SER), which reduces fruit quality and causes significant losses of fresh produce. Pathogenic fungi that colonize the stem without causing any visible symptoms become active during fruit ripening or abiotic stress, and cause fruit SER or stem and inflorescence dieback. Preliminary results indicated that most of those pathogenic fungi penetrate during flowering. In this work, we demonstrate that four treatments with fungicide spray during the month of flowering significantly reduces postharvest SER and the occurrence of pathogenic fungi within the microbial community of the fruit's stem end. As mango orchards are commercially sprayed four times against powdery mildew during flowering, we combined two treatments against powdery mildew with two treatments against SER-causing pathogens. Application of Luna Tranquility [fluopyram and pyrimethanil] or Switch [fludioxonil and cyprodinil]) fungicides or the biocontrol product Serenade [Bacillus subtilis]) during flowering significantly reduced inflorescence/stem dieback and fruit drop, and increased the number of fruit per tree, which led to an increase in yield. In addition, this application during flowering (March–April) significantly affected postharvest fruit quality (August–September) by reducing the incidence and severity of SER and even side decay after long storage. Thus, controlling the penetration and establishment of SER-causing fungal pathogens during mango orchard inflorescence and flowering reduced inflorescence/stem dieback and fruit drop, significantly increasing yield, while also reducing postharvest decay and fruit loss.

Keywords: Biological and chemical control, preharvest applications, stem-end rot

S-IV-O5 The effect of postharvest treatments on long term storage of Acorn squash

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Abstract body text:

Vertical farming, as the preferred growth technique for urban farming, is considered the next frontier of agriculture, thus is gaining increasing attention. Trellises have also been used, however, for vegetable growth in traditional agriculture for many years. Acorn squash (*Cucurbita pepo*), like many cucurbits, can easily be grown vertically on trellises, which provide several advantages. Trellising the vines saves expensive/ limited land space and promotes high plant-productivity. In addition, fruit quality is improved. For example, squash fruits are uniformly colored rather than having an orange area where they touch the ground and trellising also reduces pest insect-related damage. The growth of acorn squash in greenhouses covered with 50 mesh nets with trellises have enabled a very long growth period (up to 6 months) during the winter by providing protection against viruses transmitted by insects. The use of trellises has been shown to enable three harvests with a 50% increase in yield compared to ground production. Nevertheless, the long growth period during the wet season promoted a high incidence of fungal rots that developed on decaying plant parts. This initial inoculum of gray and green molds from the field caused a major complication for long-term cold storage of the fruits, resulting in up to 50-100% produce loss in one of the cultivars tested, depending on the storage conditions. We evaluated the effect of different cultivars and postharvest treatments, as well as storage conditions, on the storability of acorn squash fruits grown in netted greenhouses with trellises during two constitutive seasons. Results indicated that storage at 15 degrees Celsius in combination with anti-fungal treatments (dipping in fungicides or treating with hot steam) enables acorn squash fruit to be stored up to 3 months with minimal reduction in fruit quality and minimal fruit decay.

Keywords: Fruit-vegetables, Postharvest disease control, environment-friendly antifungal treatments

S-IV-O6 Role of Strbohs in the promotion of wound healing of potato tubers by BTH

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Abstract body text:

Wound healing is one of the most effective strategies for reducing postharvest disease of potato tubers. Benzo-(1,2,3)-thiadiazole-7-carbothioic acid S-methyl ester (BTH, Bion®, Actigard®), a structural and functional analogue of salicylic acid, has been acknowledged as an effective activator of systemic acquired resistance. In this study, the effects of BTH treatment at 100 mg/L on wound healing efficiency of potato tubes (cv. Longshu No.3) was investigated. Results showed that BTH treatment reduced weight loss, disease incidence and index, promoted the accumulation of suberin at wound sites, activated the activity of NADPH oxidases (NOX) and superoxide dismutase, increased the content of H_2O_2 and $O^{2.-}$. Further study indicated that NOX, encoded by Strboh genes, play an important role in wound healing of tubers by BTH. StrbohC, a member of the Strobh family of genes, was analyzed by qRT-PCR and shown to be up-regulated by the BTH treatment. In order to clarify the function of StrbohC, transgenic potatoes with over-expression and RNAi of StrbohC were constructed, and their wound healing potential was evaluated. In over-expression StrbohC transgenic tubers, weight loss and the disease index were significantly reduced, and the deposition of lignin and suberin at wound sites was accelerated. Conversely, the RNAi transgenic tubers exhibited a significantly increased amount of weight loss and a higher disease index with lower lignin and suberin deposition during wound healing than in WT tubers. Compared with WT, the content of H_2O_2 and $O^{2.-}$were also significantly higher in over-expression tubers, and notably reduced in RNAi tubers, indicating that StrbohC regulated reactive oxygen species accumulation during wound healing. In conclusion, regulation of the accumulation of reactive oxygen species by StrbohC plays an important role in BTH-induced wound healing of potato tubers.

Keywords: Potato, wound healing, BTH, Strobhs, reactive oxygen species

S-IV-O7 Biosecurity risk management of postharvest pathogens on international fruit trade

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Abstract body text:

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as the agricultural industries that are relatively free from serious pests. The risk analysis process is an important part in the development of Australia's biosecurity policies and enables the Australian Government to formally consider the level of biosecurity risk that may be associated with the importation of plant materials which are potential carriers of pests into Australia. This is comparable with the assessments undertaken by Australia's trading partners for technical market access requests supporting Australian exports of similar commodities. The risk assessment process identifies all biosecurity risks on the pathway, and for those that do not achieve the appropriate level of protection (ALOP), determines risk management measures to reduce the risks to an acceptable level, if possible. This study examines how risk assessments for market access consider the biosecurity risk posed by postharvest rot fungi taking into account the likelihood of a pest entering, establishing and spreading from the export area. The study considers key fungal pathogens on fruit pathway as examples to discuss how risk management measures are determined based on the biology, epidemiology and pathway association of the pathogens, and considers factors contributing to decision making of pathway risks and determination of risk mitigation options.

Keywords: Biosecurity postharvest fungal pathogens risk mitigation

P027 Latent postharvest pathogens and their management: from single measures to a systems intervention approach

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Abstract body text:

Postharvest diseases of pome fruit are typically caused by a wide diversity of fungal pathogens, and the list of confirmed causal agents is still growing. Well-known pathogens causing postharvest losses are *Neofabraea* spp. and *Colletotrichum* spp., but in many cases the causal agents that occur in a specific region remain unknown and their control relies on the routine use of fungicide applications. Due to the growing concern over the use of synthetic fungicides, however, alternative control measures are highly desired. Over the past several years, the use of physical treatments, natural compounds, and biocontrol agents have been investigated as alternatives. No single method has emerged, however, that can robustly and reliably control postharvest diseases of pome fruit in practice. Therefore, postharvest diseases should be regarded as complex problems that require multiple interventions at different stages of the disease process in a systems intervention approach for their control. Such an approach requires a deep understanding of the epidemiology of the causal agents in the orchard, fruit defense mechanisms against pathogens, and the molecular biology of host-pathogen interactions in order to develop novel disease control methods in which the deployment of resistant cultivars can be a cornerstone. Important postharvest pathogens of pome fruit in the Netherlands and possible strategies for their control will be discussed.

Keywords: Epidemiology, fungal pathogens, inoculum sources, postharvest losses

P028 Exploring the effects of gaseous ozone (O3) and 1-Methylcyclopropene (1-MCP) treatments on the development of *Penicillium expansum* and patulin production on apple fruits (cv. Granny Smith) using `omics´' approaches

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Abstract body text:

"Blue mold" caused by *Penicillium expansum* is considered as one of the most destructive postharvest diseases of apple. The pathogen may cause severe quantitative losses, and can contribute to qualitive deterioration of apple products due to patulin production, an important mycotoxin. The aim of this study was to evaluate the effect of 1-MCP (0.5 µL L -1, 0 °C) and ozone treatments O3 (0.3 µL L^{-1}) on disease severity and patulin production on artificially inoculated fruits (cv. Granny Smith). Additionally, the effects of 1-MCP and ozone treatments on the expression of the three main genes (idh, peab1 and p450-1) of the patulin cluster and on the apple proteome were evaluated. Artificially inoculated apple fruit, treated or not-treated with 1-MCP, were placed in cold storage (0°C, RH>95%) for 2 and 4 months either in an O3-enriched atmosphere or in a conventional cold chamber. Results showed that disease severity was higher in both O3 and/or 1-MCP-treated fruit, compared to the non-treated fruit. In terms of patulin production, 1-MCP and 1-MCP+O3-treated fruit, also had higher patulin concentration after 2 and 4 months of storage. The three patulin cluster genes (idh, peab1 and p450-1) tested, showed the highest level of expression in O3-treated fruit. In addition, a significant increase in the expression of the idh gene was observed in 1-MCP-treated fruit. Proteomic analysis of fruit treated with O3 and 1-MCP, revealed significant changes in the abundance of proteins related to plant defense. More specifically, a significant decrease in the amount of defense-related proteins was observed in 1-MCP-treated fruit. Such results emphasize that 1-MCP and O3 treatments not only do not contribute to the control of the disease but in addition, appear to be directly related to increased patulin production.

Keywords: *Penicillium expansum*, blue mold, apple, 1-MCP, proteomics, ozone

P029 Traditional and alternative strategies to protect apple fruits against scald

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Abstract body text:

Research was conducted in 2015-2018 in the experimental apple orchard of I.V. Michurin Federal Research Centre (Tambov region, Russia) on apple cultivars with different levels of susceptibility to scald: 'Granny Smith', 'Antonovka obyknovennaya', 'Martovskoye', and 'Bogatyr'. Currently, the following strategies to protect fruits against scald are used – postharvest treatment with an ethylene biosynthesis inhibitor (1-MCP), storage in ultra-low oxygen atmosphere (ULO), dynamic atmosphere (DCA), and a combination of different storage methods. The scald problem, however, has not been completely solved. The aim of the study was to determine the fruit protection mechanisms against scald by using various postharvest treatments and to develop a new fruit protection method against this disorder. Fruits were treated with 1-MCP and vaseline oil, and wrapped in oiled napkins, then stored in a normal (NA), modified (MA), and controlled atmosphere (CA, CO2 1.2-1.5%, O2 1.2-1.5%). We analyzed the concentration of ethylene, α-farnesene and its oxidation product (KT281) in fruits, the storage unit atmosphere, oiled napkins, and indicator tapes (IT), estimated losses from scald and fruit firmness. A reduction in fruit susceptibility to scald by the oil treatment or wrapping of fruit in oiled napkins was observed as evidenced by a decrease in the content of α-farnesene (oxidation substrate) and its oxidation products in fruit peel tissue due to its absorption by the mineral oil, by 1-MCP treatment – due to its ability to inhibit ethylene synthesis, α-farnesene and KT281, in ULO and DCA conditions – because low oxygen content inhibits ethylene synthesis, in DCA conditions – because high levels of ethanol inhibit the synthesis of ethylene and α-farnesene. The highly active compound, α-farnesene, was found in the napkins impregnated with vaseline oil (in which the fruits were packed) and in indicator tapes located in a chamber without direct contact with fruits. These findings demonstrate the ability of this compound to move t from cuticle of the peel to the surrounding atmosphere and possibility have an effect on scald development. The amount of α-farnesene in IT depends on cultivar, the method of storage, 1-MCP treatment etc. Absorption or oxidation of α-farnesene in storage atmosphere provides an opportunity to develop a new non-chemical method to protect fruits from scald.

Keywords: Apple fruits, scald, 1-MCP, NA, MA, ULO, ethylene, α-farnesene, KT281

P030 Promising technology to control bitter pit and other postharvest physiological diseases

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Abstract body text:

The research was conducted in 2015-2018 in the experimental apple orchard of I.V. Michurin Federal Research Centre (Tambov region, Russia) with “Sinap Orlovskii” apple trees which are highly susceptible to bitter pit, scald, and CO2 peel burning. The most prevalent postharvest strategy to protect fruits against bitter pit (BP) is the use of controlled atmosphere (CA). Decreasing the oxygen content to 0.4-0.6% reduces losses from scald and BP but does not provide protection to highly susceptible cultivars. Postharvest treatment with an ethylene inhibitor (1-MCP) provides protection from scald but has an opposite effect on BP development and can enhance progress of this disease. Aim of our research – development of innovative technology for controlling bitter pit and other postharvest physiological diseases. 1-MCP untreated and treated apple fruits were stored at 00…+10C in normal atmosphere (NA) and controlled atmosphere: CA-1 (CO2 – 1.2-1.5%, O2 – 1.2-1.5%), CA-2 (CO2 – 0.1-0.2%, O2 – 1.2-1.5%), CA+NA (within 14 days immediately after harvest fruits were stored at the temperature +18…+20C, CO2 – 1.2-1.5%, O2 – 1.2-1.5% and then in normal atmosphere. During the experiment levels of ethylene, α-farnesene, and its oxidation products (KT281), and phenolic compounds were determined in fruits. Losses from bitter pit, scald, CO2 burning, and fruit firmness were also evaluated. Treatment with 1-MCP resulted in low levels of ethylene accumulation in fruits, and protection against scald in all variants of the experiment; the lowest rates were in the CA-1 and CA-2 variants. Protection against bitter pit was provided in variant CA-2 and a significant reduction in losses from BP were observed in the CA-1 and CA+NA variants. The CA-2 treatment prevented CO2 burning which were observed in the CA-1 variant. Maximum fruit firmness and best protection against bitter pit, scald, and CO2 burning was provided in the CA-2 variant combined 1-MCP treatment.

Keywords: Apple fruits, bitter pit, scald, 1-MCP, controlled atmosphere, normal atmosphere, ethylene, and its oxidation products, α-farnesene, fruit firmness

P031 Efficacy of postharvest fungicides against Bull's eye rot of apple

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Abstract body text:

Bull's eye rot of apple is caused by the *Neofabraea* species-complex. The pathogen establishes latent infections with symptoms only becoming evident a few months into storage, resulting in significant losses. The fungicides, fludioxonil and pyrimethanil, have shown some control *in vitro* but this was yet to be confirmed *in planta*. The postharvest application of fungicides to control Bull's eye rot could help to control the incidence of the disease. The efficacy of fludioxonil and pyrimethanil were evaluated on *N. vagabunda* inoculated apple fruit via a dip and a drench application method. The fungicide dip was tested at four different concentrations and the drench at the recommended concentration. For both drenching and dipping, fludioxonil was the best in controlling Bull's eye rot lesions. Pyrimethanil did show a certain level of control, however, it was significantly less than with fludioxonil. Although fludioxonil and pyrimethanil show promise for managing this postharvest disease, further testing must be done on naturally infected fruit to positively confirm the fungicides' ability to control Bull's eye rot as a postharvest application.

Keywords: Bull's eye rot, *Neofabraea*, fungicides, apples, postharvest

P032 Selecting an isolate of *Penicillium digitatum* resistant to Imazalil from 'W. Murcott' and 'Nova' mandarin fruits

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Abstract body text:

Postharvest control of green mold in citrus packing houses in Peru, caused by *Penicillium digitatum,* mainly based on the use of imazalil fungicide (IMZ). This has resulted in an increased number of resistant biotypes of the pathogen. The objective of this work was to evaluate the resistance of 15 isolates of *P. digitatum* to IMZ following three steps. Isolates were collected from 'W. Murcott' and 'Nova' mandarin fruits with the symptoms of the disease eliminated during packinghouse processing. In the first step, all isolates were evaluated for their resistance to 1. 2 and 5ppm imazalil (PDA + IMZ). Fourteen isolates survived in 5ppm IMZ and were considered highly resistant. In the second step, the rate of infection development on 'W. Murcott' mandarin fruits was assessed. Fruits were previously cleaned by immersion in a 1 % solution of sodium hypochlorite for 60 seconds before being inoculated with the 14 imazalil-resistant *P. digitatum* isolates. Severity was evaluated after 15 days at 20 ± 2 °C by measuring the diameter of the rot. Three isolates displayed the highest percentages of severity and were used in the third step of evaluating conidia germination. Conidial suspensions of the three isolates were made in which 200 conidia were observed per visual field and then placed on slides with 1 drop of PDA and kept at 25 ° C. Only one isolate had significantly higher levels of spore germination (97.5% after 22 hours of incubation) than the other two isolates. Now that an isolate of *P. digitatum* has been identified that is highly resistant to imazalil, control trials using alternative methods that prevent the development of resistant green mold isolates can be undertaken.

Keywords: Green mold, *Penicillium digitatum*, 'W. Murcott', 'Nova', resistance, imazalil

P033 Salicylic acid enhances the positive effects of a chitosan-based edible coating in extending the postharvest life of harvested grapes

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Abstract body text:

Harvested grape berries (*Vitis vinifera* L. cv. Rishbaba) were treated with different concentrations of chitosan (0.5 and 1% w/v) and salicylic acid (1 and 2 mmol L^{-1}) and stored at 0°c ± 0.5°c with 90-95% R.H for 4 months. The effects of chitosan coating and salicylic acid treatments on fruit postharvest life and quality indices including decay extension, berry browning, berry drop, vitamin C content, bunch stem discoloration, weight loss, and edible quality were studied. Both chitosan and salicylic acid significantly affected fruit quality attributes. Treatment of grapes with 1 mmol L^{-1} salicylic acid + 1% chitosan significantly decreased fungal decay occurrence, berry drop, weight loss, bunch stem discoloration, and berry browning and enhanced edible quality. SA at 2 mmol L^{-1} had some adverse effects on fruit and caused increase in postharvest losses but chitosan effectively decreased theses adverse effects.

Keywords: Table grape, postharvest, berry drop, browning, salicylic acid

P034 Preharvest and postharvest fungicide applications for the control of gray mold on postharvest decay of strawberries, and fungicide residues on the fruit

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Abstract body text:
After harvest, fruit in general, and succulent fruit such as strawberry in particular, easily undergo fungal spoilage. *Botrytis cinerea* is the causal agent of gray mold, which represents the main postharvest strawberry disease, and even a limited infection can spoil entire fruit lots. In conventional agriculture, fungicide applications are repeated in the field from the strawberry flowering until the harvest, to control postharvest gray mold. Although in more recent years consumer concerns of the presence of fungicide residues on fruit have increased, fungicides remain the most effective means for controlling postharvest fruit decay. The aims of the present study were to compare the effectiveness of the active principles pyrimethanil, boscalid, fludioxonil, and cyprodinil applied either preharvest or postharvest for the control of postharvest strawberry decay, and to measure the consequent fungicide residues on the strawberry fruit. Regardless of the time of application, these fungicides reduced postharvest decay of strawberry fruit that were cold-stored for one week and then exposed to shelf life. In particular, fludioxonil and cyprodinil almost prevented postharvest strawberry decay, while pyrimethanil and boscalid reduced the disease by almost half, as compared to the untreated control. Moreover, these data showed that at 0, 4, 8, and 12 days after the treatments, the fungicide residues on strawberry fruit were always below the maximum residue levels.

Keywords: *Fragaria* x *Ananassa*, *Botrytis cinerea*, fungicides

P035 Effect of precooling with sodium carbonate on fruit rot and physiological changes in organic netted melon

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Abstract body text:

The effect of precooling with sodium carbonate (Na_2CO_3) on fruit rot and physiological changes in organic netted melon was studied. Melons were immersed in a cool solution of 2% Na_2CO_3 at 5 and 10°C until the temperature of the pulp was 20°C. Fruit immersed in Na_2CO_3 at 30°C were used as the control. All fruit were kept at 13°C for 12 days. The fruit immersed in 5°C had a lower disease incidence and severity than fruit immersed at 10, and 30°C during storage for 8 days. Moreover, precooling with Na_2CO_3 at 5°C maintained the quality of netted melon by delaying the physiological changes represented by low weight loss, respiration rate, ethylene production, and the activity of the cell-wall-degrading enzyme, polygalacturonase. No effect was observed, however, on pulp color changes, total sugar, and total soluble solids content of melon. these results suggest that precooling with a cool solution of sodium carbonate at 5°C can inhibit fruit rot disease and delay physiological changes in organic netted melon.

Keywords: Hydrocooling, postharvest decay, sodium carbonate

P036 Acetylsalicylic Acid treatment reduces *Fusarium* rot development and neosolaniol accumulation in muskmelon fruit

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Abstract body text:

Fusarium rot of muskmelon is a common and frequently-occurring postharvest disease of muskmelon and leads to quality deterioration and neosolaniol contamination. New strategies to control postharvest decay in muskmelon and reduce neosolaniol (NEO) contamination are of paramount importance. The effects of acetylsalicylic acid (ASA) treatment on the growth of *Fusarium sulphureum in vitro*, and *Fusarium* rot development and neosolaniol accumulation in fruits inoculated with *F. sulphureum in vivo* were investigated. Results indicated that ASA strongly inhibited the growth of *F. sulphureum*. Gross morphological changes and major cellular changes were observed under a microscope. *In vivo* testing demonstrated that 3.2 mg/mL ASA significantly suppressed *Fusarium* rot development and NEO accumulation at 6 and 8 days after pathogen inoculation. The expression of genes involved in neosolaniol biosynthesis (Tri genes) were also down-regulated after ASA treatment. We hypothesize that ASA treatment induces downstream resistance of muskmelon to reduce *Fusarium* rot development and Tri gene expression and NEO accumulation.

Keywords: Muskmelon, *Fusarium sulphureum*, trichothecenes, ASA, *Fusarium* rot

P037 Pomegranate decay fungi occurring in South Africa and their control

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Abstract body text:

South Africa is producing pomegranates with rapidly increasing exports to various northern hemisphere markets. Currently, more than 70% of the commercial plantings are in the Western Cape Province. Significant losses occur every season due to postharvest fungal diseases, despite a standard postharvest treatment protocol with chlorine and fludioxonil (dip). A survey was done of commercially handled fruit to determine the key fungal pathogens responsible for postharvest decay in stored fruit of the cultivars 'Wonderful', 'Herskovits', and 'Acco', as well as to determine the efficacy of the current industry postharvest treatment on the control of specific pathogens. The species were identified to species level using PCR-RFLP and sequencing of the internal transcribed spacer and/or beta tubulin regions and tested for sensitivity to the fungicides, fludioxonil, pyrimethanil, and tebuconazole *in vitro*. Various *Penicillium* spp. and *Talaromyces* spp. were the most frequently isolated from cold-stored (6°C) fruit, while *Aspergillus niger, Coniella granati, Cytospora punicae, Alternaria* spp., and *Colletotrichum gloeosporioides* were also isolated. Differences in the prevalence of the fungal species occurred between treated and non-treated fruit, while no differences were detected in the case of *C. punicae*. *In vitro* assays of *Penicillium* spp. and *Talaromyces* spp. indicated that fludioxonil is still the most effective fungicide to control pomegranate decay fungi, but other compounds should also be considered to avoid resistance development. Research outcomes from this work contribute to a better understanding of the suitability of current postharvest practices and will guide the development of alternative or additional postharvest management protocols for the industry.

Keywords: Fludioxonil, post-harvest disease, *Punica granatum* L., pyrimethanil, *Talaromyces* spp., tebuconazole

P038 Fludioxonil: a potential alternative for postharvest disease control in mango fruit

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Abstract body text:

Stem end rot (SER) is one of the most prevalent postharvest diseases of mango fruit grown in Mediterranean climate, whereas anthracnose disease, caused by *Colletotrichum gloeosporioides,* almost never occurs due to the dry environment present during fruit development and harvest. SER is caused by a variety of fungal pathogens. The main cause of SER in Israel is *Lasiodiplodia theobromae*, which is not well controlled by current fungicides. In a search for potential alternatives for controlling postharvest SER in mango, we assessed the efficacy of two commercial fungicides—fludioxonil and prochloraz—in controlling postharvest decay of mango fruit. Fludioxonil was significantly more effective at inhibiting *L. theobromae* mycelial growth and reducing conidial germination. Notably, treatments with fludioxonil were significantly more effective than prochloraz in controlling SER of mango fruit inoculated with *L. theobromae*. Both fungicides controlled side decay of mango fruit with similar efficiency. Fludioxonil treatments, however, significantly changed the stem-end microbiome community and reduced SER incidence and severity in mango fruit relative to similar treatments with prochloraz. We suggest fludioxonil as a postharvest treatment to control mango fruit decay in areas where harvest occurs during the dry season.

Keywords: Mango fruit, stem end rot, fludioxonil, *Lasiodiplodia*

P039 Combined efficacy of hot vapor, sodium chlorite, and PVC film on postharvest decay and browning of trimmed aromatic coconut

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Abstract body text:

Postharvest deterioration of trimmed aromatic coconuts are due to fungal infection and browning of coconut mesocarp. Two major fungi found in the mesocarp were *Aspergillus niger* and *Penicillium* spp. To control fungal infection and browning, the efficacy of sodium chlorite (SC) solution combined with hot vapor (HV) and PVC film wrapping were investigated. Trimmed coconut fruit were dipped in filtrated water, 3% sodium metabisulfite (SMS, commercial agent) for 5 min, and HV for 90 sec followed by dipping in 250 mg/l SC for 5 min. After that, they were wrapped with PVC film. The fruit dipped in filtrated water and non-wrapped served as the control. All fruit samples were stored at 4°C for 25 days. Result showed that hot vapor combined with SC and PVC film (HV+SC+PVC) was able to suppress th fungal infection and mesocarp browning relative to the control. Its efficacy, however, was not equal to SMS. HV+SC+PVC treated fruit which exhibited a lower level of color change, brown pigment, and o-quinone than filtrated-water-treated fruit (both wrapped and un-wrapped with PVC). theThe control was correlated with the lower activity of browning enzymes, such polyphenoal oxidase (PPO) and peroxidase (POD). HV+SC+PVC treatment did not affect titratable acidity, total soluble solids content, percentage of transmittance and thiobarbituric acid (TBA) values of coconut juice. Results suggest that HV+SC+PVC can reduce the level of fungal infection and browning of coconut even through its effectiveness was not equal to the SMS treatment.

Keywords: Enzymatic browning, heat treatment, sodium chlorite, sodium metabisulfite

P040 Control of postharvest anthracnose in papayas (*Carica papaya* L.) by hot water and chitosan

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Abstract body text:

Anthracnose in papayas, caused by *Colletotrichum fructicola*, is responsible for large economic losses during the export of this tropical fruit. The use of chemical fungicides is commonly used to control postharvest rots in papayas. The continued use of fungicides can result in the evolution of resistant fungal strains and the accumulation of chemical residues in the harvested fruit. Combinations of alternative methods have the potential to improve the effectiveness of these treatments compared to when they are applied individually. In this research, a combination of a hot water dip (49 ^{o}C for 20 minutes) and chitosan (1 and 2 %) were assessed for their effectiveness against *C. fructicola* on papayas in cold storage. After 28 d at 10 °C, anthracnose reduction on fruit treated with combination of a hot water dip plus 2% of chitosan (50.7 %) was significantly higher was significantly higher (p<0.05) than disease reduction on papayas treated with synthetic fungicide (48.6 %) and papayas treated with hot water dip plus 1 % of chitosan (37.8 %), all treatments were compared with untreated fruit. In addition, dip at 49 ^{o}C for 20 minutes plus spray with chitosan at 2 % significantly reduced (p<0.05) weight loss, maintained firmness of papayas and slowed the changes on chemical quality parameters (total soluble solids (TSS), titratable acidity (TA) and pH), after 28 d of cold storage at 10 ^{o}C. According to results obtained in this study, hot water dip and chitosan combination may be potentially used for controlling anthracnose on papayas during postharvest conservation without negative influence on its physicochemical quality. It is a residue-free method, respectful with human health and environment. However, further experiments will be needed to overcome the lack of knowledge about combinations of alternative treatments for controlling postharvest diseases in tropical fruits.

Keywords: Fruit, *Colletotrichum fructicola*, postharvest, combination, alternative methods

P041 Effect of ascorbic acid and modified atmosphere packaging on browning of fresh-cut eggplant

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Abstract body text:

The growing demand for fresh-cut products has led to an increasing interest in the development of methods that enhance the quality of ready-to-eat products. Eggplants are increasingly being consumed as fresh-cut vegetables. To extend the shelf-life of the product, a combination of treatments were evaluated to inhibit the browning index. In the first experiment, the concentration of ascorbic acid (Vc) (1g/L, 2g/L, 3g/L, 4g/L) and modified atmosphere packaging (MAP) (O2:80Kpa + CO2:0Kpa; O2:5Kpa + CO2:15Kpa; O2:10Kpa + CO2:10Kpa; O2:15Kpa + CO2:5Kpa; O2:0Kpa + CO2:80Kpa) were evaluated for their effect on the browning index. Then the effect of Vc combined with MAP on the browning index, phenolic compounds, polyphenol oxidase (PPO), and sensory evaluation of fresh-cut eggplant was investigated over 4 days of storage at 16 °C. Samples with no ascorbic acid treatment under normal atmosphere were used as a control. Results showed that the treatments with Vc (2 g/L) combined with MAP significantly inhibited increases in the browning index of fresh-cut eggplant. The application of Vc (2 g/L) combined with MAP (O2:5Kpa, CO2:15Kpa) inhibited increases in total phenol content and PPO activity throughout storage. Based on the sensory evaluation, the combined treatment of Vc and MAP (O2:5Kpa, CO2:15Kpa) resulted in a shelf-life for up to 4 days, with the other combinations resulting in a shorter shelf-life. Taken together, the combined use of ascorbic acid with MAP may constitute a potential approach for maintaining the quality and inhibiting the browning of fresh-cut eggplant.

Keywords: Fresh-cut eggplant, preservation, ascorbic acid, modified atmosphere packaging

Session V - Alternative Postharvest Disease Control Technologies

KEYNOTE SPEECH Alternative means for the management of postharvest pathogens on fruits

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Abstract body text:

Traditionally, chemical fungicides have been used to preserve the quality of fruit and vegetables over extended periods of storage or transportation. However, the growing public concern over the health and environmental hazards associated with high levels of pesticide use, have resulted in restrictions in their use imposed by legislation and distribution companies. A huge effort in research during the last 25 years has been conducted in order to develop environmental-friendly alternative strategies to synthetic fungicides to control postharvest diseases over the world. Although a large number of studies have demonstrated the efficacy of these alternative treatments, only few of them are currently applied under commercial conditions. Biocontrol agents, natural compounds from different origins and physical means are the main studied approaches with different success level. There are several reasons for the limited success of these products, such as inconsistency of results, variability of the efficacy under commercial conditions, low persistence, a narrow spectrum of activity, the difficulties in developing a shelf-stable formulated product that retains efficacy in the case of biocontrol and economical and regulatory limitations. It is generally accepted that the combination of different strategies are necessary to improve the control extent of postharvest diseases and that the real solution needs to integrate different tools to achieve the disease control. The aim of this talk is to review the main efforts conducted by our research group to develop alternative strategies to control postharvest diseases.

Keywords: Postharvest disease, physical treatments, GRAS, biological control

S-V-O1 Study of biological control efficacy of *Yarrowia lipolytica* against postharvest decay of table grape caused by *Penicillium rubens* and its possible mechanisms of action

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Abstract body text:

Table grapes are one of common fruits grown and consumed worldwide and provide a nutrient for human diet. Disease in grape caused by pathogenic fungal have inflect considerable economic losses. This present work investigates the effect of *Yarrowia lipolytica* against *Penicillium* rubens on the control of postharvest decay of grapes and its possible involved mechanisms of action. The results indicate that *Y. lipolytica* significantly controlled postharvest decay of grape caused by *P. rubens* compared with control fruits. Decay incidence and decay diameter of grapes by using *Y. lipolytica* at concentration 1 × 109 cells/mL were 12.45% and 6.19 mm, respectively. Furthermore, *Y. lipolytica* reduced spore germination and germ tube length of *P. rubens*. Moreover, the results demonstrated that the activities of defense-related enzymes, including polyphenoloxidase (PPO), peroxidase (POD), catalase (CAT), phenylalanine ammonialyase (PAL), ascorbate peroxidase (APX) and β-1,3 glucanase (GLU), were significantly enhanced in grapes treated with *Y. lipolytica*. Additionally, the expression levels of these genes were also increased in grape fruits treated with *Y. lipolytica*. The results suggested that the possible mode of action of *Y. lipolytica* consists in enhancing the defense-related enzymes and genes of grapes, ultimately reducing postharvest decay caused by *P. rubens*. Therefore, the investigation confirmed that *Y. lipolytica* has potential biocontrol efficacy and could be used as a biocontrol agent to prevent the postharvest decay of grape fruits.

Keywords: Table grapes, *Yarrowia lipolytica*, *Penicillium rubens*, biocontrol, enzyme activity

S-V-O2 Isolation and in vivo screening of yeast antagonists for the control of *Botrytis cinerea* and *Penicillium expansum* of pome fruit

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Abstract body text:

A total of 100 epiphytic yeast isolates were obtained from the fruit surface of "Golden Delicious" apples and "Packham's Triumph" pears, and screened against *Botrytis cinerea* and *Penicillium expansum*, the causal agents of grey and blue moulds respectively. Fifteen yeast isolates reduced grey mould incidence by > 50%, when applied four hours before inoculation with *B. cinerea*. Similarly, seven yeast isolates reduced blue mould incidence by > 50%, when applied four hours before inoculation with *P. expansum*. Yeast isolates YP16, YP24, YP25, and YieldPlus®, a commercial biological control agent, provided the best control of grey mould on apples when applied 48 hours prior to inoculation with *B. cinerea*. This reduction was significantly different ($P < 0.001$) compared to the pathogen inoculated control. Furthermore, YieldPlus® and yeast isolates; YP28, YP53, YP60, YP43, YP5, YA33 and YP84, when applied 48 hours prior to inoculation with *P. expansum*, significantly ($P = 0.05$) reduced blue mould incidence compared to the pathogen inoculated control. YieldPlus® and yeast Isolate YP25 provided the best control of *B. cinerea* (16.7%), compared to 100% incidence in control fruit. Both isolate YP60 and YieldPlus® reduced *P. expansum* by 16.7% on "Golden Delicious" apples compared to 100% incidence in control fruit. A mixture of YP25 and YP60 provided complete control of both *B. cinerea* and *P. expansum*, when applied to "Golden Delicious" apples before inoculation with either *B. cinerea* or *P. expansum*. The results of this work further stresses the benefits of using yeast antagonist as a measure to reduce the use of agrochemicals on postharvest fruit diseases.

Keywords: Blue mould, biological control, grey mould, yeast

S-V-O3 Characterization of Volatiles Organics compounds of two biocontrol agents *Pichia anomala* strain K and *Candida oelophila* strain O

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Abstract body text:

Among the large diversity of microbial secondary metabolites, low molecular-weight volatile organic compounds (VOCs) have received growing attention in the past decade. Many fungal species and yeast have the ability to produce low concentrations of antifungal substances. This would open the way as alternative method to control microbial decays via biofumigation, as it does not require physical contact with the product or commodity to be treated. The yeasts antagonists, *Pichia anomala* strain K, and *Candida oleophila* strain O were among the most studied yeast antagonists in our Integrated and Urban Plant Pathology Laboratory. Both strains are well known as potential biocontrol agent to manage postharvest disease of apples. Beyond their primary mode of action, which rely on nutrient competition and glucanase production, the ability of these yeasts to produce volatiles organic compounds was investigated. The VOCs were assayed with a double petri dish test against *P. expansum* and *B. cinerea*. Results showed that the VOCs generated by the antagonists inhibited significantly pathogen growth. In parallel an in vivo trial was carried out to assess the ability of produced VOCs to inhibit pathogen growth in in vivo conditions. The characterization of produced volatiles was assessed using solid-phase microextraction (SPME)–gas chromatographic technique. The results showed three common produced compounds: the 1-Propanol, 2-methyl, Isoamylalcohol and the phenethyl alcohol. The pure standard compounds were tested individually to assess their ability in pathogen growth inhibition.

Keywords: Volatiles organics compounds, biocontrol agent, biofumigation, efficacy, *in vivo* trial, *in vitro*

S-V-O4 Volatile organic compounds produced by *Aureobasidium pullulans* inhibit the growth of *Botrytis cinerea* and *Alternaria alternata*

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Abstract body text:

Botrytis cinerea and *Alternaria alternata* are two necrotrophic fungal pathogens causing grey and black mould respectively on horticultural crops, including tomatoes and grapes, leading to enormous preharvest and postharvest losses worldwide. *Aureobasidium pullulans* is a yeast-like saprophytic fungus which naturally inhabits plant and fruit surfaces and is a potential biocontrol agent against a wide range of pathogenic fungi. Production of antifungal volatile organic compounds (VOC) has been postulated as one of the biocontrol mechanisms of *A. pullulans.* In this study the efficacy of antifungal VOC from four *A. pullulans* isolates were tested in vitro against two B. cinerea isolates from tomato and wine grapes and one *A. alternata* isolate from tomato using a double Petri dish assay. Two base Petri dishes containing PDA were stacked open-end to open-end. *A. pullulans* was inoculated on the upper dish and the pathogen inoculated on the second (lower). Inhibition of radial growth of the pathogen colony was measured. In a second experiment a Petri dish containing a glass slide with a pathogen conidial suspension in PDB was exposed to the *A. pullulans* inoculated dish to assess the inhibition of conidia germination. Exposure to the headspace of four *A. pullulans* isolates caused a 37- 85 % reduction of colony diameter of *B. cinerea* and 35-47 % for *A. alternata* compared to non-fumigated controls after three days of incubation at 25 °C. A. pullulans VOC also inhibited conidial germination of the three pathogen isolates, by 29-75% and 22-83% for the *A. alternata* and *B. cinerea* isolates respectively. Morphological deformations were observed in fumigated conidia and germ tubes of the pathogens when exposed to the headspace of the *A. pullulans* culture. To elucidate the nature of the *A. pullulans* VOC, the culture headspace was analysed by SPME-GC-MS. Thirteen VOC were identified that included alcohols, ketones and esters.

Keywords: Biological control, bio fumigation, *Aureobasidium pullulans*, volatile organic compounds

S-V-O5 Strawberry fruit decay is affected by plant volatiles

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Abstract body text:

There are extensive efforts and interests to identify and develop safe and eco-friendly practices to control fruit pathogens. Extensive attention has been given to natural safe products, such as plant volatiles. These natural compounds are part of plant self-defense system and specific in their action. Their volatility makes them suitable as fumigants, in protected environments, to control postharvest diseases of horticultural crops. Plant volatiles have shown promising results in controlling pathogens under in vitro conditions and laboratory settings. However, there are only a few reports on the application of plant volatiles to control pathogen growth in storage. We hypothesized that volatiles will extend the shelf life of the strawberries by reducing fungal infections and preserving fruit quality. The efficacy of two plant volatiles was tested on reducing fruit decay and extending the shelf life of strawberries. Up to 10 strawberries were placed in the polystyrene containers with snap-on-lids and kept at 4^{o}C and 95% humidity for 4 weeks. Thymol and Carvacrol (at 30 and 60 ppm respectively) and a combination of them were put on a cotton ball, in the containers to vaporize. Fungicide (Switch) and water were sprayed as positive and negative controls, respectively. Weight and fungal contamination of strawberries were recorded at the beginning of the storage and every week for 4 weeks. Both volatiles and their combination were able to control fungal contamination compared to water. However, Thymol treated strawberries had the least amount of fungal contamination and were as effective as fungicide spray. The treatments did not change the weight loss of strawberries compared to the control mainly because they were kept in closed containers, therefore, commercial strawberry containers were used for further studies.

Keywords: Essential oils, thymol, carvacrol, fruit quality, pathogens, shelf life

S-V-O6 Alternative postharvest treatment of mango: potential use of essential oil with thymol to control anthracnose development caused by *Colletotrichum gloeosporioides*

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Abstract body text:

Anthracnose, a fungal disease caused by the *Colletotrichum gloeosporioides* species is the main postharvest problem concerning mango (*Mangifera indica*) production on La Reunion Island. Traditional postharvest treatments involve chemical compounds that do not comply with the expectations of consumers or importing countries. Our goal was to develop alternative postharvest treatments using the fungitoxic properties of two essential oils (EO). Two commercial essential oils X2 (eugenol) and X5 (thymol) were used at various concentrations and compared to a no-oil control. A first batch of treatments were tested in vitro for studying mycelial growth and the inhibition of conidial germination. The second experiment measured the effects of the treatments on the fruit quality of inoculated mangoes var. Tommy Atkins with a suspension of *C. gloeosporioides* spores. In vitro, X5 mainly composed of thymol was very fongitoxic against *C. gloeosporioides*. The concentrations of phenolic compounds and resorcinol in the fruits were increased after the X5 treatments, expressing some positive effects of essential oil treatments on fruit resistance mechanisms. The quality of treated fruits verified the requirements to meet consumers' expectations. Thymol-based EO exhibited a strong fongitoxic in vitro activity but it had no detectable effect when applied by volatilization on mango necrosis. Alternatives ways of treatments should be tested.

Keywords: Mango, *Mangifera indica*, anthracnose, *Colletotrichum gloeosporioides*, biological control, fruit quality, phenolic compounds

S-V-O7 Effects of chitosan coatings on avocado postharvest diseases and expression of phenylalanine ammonia-lyase, chitinase and lipoxygenase genes

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Abstract body text:

Amongst avocado cultivars, 'Hass' is the most popular to retailers and consumers alike, due to their characteristic resistance traits and smooth endocarp texture. Retention of the phytonutrients and fruit quality for an extended period of time is important in order to make a profit during sales. The effect of coating the fruit with chitosan (1% w/v or 1.5% w/v) was investigated on disease incidence, antioxidant compounds, defence related enzymes and expression of defence genes [phenylalanine ammonia-lyase (PAL), chitinase (CHI) and lipoxygenase (LOX)] in drop-inoculated, artificially- and naturally infected 'Hass' avocado fruit stored for 14 and 28 days respectively at 7.5 °C, and subsequently for 5 days at 15 °C. Chitosan at 1.5% w/v significantly reduced the incidence of stem-end rot and anthracnose in both inoculated and naturally infected fruit. The up-regulation of PAL and down=regulation of LOX genes moderately retained higher epicatechin content (90 mg kg-1)in the exocarp, resulting in improved anthracnose control. Similarly, the up-regulation of CHI gene expression could be responsible for better control of stem-end rot. Chitosan coating (1.5%) also retained moderate levels of C7 sugars and firmness up to Day 5 after cold storage. The residual effect of initial antifungal activity was retained in Chitosan-coated (1.5%) fruit during ripening.

Keywords: Antioxidant enzymes, edible coatings, gene regulation.

S-V-O8 Alternative methods for controlling banana crown rot in an organic production context

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Abstract body text:

Crown rot, caused by the pathogenic fungus *Colletotrichum musae* (Berk. and Curt.) Arx, is the main disease occurring during banana shipping and storage in the French West Indies. The rot is not visible when bananas are boxed, with symptoms generally only appearing after sea-shipping. The rot begins with mycelium development on the surface of the crown, followed by internal development that might later affect the peduncle and the fruit. Chemical fungicides have been used for many years to control postharvest diseases. However, with the development of fungus resistance, these treatments are not always effective, and the public authorities, who are concerned about the impact of pesticide treatments on the environment and on consumer health, are imposing increasingly stringent phytosanitary regulations. Our results allowed us to identify and eliminate the main source of fruit contamination by removing the upper section of the crown. This elimination of the pad reduces the internal necrotic area of the crown by 70%, without any chemical fungicide treatment. In vitro, a high concentration of CO2 slows down the mycelial development of *C. musae*: diameter growth is reduced by 80%. In vivo, the internal necrotic area of the crown can be reduced by 70% with a modified atmosphere in polybags (BanaVac type, 6% CO2 and 4% O2) without chemical fungicide treatment. Alternative methods integrated into new postharvest practices are essential for developing an organic banana production framework.

Keywords: Banana, crown rot, postharvest, *Colletotrichum musae*, quality, fruit

S-V-O9 **Hot water dipping of apple - Not living up to its promise?**

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Abstract body text:

Apple is an important fruit commodity in Belgium. It has the second highest production value by mass. The fruit can be stored year round using controlled atmosphere storage. During this storage, losses can occur by fungal decay or physiological disorders. One approach that was previously studied to reduce these losses and better retain fruit quality is hot water dipping of the fruit. In our study we investigated the effect of a hot water dip of 50 °C for 4 min on the quality of Jonagored apples and their susceptibility for *Botrytis cinerea* and *Penicillium expansum*. Fruit were treated at harvest and stored under controlled atmosphere. Evaluation of quality, physiological parameters and disease susceptibility was carried out immediately after treatment, after 1 week, 1 month, 3 months and 9 months. Our results show that the tested treatment has no protective effect against artificial wound infections with either pathogen. Furthermore, most quality (titratable acidity, total soluble solids content, firmness) and physiological effects of the treatment disappeared after six months of storage. Treated fruit had a significantly higher mass loss throughout the 9 months of storage, which is in contrast to what has been reported in literature. Because this effect is already observed after 1 week we hypothesize that it is a direct effect of the hot water dip. After 9 months of storage, remaining fruit were placed in shelf-life for two weeks and the incidence of rot was recorded. The incidence rates were 17.45 % and 7.63 % for the control and treated fruit, respectively. This indicates that there may be a protective effect of the hot water dip. Further research is ongoing to determine which factors explain this positive effect after 9 months storage.

Keywords: Hot water dip, *Malus x domestica*, *Botrytis cinerea*, *Penicillium expansum*

S-V-O10 Development of hot water treatment to control postharvest diseases of carrots

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Abstract body text:

The fresh fruit and vegetable industry is continuously searching for alternative methods to meet consumers and retailers demand for chemical-free, fresh produce with a long shelf life without compromising food quality. Hot water treatment (HWT) is a non-conventional physical method to control postharvest decay before storage or entry of the fresh produce into the supply chain. The method involves dipping in water by immersion or rinsing by overspray at temperatures above 40 °C. The technique is safe for human and environment and can be applied without registration. The HWT has mainly been applied to fruits after harvest and little to other commodities. The aim of this study was to evaluate hot water treatment to control postharvest decay and prolong shelf life of carrots. Natural infected carrots were dipped in different combinations of hot water from 45 to 65 °C for 15 to 90 sec in the laboratory, stored at 20 °C for 14 days and evaluated for weight loss, rooting, sprouting and decay. The results showed that dipping at low temperatures (55 °C) wounded the tissue. The optimal dipping temperature was thus in between 45 and 55 °C. Similar results were obtained with hot water dipping and hot water overspray using small-scale industrial equipment for treatment of natural infected carrots. However, dipping was more efficient than overspray to control *Botrytis cinerea* on the carrot surface due to a more uniform heat treatment in dipping than overspray. The results showed that hot water dipping is a promising technique for control of postharvest decay of carrots given that the treatment is uniform and gentle without wounding the tissue of the produce.

Keywords: Carrot, root crops, shelf life, hot water dipping, hot water overspray, *Botrytis cinerea*

S-V-O11 Semi-commercial hot water treatments to control apple Bull's eye rot (*Neofabraea alba* syn. *Phlyctema vagabunda*)

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Abstract body text:

Bull's eye rot (BER), caused by *Neofabraea alba*, is an important postharvest apple disease worldwide. Reduction of BER by application of hot water treatments (HWT) has been demonstrated in laboratory studies. Our aim was to investigate the feasibility of using HWT in a semi-commercial packing line. One bin of naturally infected 'Scired'/Pacific Queen™ apples was harvested from a Hawke's Bay, New Zealand, orchard with a known high incidence of BER, then placed into a coolstore at 0.5 ± 0.5°C for 1 week until treated. All fruit were passed through a high pressure water washer then air dried. Half the bin's fruit were packed into cardboard trays in apple boxes with a plastic polyliner. The other half were treated for 2 min with hot water at 51°C in a semi-commercial hot water bath, then air dried before packing as before. After all treatments were conducted, fruit were placed in a coolstore at 0.5 ± 0.5°C and assessed after 6, 12, 16 and 20 weeks. After 20 weeks of coolstorage, the hot water treated fruit showed less lesion growth (identified by symptoms as BER) than untreated control fruit. Untreated fruit lesions had a mean diameter of 12.6 ± 1.27 mm; treated fruit lesion mean diameter was 0.8 ± 0.22 mm, or a 93% reduction ($P < 0.0001$). The incidence of treated fruit with Bull's eye rot was 51/900 (5.7%) and of untreated fruit was 376/1034 (36.4%); thus HWT resulted in a 6–fold reduction of fruit developing symptoms ($P < 0.0001$). HWT effectively reduced both lesion size and number of natural infections by *Neofabraea alba* by 93% and 84%, respectively, and shows promise for use in commercial packing houses.

Keywords: Postharvest, pathology, *Malus domestica*, Bull's eye rot, thermotherapy

P042 In vitro and in vivo screening of yeast isolates on *Penicillium digitatum* and *Galactomyces citri-aurantii* of citrus

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Abstract body text:

Penicillium digitatum and *Galactomyces citri-aurantii* are two of the most important fungal pathogens of citrus causing green mould and sour rot, respectively. These pathogens are responsible for about 90% of the postharvest losses in the citrus industry worldwide. *P. digitatum* and *G. citri-aurantii* were isolated from untreated diseased citrus fruit in KwaZulu-Natal, South Africa. A total of 200 yeasts were isolated from orchard soils, weeds, grasses, citrus peels and leaves; and screened against green mould and sour rot. The highest antagonistic activity was shown by 10 yeast species isolated from lemon and sweet orange fruits and leaves, with biocontrol efficacies ranging between 20% and 90%. These isolates were further applied as preventative and curative treatments of “Navel” and “Valencia” cultivars against the two pathogens. Two yeast strains depicted antagonistic activity against green mould and three strains were observed to have antagonistic activity against sour rot on both cultivars. Yeast isolates inhibited pathogen development on fruit when applied preventatively compared to curative treatment. Scanning electron microscopy studies showed shrinked and collapsed hyphal structures of *P. digitatum* and *G. citri-aurantii* after interaction with yeast isolates in vitro. Furthermore, yeast isolates significantly inhibited spore germination and mycelial growth of *P. digitatum* and *G. citri-aurantii* on sweet orange wounds. These results suggest that yeast antagonists could be an alternative control method for green mould and sour rot in the citrus industry.

Keywords: *Penicillium digitatum*, *Galactomyces citri-aurantii*, yeast, biocontrol, citrus

P043 Screening of biological control agents against *Alternaria alternata* causing postharvest black spot of persimmon

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Abstract body text:

Consumer demand of persimmon (*Diospyros kaki* L.) in European markets has raised due to the high quality of the Spanish cultivar 'Rojo Brillante' and as a consequence commercial production area and yield have doubled in Spain in the last years. Black spot caused by *Alternaria alternata* is the main responsible for persimmon postharvest losses in commercial packinghouses in Spain. The aim of this study was to set up an assay to easily screen microorganisms to test their ability to control black spot in persimmon. As a first step, the best conditions to inoculate fruits were established. Two inoculation methods, two concentrations of inoculum and the duration of the assay were tested to get the most consistent results. The number of infected wounds and the diameter of the lesions were recorded. In a second step, the ability of a collection of microorganisms (previously isolated by the research group) to control *A. alternata* in persimmon was tested under the optimized conditions. Two inoculum concentrations of the microorganisms were assayed. Results show that inoculation of *A. alternata* with a steel rod at 106 conidia ml^{-1} and an incubation time of 9 days was optimal to get consistent infection results. When applied 2 hours after the inoculation of the pathogen, a yeast and a bacteria showed the ability to reduce both the severity (by 45 and 38%, respectively) and the incidence (by 47 and 19%, respectively) of the lesions produced by *A. alternata*. In conclusion, a screening method to test the biological control ability of selected microorganisms has been set up and, based on the promising results, further research to combine the microorganisms with edible coatings is planned.

Keywords: *Alternaria alternata*, persimmon, biological control, postharvest, black spot

The authors are grateful to INIA (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria) and FEDER (Fondo Europeo de Desarrollo Regional) for financial support through national project RTA2015-00037-C02-02. They are also grateful to the CERCA Programme/Generalitat de Catalunya.

P044 Biocontrol of mango anthracnose: isolation of new bacterial antagonists of *Colletotrichum* from mango surface

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Abstract body text:

Mango anthracnose appears as irregular-shaped black necrotic spots on the fruit surface, which occur during ripening or when the fruit is wounded. In Reunion Island, mango production is severely affected by *Colletotrichum gloeosporioides*. With an objective of reduction of chemical treatments, new microbial agents able to limit *C. gloeosporioides* development were searched in the indigenous natural flora of mangoes. For this, epiphytic bacteria were isolated from the mango surface, and characterized for their ability to interfere with the development of *C. gloeosporioides*. From 17 cultivars grown over eight locations on Reunion Island, with different agricultural practices, 311 epiphytic bacteria were isolated from mango surface. In vitro, different isolates showed remarkable ability to limit *C. gloeosporioides* mycelial growth or conidia germination. The most efficient bacteria belong to the species *Enterobacter asburiae, Enterobacter kobei, Kosakonia cowanii, Leclercia adecarboxylata* and *Leuconostoc mesenteroides*. Preliminary scanning electron microscopy showed two different patterns for bacteria inhibiting fungal growth: an inhibition mediated by compounds and a large inhibition area around the bacteria or a bacterial growth occurring across fungal mycelium. The further biocontrol treatment would consider either preharvest application to prevent the fruit infection, or postharvest application to prevent the development of symptoms.

Keywords: Anthracnose, *Mangifera indica* L., *Colletotrichum gloeosporioides*, epiphytic bacteria, bacterial biocontrol agents, lactic acid bacteria

P045 Antifungal effect of *Bacillus subtilis* B6 strain on *Monilinia fructicola*

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Abstract body text:

Brown rot caused by *Monilinia* spp. is one of the major factors limiting the storage period and market life of stone and pome fruits. Control of postharvest decay is currently based on the use of synthetic fungicides during bloom and preharvest periods, while postharvest use of fungicides is restricted in EU countries, as well as in Serbia. In recent years, the use of environmentally friendly approaches, such as biological control agents, has increased continuously due to public concerns over the risks of pesticide residues remaining in food and their negative impact on the environment. One of the most significant practical constraints in the use of biocontrol products is the required development of their shelf-stable formulations.
The aim of this study was to test antifungal properties of numerous bacterial strains from Serbia against *Monilinia fructicola*, to develop a suspo-emulsion (SE) formulation, and to test its efficacy in apple protection against one of the most damaging brown fruit rot pathogens. We conducted in vitro screening of many bacterial isolates originating from different substrates for their antifungal properties against a *M. fructicola* isolate as a model organism. In vitro antagonistic activity assays were performed in 90 mm Petri plates using the wells technique. Based on antagonistic effects in vitro, seven of 108 isolates were chosen for further studies. The isolates were identified to the species level based on morphological and molecular characteristics. One the most promising antagonistic strains was then selected to develop a SE biopesticide formulation and test its bioactivity in vivo on apple fruits cv. Golden Delicious. The results showed that the investigated bacteria exhibited antifungal properties against *M. fructicola* in vitro, and that the B6 strain of *Bacillus subtilis* qualifies to be selected as the best for further testing in vivo. The experiment on wound-inoculated apple fruits showed that the SE formulation of B6 strain was as effective as a reference synthetic fungicide and that its effectiveness remained stable for at least 24 hours. On inoculated apple fruits, the 10% concentration of SE formulation was the most effective, achieving 80% efficacy compared to the control. This work confirmed a great potential of the isolated bacterial strain and its formulation for biological control of brown rot in apple fruit.

Keywords: Biological control, biopesticides, brown rot, antimicrobial activity, apple fruit

This work is supported by Ministry of Education, Science and Technological Development of the Republic of Serbia, Project No. III46008.

P046 Efficacy of *Bacillus amyloliquefaciens* cyclic lipopeptide supernatant to control pomegranate blue mould fungi in vitro

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Abstract body text:

Blue mould on pomegranate (*Punica granatum* L.) caused by *Penicillium* spp. and *Talaromyces* spp. causes economically significant losses due to postharvest decay. The fungi infect fruit through wounds caused by insects in the orchards or due to injury during harvest. The purpose of the study was to determine the efficacy of *B. amyloliquefaciens* cyclic lipopeptide metabolite in vitro. Sensitivity of fungal isolates was evaluated by germ tube length and mycelial growth tests. Potato dextrose agar was amended with different concentrations of the *B. amyloliquefaciens* cyclolipopeptide acid precipitate (CLP: 0.05x; 0.1x; 0.25x; 0.5x) including unamended media as the negative control. Four *Penicillium* spp. and three *Talaromyces* spp. isolates were tested for CLP sensitivity. The complete inhibition of mycelial growth was seen at 0.5x concentrated CLP. The mean EC50 was 0.16x concentrated CLP for *P. adametzioides*, 0.15x for *P. glabrum*, 0.18x for *T. albobiveticillius*, 0.17x for *T. erythromellis* and 0.18x for *T. purpurogenus* respectively. In addition, *Penicillium glabrum* isolate was found to have the highest spore size and germ tube length compared to other isolates which indicate low sensitivity to application of CLP. However, the application of cyclolipopeptide metabolite might be presented as an alternative of agrochemical in postharvest. Therefore, it can be concluded from this study that the application of acid precipitate metabolite is a reliable approach in controlling the *Penicillium* and Talaromyces species in vitro and might have a great potential as a biofungicide application to control blue mould.

Keywords: Biofungicide, metabolite, postharvest, *Penicillium*, *Talaromyces*

P047 Lipopeptides, fengycin and iturin A, from *Bacillus amyloliquefaciens* as postharvest fungicides on pome

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Abstract body text:

Postharvest diseases are a major factor influencing fruit quality. Currently the norm to manage postharvest diseases is the use of synthetical fungicides, but the resistance of some pathogens to fungicides and concern for public safety has led to an increase in research into alternative methods to control fruit diseases. Two major postharvest pathogens on pome fruit are *Penicillium expansum* (causing blue mould on apples) and *Botrytis cinerea* (causing grey mould on pears). Cyclolipopeptides, fengycin and iturin A, produced by *Bacillus amyloliquefaciens* has been identified as potential biological fungicides due to their growth inhibiting action against plant pathogenic fungi causing major postharvest, pome fruit diseases. The aim of this study was to evaluate the efficacy of CLPs as an application on fruit, inoculated with *P. expansum* ('Golden Delicious' apples) or *B. cinerea* ('Packham's Triumph' pears). The efficacy was tested by applying acid precipitate of *B. amyloliquefaciens* culture filtrate to the wound of the fruit at different concentrations, after inoculation. Lipopeptide concentrations of 2.79 g L^{-1} (10x), 0.279 g. L^{-1} (1x), 0.209 g. L^{-1} (0.75x), 0.134 g L^{-1} (0.50x) and 0.07 g. L^{-1} (0.25x) fengycin and 0.625 g. L^{-1} (10x), 0.063 g. L^{-1} (1x), 0.047 g. L^{-1} (0.75x), 0.031 g. L^{-1} (0.50x) and 0.016 g. L^{-1} (0.25x) iturin A were used to treat both 'Golden Delicious' apples and 'Packham's Triumph' pears. Fruit treated with fludioxonil were used as positive control. The use of *B. amyloliquefaciens* acid precipitate as biological control of grey mould on pears showed promising results at 2.79 g L-1 fengycin and 0.625 g L-1 iturin A. However, compared to fludioxonil there is still room for improvement. The lipopeptides had no significant effect on controlling blue mould on apples and it might be that higher dosages are needed to control *P. expansum.*

Keywords: Blue mould, grey mould, *Penicillium*, *Botrytis*, biological control

P048 Antifungal activity of *Pseudomonas* sp. BM14 for the biocontrol of apple blue mold rot and initial study of mechanisms of action

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Abstract body text:

Apple blue mold rot is one of the most important fruit postharvest disease that caused by *Penicillium expansum*, which affects the quality of the fruit and leads to the rot of the apple resulting in economic losses. The use of biocontrol agents as an alternative approach to synthetic chemical fungicides has aroused general concern about how to control plant diseases that are caused by phytopathogenes. The purpose of this work is to isolate and identify effective biocontrol strains to inhibit *Penicillium expansum* and to explore the mechanisms by which they could be used in the biocontrol of apple blue mold rot. We tested 109 strains, which were isolated from the potato soil rhizosphere from Dingxi region in Gansu province in China. Antagonistic bacteria were screened by plate confrontation method with *Penicillium expansum* as the target strain. Bacterial strain identification was based on morphology, physiological and biochemical characteristics and 16S rRNA gene sequence analysis. The effects of cell-free fermentation filtrate with different concentrations on the growth colony diameter, spore germination, mycelial dry weight of *P. expansum* and the lesion diameter of wounded inoculated apple fruit were also studied. Finally, we explored impact of the conductivity, nucleic acid and protein release, AKP content, SDH activity, ATPase activity and ATP content to reveal the inhibitory mechanism. Strain BM14 was isolated from the potato soil rhizosphere and exhibited an excellent antagonistic activity against *Penicillium expansum*, which was identified as Pseudomonas sp., the cell suspension and the cell-free supernatant of its culture showed significant antifungal activity against *Penicillium expansum, Fusarium sulphureum, Fusarium solani*, *Trichothecium roseum*.BM14 showed the best inhibitory effect against mycelial growth, spore germination of *P. expansum*. The diameter of inhibition zone was 22.53±0.19mm and the inhibition titer (mm/mL) was 72.65. It also could effectively inhibit spore germination. The inhibition rate of 50% cell-free filtrate to *P. expansum* was 87.3%; 75% cell-free filtrate completely inhibited spore germination. The dry weight of mycelium was 2.7 mg/mL and the inhibition rate reached 65.54% when the volume fraction was 100%. Moreover, cell-free fermentation filtrate effectively inhibited extension of lesion diameter of blue mold of apple. The maximum inhibitory rate reached 49.2% at 3d. In addition, cell-free fermentation filtrate treatment increased electrical conductivity, intracellular nucleic acid, protein release, extracellular AKP content and decreased SDH activity, ATPase activity and ATP content of *P. expansum*. The effect was enhanced by the fermentation broth concentration. Strain BM14 significantly inhibited the growth of the *Penicillium expansum*, destroied the structure of cell membrane and reduced the activity of energy metabolism enzyme, had a notably biological control effects on apple blue mold rot, it would be a potential biological control agent.

Keywords: Apple blue mold rot, biocontrol, *Pseudomonas*, identification

P049 Investigating the protein expression profile and transcriprome characterization of *Penicillium expansum* induced by *Meyerozyma guilliermondii*

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Abstract body text:

Meyerozyma guilliermondii is one of the antagonistic yeasts exhibiting antagonistic activity against *Penicillium expansum* in our previous research. However, the molecular mechanisms of inhibiting activity of *M. guilliermondii* are still unknown. Therefore, the proteomes and transcriptomes characterization of *P. expansum* induced by *M. guilliermondii* were investigated in this study. The proteomics results showed that there were 66 differential expression proteins (DEPs) from *P. expansum* induced by *M. guilliermondii*. These DEPs were related to oxidative phosphorylation, ATP synthesis, basal metabolism and response regulation. Simultaneously, a transcriptomic approach based on RNA-Seq was applied to annotate the genome of *P. expansum* and then the changes of gene expression in *P. expansum* treated with *M. guilliermondii* were studied. The results showed that differentially expressed genes (DEGs) such as: HEAT, Phosphoesterase, Polyketide synthase, ATPase were significantly down-regulated in accordance with similar down-regulation with the relative DEPs.

Keywords: *Penicillium expansum*, *Meyerozyma guilliermondii*, proteomic, transcriptome, RT-qPCR

P050 *Aureobasidium pullulans* strain Ach1-1 a potential biocontrol agent of postharvest diseases of apples

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Abstract body text:

Aureobasidium pullulans strain Ach1-1was isolated form the surface of Golden Delicious apple fruit. The efficacy of strain Ach1-1 was monitored on time along a period of 5 to 10 days storage at 25°C and one to six months storage at 4°C. The efficacy of Ach1-1 to control blue mold infection was evaluated through disease incidence (%) and severity (lesion diameter cm) against a large number of *P. expansum* strains originated from different countries. The results showed that strain Ach1-1 display high efficacy to control bleu mold infection disease. The strain Ach1-1 control significantly all the tested pathogens and sustain this efficiency along a storage period of 4 months at 4°C. Which make it a well-placed biocontrol agent to manage postharvest disease of apples. The industrial production of the yeast strains was carried out using the Fed Batch technology and freeze drying process. The efficacy of the produced strain was investigated, and results showed lower biocontrol efficiency than the active yeast. Hence a downstream formulation trials were carried out in an attempt to enhance the efficacy of produced yeast using amino acids, salts, and polyols. The results showed that the application of some adjuvants individually may enhance the efficiency of the yeast applied at low concentration.

The above findings are in the frame work of the development of *Aureobasidium pullulans* strain Ach1-1 towards its commercialization and supported by Elephant vert Group.

Keywords: Biocontrol agent, Aureobasidium pullulans, Efficacy, Industrial production.

P051 Verifying the potential of novel film-forming formulations of the biocontrol agent *Candida sake* CPA-1: influence of abiotic factors and efficacy on different hosts

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Abstract body text:

Efficacy of the yeast *C. sake* CPA-1 as a biocontrol agent against several diseases has been studied since it was isolated twenty years ago. Recently, two convenient and effective film-forming formulations have been developed by the fluidised-bed spray-drying system. One formulation is based on potato starch compounds, and the other one is based on maltodextrin substances. The present work aims to confirm the capability of both novel formulations by testing their resilience on grapes under different temperatures (0 °C, 22 °C and 30 °C), relative humidity (40% and 85%) and simulated rainfall. Another objective is to broad the spectrum of action of the formulations to different hosts. CPA-1 cells from both dried formulations survived better than the liquid formulation on grapes stored at 0 °C and 22 °C, regardless of the relative humidity. After simulated rainfall, potato starch formulation achieved significantly higher populations than maltodextrin formulation, although the highest reduction was -1.6 Log N N0-1. A positive effect of cells establishment prior to simulated rainfall was shown in both formulations. Recovered cells from potato starch formulation were significantly higher after 72 h of cells establishment. Finally, both formulations reduced the incidence and severity of *B. cinerea* on pears, apples and tomatoes. The results obtained in the present study, summarised as: (i) the possible application of both dried formulations at pre- and postharvest; (ii) their adherence over grapes after a simulated rainfall; and (iii) the high reductions of *B. cinerea* disease on different hosts, verified the potential of these novel film-forming formulations of *C. sake* CPA-1.

Keywords: *Candida sake*, *B. cinerea*, temperature, relative humidity, rainfall, formulation

P052 Ecological niches and environmental resilience of different formulations of the biocontrol agent Candida sake CPA-1 using the Bioscreen C

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Abstract body text:

Environmental resilience of biocontrol microorganisms has been a major bottleneck in the development of effective formulations. This study aimed to examine the environmental niches occupied by different formulations of the biocontrol yeast, *Candia sake*, using the Bioscreen C. The effect of a range of water activity levels (a_w; 0.94-0.99), temperatures (15-30 oC) and pH levels (3-7) on the temporal growth of the different yeast formulations was examined. Initially, the automated turbidimetric method was optimised for use with different formulations of this biocontrol yeast. The best growth curves were obtained for *C. sake* strain CPA-1 when grown in a synthetic grape juice medium under continuous shaking and with an initial concentration of 10^5 CFUs ml-1. The liquid formulation and two fluidised-bed spray-dried formulations all showed a direct relationship between optical density values and yeast concentrations. Significant differences in the resilience were observed among the formulations under the tested environmental conditions. Temperature and aw influenced the yeast resilience most profoundly, whereas the effect of pH was minimal. Based on the time to detection, the liquid formulation grew faster in more interacting environmental conditions but only the yeast cells in the dry potato starch formulation could grow in some stress conditions. The use of the Bioscreen C allows the effective comparison of different formulations of a biocontrol agent in relation to ecological and environmentally relevant characteristics to help identify the most resilient formulations.

Keywords: Dry formulations, environmental stress, antagonist, survival, yeast

Acknowledgments
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P053 Strategies to enhance the efficacy of biological control organisms against wound pathogens causing storage diseases on apples

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Abstract body text:

On pome fruits various storage diseases can occur. One of the most important fruit rot pathogens on apple and pear is *Botrytis cinerea*, which infects the fruit via wounds. Different methods for the control of storage diseases on apple and pear are available for the fruit growers. Most of the times, specific fungicides are applied in the orchard during the last weeks prior to the harvest, depending on the pre-harvest interval of the product. Furthermore, also postharvest treatments can be performed with, for example, Xedathane-A (a.i. pyrimethanil) or Penbotec (a.i. pyrimethanil), both registered in Belgium. However, the presence of residues on fruits is now a public and governmental concern, and in practice sometimes longer pre-harvest intervals need to be applied or less treatments can be performed to meet the extra-legal residue requirements (max 4 residues or max. 1/3 of MRL's) imposed by retailers. In order to reduce the chemical residues on fruits to a minimum, more research is done on alternative disease management. A lot of research on the use of pre-harvest applications with biological control organisms (BCOs) is already performed. However, postharvest applications with BCOs can also be a good alternative and can open perspectives for a more integrated control. In practice, BCO applied alone mostly do not reach very high control levels as they grow slower than the specialised plant pathogen. Moreover, the infection with pathogens causing storage diseases can already take place in the orchard or shortly after harvest, meaning that the pathogen is already present on the fruits when applications with BCOs during postharvest are performed. In order to enhance the effect of BCOs during postharvest treatments different strategies, including influence of additives or temperature on growth and efficacy of the BCO, were tested and will be shown.

Keywords: Postharvest, BCO, apple, storage diseases

P054 Antifungal activity of sage (*Salvia triloba* L.) essential oil against key postharvest pathogens

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Abstract body text:

Essential oils (EO) derived from Medicinal and Aromatic plants are extensively used in food sector due to their strong antioxidant and antimicrobial properties. Sage (*Salvia triloba* L.) oil (ranging between 25 and 500 ppm) was tested in vitro for antifungal activity against key postharvest pathogens as *Colletotrichum coccodes*, *Botrytis cinerea*, *Cladosporium herbarum*, *Rhizopus stolonifer*, and *Penicillium digitatum*. The main compounds of sage EO were eucalyptol, cis-thujone, camphor, α-pinene, and β-pinene. Oil-enrichment resulted in significant ($P< 0.05$) reduction on subsequent colony development for the examined pathogens and was mainly concentration dependent. Fungal spore production was inhibited up to 87.7% at 100 ppm of sage oil concentration when compared to equivalent plates stored in ambient air. When the highest oil concentration (500 ppm) employed, fungal sporulation was completely retarded. Sage oil reduced spore germination and germ tube length in *C. coccodes*, B. cinerea, *C. herbarum*, *R. stolonifer* and *P. digitatum*; the effects were proportional to the oil concentration. This work is currently focusing on the mechanisms underlying the impacts of essential oil volatiles on disease development, and their contribution on limiting the spread of the pathogen by lowering the spore load in the storage/transit atmospheres, as well as the use of essential oils as an alternative food preservative.

Keywords: Antifungal activity, essential oils, fungal growth, sage, spores

P055 Screening of essential oil as potential postharvest biofungicide

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Abstract body text:

Plant extracts, such as essential oils (EOs), have been known for centuries for their ability to prevent and/or to cure diseases through their fungicidal and bactericidal effect. In this project we evaluated the fungicidal activity of 90 essential oils on several pathogens associated with postharvest diseases (*Botrytis cinerea*, *Penicillium expensum*, *Pectobacterium atrosepticum* and *Pectobacterium carotovorum*). The efficacy of the EOs was first tested in vitro using 96 wells ELISA microplates. This step allowed the selection of 9 EOs, sufficiently effective (complete growth inhibition up to 72 hours of contact with pathogen in liquid of medium) against these pathogens to be tested under in vivo conditions. The phytotoxicity of the selected EOs was then tested on apples, pears and potatoes. While no phytotoxicity was observed when the EOs were applied on intact fruits and tubers, a clear toxicity was observed when EOs were applied on wounded fruits. For the EOs showing a moderate toxicity, the in vivo tests were carried on by inoculating the pathogens into wounded apples (*P. expensum*), pears (B. cinerea) and potatoes (*P. atrosepticum* and *P. carotovorum*) treated with lower EOs concentration. At these concentrations, the EOs showed less phytotoxicity but also a lower efficiency (30% in the best case). To conclude, while the EOs showed good results in-vitro, the efficiency in-vivo was too low at the concentration tested in order to be used as a way to control postharvest diseases.

Keywords: Essential oils, fungicide

P056 Exposure to volatiles of essential oils to control gray mold disease of strawberry

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Abstract body text:

Postharvest diseases reduce vegetables shelf life due to losses in products appearance and commercialization. Strawberry is a perishable fruit and its main deterioration is gray mold rot caused by *Botrytis cinerea* which limits the shelf life. Essential oils (EOs) are natural antimicrobials, and are generally recognized as safe and natural alternatives to food additives. Also an efficient option to chemical fungicides. The objective of this study was to evaluate the effect of EOs of rosemary (*Rosmarinus officinalis*), eucalyptus (*Corymbia citriodora*) and cinnamon (*Cinnamomum verum*), applied by volatilization, on *B. cinerea* in vitro inhibition. PDA plates containing fungus mycelial discs were treated with volatile essential oils in the concentrations of 0 (control), 100, 250 and 500 ppm for 1, 2 and 3 hours. Sealed boxes of 46 L were used. Six replicates were performed per treatment. Essential oils inhibitory effect was evaluated by measuring the diameter of the colonies until reaching the edge of the plate. Data were submitted to analysis of variance and the means were compared by Tukey test ($P < 0.05$). The three essential oils used inhibited the mycelial growth of B. cinerea when exposed for 3h at the highest concentration (500 ppm). The rosemary oil treatment was a highlight. It completely inhibited fungal growth at 250 ppm for 2h. These results suggest the essential oils of rosemary, eucalyptus and cinnamon may be a potential alternative to control gray mold and extend the shelf-life of strawberries.

Keywords: *Fragaria ananassa* Duch, *Botrytis cinerea*, volatilization, alternative control

P057 Improved quality of washed carrots by use of essential oils

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Abstract body text:

The fruit and vegetable industry is continuously searching for alternative preservation methods to meet consumers demand for cleaner products with less chemical residues. Active compounds of essential oils (EOs) from plants have been widely tested as replacements for chemical processing aids due to their antimicrobial and antifungal properties and their eco-friendly impact on the working environment. The aim of this study was to test selected EOs and asses their effect on the shelf-life of fresh carrots following washing and polishing in the industry. Carrots were dipped for 3 min in different concentrations (0.01-1.00 %, W/V) of EOs made from oregano, thyme, fennel and grapefruit. The treated carrots were stored at room temperature for 10 days in glass jars closed with perforated cling film and evaluated for mold growth, tissue wounding, rooting and sprouting. Oregano and thyme EOs resulted in wounding of the carrot periderm regardless of concentration. The carrots spoiled and had more secondary mold growth that the control carrots dipped in water. In contrast, carrots were not wounded following dipping in 0,2% fennel or 0,2% grapefruit EO. Moreover, the fennel EO had positive effects against gray mold (*Botrytis cinerea*) as the mold index was lower than that of the control carrots. The results show that EOs of fennel can prolong the shelf-life of carrots in the supply chain as less mold developed during storage.

Keywords: Root crops, postharvest, fennel essential oil, oregano essential oil, thyme essential oil, grapefruit essential oil

P058 Antifungal activity of essential oils and their combinations against postharvest fruit pathogen

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Abstract body text:

Rhizopus stolonifer is considered the most devastating storage fungi of horticultural commodities such as strawberry and peaches. The antifungal activity of the essential oils (EOs) *Mentha piperita*, *Cymbopogon martinii* and *Cinnamomum camphora*, as well as synergism of their possible double combinations, were investigated in vitro by contactand by exposure to volatiles against plant pathogen *Rhizopus stolonifer*. The highest antifungal activity was promoted by *M. piperita* and *C. martinii* EOs, individually, and by mixture combination M2 (*M. piperita/C. camphora*) and M3 (*C. martinii/C. camphora*) with total inhibition of mycelial growth between 500 and 750 µL/L concentrations evaluated by contact. On the other hand, fungi exposure to volatiles demonstrated that *C. martinii* and *M. piperita* OEs presented the highest activity, with a total inhibition of *R. stolonifer* mycelial growth in the concentrations 5 µL and 10 µL, respectively. Although the OEs of M. piperita and C. martinii presented the highest antifungal potentials when evaluated individually, their combination did not result in a better antifungal development by direct contact and neither by volatiles exposure. Among all oils and mixtures evaluated in vitro, *M. piperita* and *C. martinii* EO(s) presented the highest capacity of *R. stolonifer* inhibition. Therefore, these oils can be a potential alternative to the synthetic fungicides for disease postharvest control. The authors are grateful to FAPESP (process 2018/24612-9) and CAPES for financial support.

Keywords: *Mentha piperita*; *Cymbopogon martini*; *Cinnamomum camphora*; *Rhizopus stolonifera*

P059 Antifungal activity of *Zingiber officinale* Roscoe (ginger) oil and extracts on postharvest pathogen

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Abstract body text:

Considerable economic loses of many types of crops are caused by phytopathogens, with fungi being responsible for the most incidence of post-harvest spoilage. Essential oils and plant extracts can be eco-friendly alternatives for reducing microorganisms in foods to synthetic preservatives and fungicides that may be toxic, carcinogenic, environmental contaminants, or whose widespread use has already led to resistance. The potential control of phytopathogens using ginger oil and extracts has been studied in vitro, however antifungal activity of it with fruit coatings and in vivo experiments have not been exhaustively investigated. The goal of this research was to evaluate the antifungal activity of ginger essential oil (GO) and ginger ethanolic extracts (GE) to control fungi decay. Antimicrobial activity of GO and GE to *Colletotrichum gloeosporioides* were evaluated using minimum inhibitory concentration (MIC) and minimum fungicide concentration (MFC). In vitro experimentswereperformed with *C. gloeosporioides* inoculated Petri dishes (IPD) coated with carnauba wax nanoemulsion coating and the coating containing GO. The GO showed antimicrobial activity and significantly reduced the mycelium growth of *C. gloeosporioides*. The MIC of GO and GE were 0.1% to 0.8% and 2.5% to 5%, respectively. After 24h of inoculation for IPD, the combination of nanoemulsion + GEO was more effective than the GEO alone. However, after 7 days, carnauba wax nanoemulsion showed antimicrobial ability on its own, with or without GEO, and better than GEO alone. We are also carrying out an in vivo experiment to test the effect of GO in a nanoemulsion coating for natural decay of papayas stored at 22 °C which results will be discussed. The authors are grateful to Brazilian agencies FAPESP (process 2016/23419-5) and CAPES for financial support.

Keywords: Fruit decay, ethanolic extracts, edible coatings, papaya

P060 In vitro antifungal activity of lemon (*Citrus limon* L.) waste extracts against *Alternaria alternata* and *Alternaria citri*

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Abstract body text:

Alternaria alternata and *Alternaria citri* are two pathogens affecting sweet cherries and citrus, respectively, leading to significant postharvest losses. Both species can be controlled with synthetic fungicides, but due to the development of resistance and the need to find more sustainable disease control solutions, alternative control measures need to be developed. We have previously shown that extracts derived from lemon waste (pomace) contain bioactive compounds with high levels of antioxidant, antifungal, and antibacterial activities. The aim of this research was to investigate the in vitro antifungal activity of lemon waste aqueous extracts at different concentrations (14, 7, 3.5 and 1 $mg.mL^{-1}$) against two different species of *Alternaria* (*A. alternata* and *A. citri*). The results showed that lemon aqueous extracts suppressed the mycelial growth and spore germination of both species in a concentration-dependent manner. The mycelial growth inhibition (MGI) for *A. alternata* varied between 31 to 68%, while for the *A. citri* the MGI varied between 15 to 49%. High performance liquid chromatography was employed for the identification of compounds with potential antifungal activity. Scanning electron microscopy showed that lemon waste extracts affected the morphology of both species after treatment.

Keywords: *Alternaria*, sweet cherry, citrus, by-products, postharvest

P061 Transcriptomic response of orange fruit to a pomegranate peel extract

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Abstract body text:

A Pomegranate Peel Extract (PGE) has been proposed as a natural antifungal preparation with a wide range of activity against plant diseases. Previous studies showed that the extract has a direct antimicrobial activity and can elicitate resistance responses in plant host tissues. In the present study we analysed the transcriptomic response of detached oranges to PGE treatments. RNA-seq analyses, conducted on wounded fruits 0, 6, and 24h after PGE applications, showed a significantly different transcriptome in treated oranges as compared to control samples. The majority (273) of the deferentially expressed genes (DEGs) were highly expressed compared to only 8 genes that were down-regulated. Gene ontology (GO) analyses yielded 214 annotated DEGs and 1233 GO terms involved in the biological process, molecular function and cellular component. Pathway classification showed that the highly expressed genes were involved in 35 metabolic pathways, among which 23 were involved in the plant's primary metabolic pathways, including carbohydrate, amino acid, and nucleotide metabolisms. Other highly expressed genes were involved in the secondary metabolism, antibiotic biosynthesis, and xenobiotic metabolism pathways. On the other hand, the down regulated genes were found to be involved in monoterpenoid biosynthesis. Interestingly, the majority of these pathways are known to be related to disease resistance plants, which may explain the underlying preventive and curative activity of PGE against plant diseases. Although the present study used orange as a model fruit, several evidences indicate that similar transcriptomic responses may occur in other plants.

Keywords: Orange, pomegranate peel extract, PGE, RNA-seq, transcriptomics, alternative control methods

P062 Physical and antifungal characterization of starch-based-edible film containing Fennel oil

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Abstract body text:

The objective of this study was to evaluate the physical properties of starch-based films enriched with funnel oil (FO)and its potential to inhibit the growth of *Penicillium expansum*. Moreover, their antifungal properties and fruit preservation performance in Fuji apple were also investigated. Firstly, FO was extract by steam distillation from fennel seeds. Then the edible starch films were prepared by casting methods with adding FO. The edible starch films properties (thickness, moisture content, transparency) were analysis. Water vapor permeability (WVP) and the mechanical tensile were also analysis. Fourier transform infrared (FTIR) spectroscopy was used to determine interaction between plasticizers and the polymers. Scanning electron microscopy (SEM) observations of the films presented surfaces and fracture surface. The results showed that all of the film formulations were of similar thickness (about 110μm). The moisture content of film samples increases with the content of glycerol. The transparency values increased with increasing of FO concentration. The content of FO affected the structure of edible starch film. The maximum micro-porous spots were observed in the F3 with the highest content of essential oil among them. The WVP of starch films ranges from 2.088±0.086 to 2.849±0.164 g.mm / KPa.h.m2. It increased significantly after increasing the concentration of glycerol. TS decreases with increasing glycerol content, these films with the highest FO content were effective at preservation and controlling Fuji apple against *P. expansum*.

Keywords: Tensile properties, starch film, antifungal properties, microstructure

P063 Effect of carnauba wax nanoemulsion coating on postharvest papaya quality

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Abstract body text:

Papaya is a fruit of great economic importance worldwide, but still presents a high rate of post-harvest loss. There can be different reasons for this, but mainly due to intensive labor and not appropriate storage conditions. Carnauba wax nanoemulsion coating may be an alternative to this problem, preserving postharvest fruit quality. Therefore, an experimental carnauba wax nanoemulsion was developed and a set of three trials were conducted to evaluate its performance on storage of papaya fruits solo type. On the first trial, this coating was applied to the fruits at concentrations of 4.5%, 9.0%, 13.5% and 18.0% compared to control group (fruits coated with water). In a second trial, the best concentrations determined in the first one were used (13.5 and 18.0 % respectively). On the last trial, carnauba wax nanoemulsion on a high concentration 18% was compared to a commercial and to non-treated fruits. Fruits were stored for 12 to 20 days at 16 to18 oC and Relative Humidity (RH) upper to 70%. Physicochemical analyzes carried were soluble solids (SS), titratable acidity (TA), pH, weight loss, firmness, color, CO2 and ethylene production, while postharvest disease incidence and severity was only performed on the last trial. Significant difference was observed on treatments with high concentration (13.5% and 18.0%) in relation to reducing

weight loss, delay ripening and decreasing ethylene production compared to control, commercial coating and even to low carnauba nanoemulsion concentrations. For disease severity it was observed a reduction for fruits coated with high carnauba nanoemulsion concentration when compared to control and commercial coating. Carnauba nanoemulsion has a potential use for extending papaya postharvest shelf life.

Keywords: Papaya, shelf life, nanotechnology, diseases.

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P064 Effects of carnauba wax and chitosan bilayer edible coating on the shelf life of fresh-cut apple

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Abstract body text:

Apple fruit is one of the most consumed fruit worldwide for fresh market, industry processing and fresh-cut. Edible coatings can be an alternative to keep and extend shelf-life quality on fresh-cut, being a barrier to avoid physical and microbiological damage. Edible coatings can be applied on individual or in two layers. Therefore, the main goal of this study was to evaluate the effect of a bilayer coating of carnauba wax and chitosan in the quality of fresh-cut apples. Previous to trials, chitosan and carnauba wax samples were characterized individually and combined in a bilayer by Attenuated Total Reflectance (ATR). Trial was carried with apples cv. Gala, sliced and sanitized in five treatments (T1) uncoated, used as control, (T2) Ascorbic acid solution at 1%; (T3) Chitosan at 1.5%; (T4) Carnauba wax 0.5% and (T5) Bilayer – (Chitosan 1.5% + Carnauba wax 0.5%). Physic-chemical and microbial analyses were taken place every two days during storage for 10 days at 5 oC. Sensorial analyses were performed on the fifth and tenth day of storage, based on hedonic scale with 30 non-trained panelists. By ATR it was observed no interaction of the components – carnauba wax and chitosan on bilayer treatment. On the physic-chemical analyses was not possible to detect significantly differences for firmness and weight loss based on daily rate change. For color there were differences on daily rate change, showing coated treatments darker than other treatments. On microbial analyses, for pathogenic bacteria, slices coated with chitosan or carnauba+chitosan bilayer showed delay on growing rate. For sensorial analyses panelists pointed preference for apple slices treated with carnauba, which may be related to lightness.

It can be concluded that besides antimicrobial chitosan action, bilayer treatment was not consumer preference. Then, further studies have to be taken to confirm this.

Keywords: Fruit quality, physic-chemical, microbial analyses, sensorial analyses.

The authors are grateful to financial support to Embrapa (project process 02.13.05.003.00.00)

P065 Postharvest quality of papaya fruit wrapped with polyvinyl chloride film added with silver

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Abstract body text:

Papaya is an important climacteric tropical fruit consumed in many countries, being an important source of vitamins and nutrients for human diet. However, inadequate packing can influence papaya quality and cause a high level of fruit losses. The main goal of this research was to evaluate postharvest quality during storage of papaya wrapped with polyvinyl chloride containing silver and compare it with fruits unwrapped and wrapped with conventional polyvinyl chloride. For the polyvinyl chloride film characterization Fourier Transform Infrared Spectroscopy, scanning electron microscopy and atomic absorption spectroscopy were employed. For the postharvest experiments, unwrapped fruit were compared to individually wrapped in both conventional polyvinyl chloride film and polyvinyl chloride film containing silver and stored under two conditions (10 days at 15ºC, and 2 days at 22°C to simulate market conditions). The physicochemical analyzes, including soluble solids, titratable acidity, ratio, pH, ascorbic acid, weight loss, firmness and color were performed at every two days of storage, while microbiological analyzes were performed on the 1st and 10^{th} day of storage. Sensory analysis was carried on the last day of storage. Physicochemical analyses showed that fruits wrapped with polyvinyl chloride films (with and without silver) presented a lower weight loss compared to than unwrapped fruits, which results agreed with sensory analysis. More importantly, papaya wrapped with polyvinyl chloride film containing silver kept papaya peel green for longer time causing a delay in ripening, indicating its potential to extend postharvest shelf life of papaya and reduce postharvest losses.

Keywords: PVC, microorganism, color, ripening, smart packing, *Carica papaya*

The authors are grateful to financial support to Embrapa (process 13.16.04.041.00.00).

P066 Eliciting, antimicrobial and film-forming properties of chitosan on postharvest decay of fruit and vegetables

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Abstract body text:

Chitosan is a natural biopolymer from crab shells that is known for its biocompatibility, biodegradability and bioactivity. In human medicine, chitosan is used as a stabiliser for active ingredients in tablets, and is popular in slimming diets. Due to its low toxicity, it was the first basic substance approved by the European Union for plant protection (Reg. EU 2014/563), for both organic agriculture and integrated pest management. When applied to plants, chitosan shows triple activity: (i) elicitation of host defences; (ii) antimicrobial activity; and (iii) film formation on the treated surface. The eliciting activity of chitosan has been studied since the 1990's, which started with monitoring of enzyme activities linked to defence mechanisms (e.g., chitinase, β-1,3 glucanase, phenylalanine ammonia-lyase) in different fruit (e.g., strawberry, other berries, citrus fruit, table grapes). This continued with investigations with qRT-PCR (Quantitative Real-Time Polymerase Chain Reaction), and more recently, with RNA-Seq. The antimicrobial activity of chitosan against a wide range of plant pathogens has been confirmed through many in-vitro and in-vivo studies. Once applied to a plant surface (e.g., dipping, spraying), chitosan forms an edible coating, the properties of which (e.g., thickness, viscosity, gas and water permeability) depend on the acid in which it is dissolved. Based on data in literature, we propose that overall, the eliciting represents 30% to 40% of the chitosan activity, its antimicrobial activity 35% to 45%, and its film-forming activity 20% to 30%, in terms of its effectiveness in the control of postharvest decay of fresh fruit. As well as being used alone, chitosan can be applied together with many other alternatives to synthetic fungicides, to boost its eliciting, antimicrobial and film-forming properties, with additive, and at times synergistic, interactions. Several commercial chitosan formulations are available as biopesticides, with their effectiveness due to the integrated combination of these three mechanisms of action of chitosan.

Keywords: Antimicrobial activity, biopolymer, coating, induced resistance, natural fungicide

P067 Preharvest chitosan sprays promote epidermal lignification of harvested potato tubers

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Abstract body text:

Epidermal lignification of harvested crops plays an important role in preventing pathogen infection and reducing evaporation. In this study, the effect of preharvest treatment with chitosan on epidermal lignification of potato tubers was investigated. Potato plants (Solanum tuberosum L. cv. Longshu No.7) were sprayed three successive times with chitosan at 2%: during tuber development, at flowering period, enlarging period (after 30 days of flowering) and two weeks before harvest. The epidermal lignification of harvested tuber was observed, and lignin metabolism in treated tubers was determined. The results indicated that chitosan sprays significantly sped the accumulation of lignin in epidermal cell of harvested tubers. The treatment reduced weight loss and the disease index of tubers inoculated with Fusarium sulphureum. Furthermore, the treated tubers had more content of total phenols, flavonoids and lignin, which involve in lignin metabolism. The activity of phenylalanine ammonialyase, 4-coumarate-coenzyme A ligase, cinnamyl alcohol dehydrogenase and peroxidase in treated tubers respectively were 20%, 72%, 64% and 37% higher than the control after 7 days of inoculation. These results suggest that chitosan sprays during tuber development promote the epidermis lignification of harvested potato tuber by activating the lignin metabolism.

Keywords: Potato tubers, chitosan, lignin metabolism

Acknowledgement
This work was funded by Gansu Provincial Key Laboratory of Aridland Crop Science, Gansu Agricultural University (No.GSCS-2017-7); National Natural Science Foundation of China (No. 31760473); China Agriculture Research System（CARS-09-P14）and Program for Fu Xi Talents in GAU (No.FXYC20130110).

P068 Salicylic acid dipping promotes wound healing of potato tubers

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Abstract body text:

Wound healing plays an important role in reducing postharvest disease of potato tubers. However, the complete wound healing takes a long time, therefore, it is necessary to take measures to accelerate the process. Salicylic acid (SA) is endogenous plant growth substance that plays key roles in plant growth and development, and responses to environmental stresses. In this study, we used SA at 4mM dipped potato tubers 'cv. Longshu No.3'. The effects of wound healing were evaluated on artificially wounded tubers, and the mechanisms of this process were partially explored. The results showed that SA treatment effectively reduced weight loss and disease index of artificially wounded tubers during wound healing. The treatment promoted the accumulation of suberin at wounded sites of tubers. SA increased the activity of phenylalanine ammonialyase, courmate 3- hydroxylase, cinnamate-4-hydroxylase, ferulate-5-hydroxylase, cinnamyl alcohol dehydrogenase and peroxidase. The content of cinnamic acid, p- coumaric acid, ferulic acid and lignin was also enhanced by SA in treated tubers. However, no significant difference was found in the content of caffeic acid and erucic acid. It is suggested that postharvest SA treatment accelerates the wound healing of potato tubes by activating phenylpropanoid pathway and peroxidase activity.

Keywords: Potato tubers; elicitors, wound healing, phenylpropanoid pathway, peroxidase

P069 Effect of wound-healing strategies on postharvest disease development in carrot (*Daucus carota* subsp. Sativus)

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Abstract body text:

Storage losses of Norwegian carrots are estimated to 20-30%. Control of storage conditions can be used to control postharvest losses due to diseases. Maintaining carrot quality during storage requires a storage environment which is adjusted to minimize root deterioration. Temperature, humidity and air movement can affect the keeping quality of stored carrots. It is questioned whether carrots need a wound-healing period in the beginning of the storage period or whether rapid cooling is a better strategy. During wound-healing suberin and lignin is accumulating in cells near the wound surface and creates a barrier, protecting the roots from pathogenic infections. Antifungal substances are also accumulating during wound-healing. These antifungal substances can reduce disease development in the root. The main aim of this study is to gain knowledge on how different wound-healing strategies (temperature and relative humidity) in the beginning of the storage period affect quality and losses caused by postharvest pathogens during long-term storage in carrot. Carrots for storage experiments were grown on a loam soil (Cambisol, low erosion risk, moderate natural drainage) (WRB, 2006) in Østre Toten, Oppland, Norway (60.70°N, 10.87°E). The carrot cultivars Nelson, Triton, Romance and Nominator were grown in 2016 and 2017. The roots were stored in small-scale stores from September to April (7 months) where effects of wound healing strategies were tested using seven different temperature strategies (strat 1. Directly to 0°C, strat 2. Decreasing temperature 1°C per day, strat 3. Decreasing temperature 0.2°C per day, strat 4.-7. Two weeks at 10°C with high or low RH and then directly to 0 or decreasing temperature 1°C per day). Visual assessment of storage diseases was carried out before and after long-term storage. The concentrations of polyacetylenes were measured in the two cultivars Nelson and Triton before and after wound-healing and after long-term storage. Pathogens identified after long-term storage included grey mould (*Botrytis cinerea*), white mold (*Sclerotinia sclerotiorum*, *S. subarctica*), *Fusarium* root rot (*Fusarium sp*.), liquorice rot (*Mycocentrospora acerina*), cavity spot (*Pythium spp*.), crater rot (*Fibularhizoctonia carotae*), root spotting pathogens (*Rhexocercosporidium carotae* (syn. *Acrothecium carotae* and *Pseudocercosporidium carotae*)), tip-rot (symptoms are described with discoloration and necrosis starting from the tip of the root and progressing upwards) and crown rot (*Rhizoctonia solani*). Wound-healing significantly reduced loss due to fungal infections in carrot compared to roots stored at 0°C immediately. Another important task of the project will be to correlate polyacetylene concentrations during storage with disease development.

Keywords: Storage strategies, carrot storability, pathogens

P070 Foliage sprays of calcium during cultivation to control postharvest gray mold rot of bell peppers

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Abstract body text:

Gray mold disease caused by the phytopathogenic fungus *Botrytis cinerea* is a major source of postharvest losses of bell peppers during long-term cold storage. While infection of fruits with fungal spores occurs in the field, the disease symptoms may develop only after harvest. The application of fungicides to control the disease is not adequate due to limited efficiency and in-line with public demand to reduce the use of pesticides. Previous works indicated that application calcium by fertigation can improve plants resistance to foliage pathogens, which may also be beneficial to the fruits. However, calcium translocation from the leaves to the fruit is limited. To increase calcium levels in fruits, we have examined the application of calcium by foliage sprays during cultivation of *Capsicum*. Several commercial calcium formulations were examined, in comparison with the common fungicides treatment. Specifically, fruit calcium level at harvest, postharvest susceptibility of the fruit to *Botrytis* and fruit quality after cold storage were tested. Foliage sprays of CaO chelated with Diethylenetriaminepentaacetic acid (DTPA) was found to significantly increase calcium levels in the pulp, increase fruit firmness after storage and reduce postharvest gray mold rot of the fruits. Although the DTPA-Calcium complex was found to inhibit *B. cinerea* hyphal growth *in vitro*, the observed effect on the fruit cannot be attributed to direct inhibition since the calcium level of the fruit peel was not altered. The results obtained may pave the way for the development of an environmental-friendly, fungicide-free control of gray mold disease during postharvest storage of peppers.

Keywords: Gray mold, pre-harvest treatments, calcium, environmental-friendly control, *Botrytis cinerea*

P071 Preliminary evaluations of postharvest organic treatments against *Monilinia* and *Botrytis* cherry decay

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Postharvest fungal rots are the limiting factor in the storage and marketing of sweet cherry fruit, where the major decay organisms are *Monilinia fructicola* (cause of brown rot) and *Botrytis cinerea* (cause of gray mold). Postharvest decay can be controlled with registered postharvest fungicides, but many countries do not have registered postharvest treatments and consumers prefer more natural postharvest treatments. In these experiments, a range of organic treatments (a combination of potassium bicarbonate with potassium silicate, a rhamnolipid biosurfactant, a fatty acid soap, and a combination of these treatments) were assessed for their efficacy at 20°C over 7 days on sweet cherry fruit infected with either *Monilinia fructicola* and *Botrytis cinerea*. A further experiment compared the rhamnolipid biosurfactant product combined with a product containing the biocontrol fungus *Muscador crispans* and a separate treatment of a commercial formulation of the biocontrol bacterium, Pseudomonas fluorescens on sweet cherry fruit infected with *Monilinia fructicola* that were then stored at 1 °C for up to 3 weeks. The results from the first experiment showed there were significantly lower levels of rot due to *Botrytis* infection when fruit were dipped in the fatty acid soap while the rhamnolipid treatment also reduced rots due to both fungi at 3 days. Fruit quality was also assessed and a significant negative effect of the combination of potassium bicarbonate with potassium silicate was observed. All treatments from the second experiment failed to significantly reduce fruit rots caused by *Monilinia fructicola*. These results show some promise at suppressing postharvest cherry rots, but it appears that alternative treatments or combinations of treatments, possibly with physical treatments, are needed to reduce the incidence of decay during storage.

Keywords: Sweet cherry, decay, postharvest, organic

P072 Effect of hot water dip treatment on postharvest control of *Penicillium expansum* and *Botrytis cinerea* on apples

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A hot water dip treatment was used to evaluate its efficacy for the reduction of *Botrytis cinerea* and *Penicillium expansum* development on "Golden Delicious" apples. Fruit were artificially wounded and inoculated with 30 µl of 1×104 conidia ml^{-1} suspension of either *P. expansum* or *B. cinerea*. The inoculated apples were left to air dry at 24±1°C. After 2 hours, the fruit were immersed in hot water for 50-75°C x 30-900 seconds. Control fruit were dipped in tap water (20°C) or were not treated. Treated fruit were subsequently stored at 25°C for seven days after which wounds were examined and the percentage of disease incidence was determined. In vivo tests showed that the disease incidence of *P. expansum* was reduced by hot water dip treatments at 60°C for 60 seconds (40%), compared to the control fruit (100%), without causing any skin injuries. Furthermore, in vivo studies also indicated that a hot-water dip at 60°C for 60-90 seconds, reduced grey mould development in inoculated wounds to 30% compared with control fruit treated with tap water (100%), without causing any skin injuries.

Keywords: Postharvest treatment, apples, blue mould, grey mould

P073 Ozone as an alternative method to control postharvest diseases on apples

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Abstract body text:

Fungal diseases developing on apples during storage can lead to substantial fruit losses. Pathogens infecting apples on the orchards and developing during storage are particularly difficult to control. Chemically synthetized treatments are today the most effective methods to limit fungal diseases on apples but their application is more and more restrictive in conventional agriculture and prohibited in organic crops. Alternative methods are therefore needed to better control postharvest diseases and to mitigate the risks of high economical losses after harvest. In this study, we evaluated the effect of a gaseous ozone treatment applied during storage on two apple cultivars, 'Topaz' and 'Otava'. Fruits were stored at 4 °C during 6 months and treated with gaseous ozone at different concentrations and frequencies of application. Development of rot and assessment of fruit quality in terms of firmness, total soluble solids, acidity and texture were evaluated. Results showed that ozone was effective to limit fungal growth, but not to stop it. Key fruit quality attributes were not altered by the treatments, but ozone application at high doses and frequencies induced the development of greasiness on 'Topaz' and lenticel breakdown on 'Otava'. This study brings robust evidences that ozone is an interesting alternative method to limit fruit losses after harvest and that the dose and frequency of application are determinant for commercial fruit quality.

Keywords: Ozone treatment, apples, storage, fungal diseases, fruit quality

P074 Infectivity of Cashew pseudo-apple by Gilbertella persicaria exposed to Ultraviolet-B

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Disease development by fungi on plants is a result of pathogen colonizing host while infective ability partially depends on spores germinating on host. The ability of *G. persicaria* spores exposed to UV-B to infect Cashew fruit flesh was tested in media obtained from Cashew fruits. Juice from unripe and ripe Cashew were tested separately and compared with water. Sporangiospores of the mold were exposed to UV-B and then inoculated into unripe, ripe Cashew juices and water. Germ tube emergence after incubation at 28^{o}C showed that all three media supported spore germination which decreased with increase in length of exposure to UV-B except in water. In unripe juice, the decrease was consistent as length of exposure to ultraviolet light increased. In ripe juice, there were also significant differences between unexposed and exposed spores but there was inconsistent trend of decrease in contrast to that observed for unripe. However, the spores exposed longest still had the lowest percentage germination in ripe juice. UV-B treated spores cultured in water produced a different trend in which longest exposure (7 minutes) resulted into significantly highest germination percentage. Unexposed spores failed to germinate in water. These results indicate that spores treated with ultraviolet light could still infect both unripe and ripe Cashew and infectivity decreased consistently with exposure in unripe fruits. It also explains why harvested fruits were still rotted by G. persicaria despite UV-B treatment even though the rotting decreased with ultraviolet light treatment. UV-B on the other hand enhanced spore germination in water, indicating resistance in the neutral medium of water and susceptibility in the nutrient medium of Cashew fruit.

Keywords : Spore germination, ultraviolet-B, *Gilbertella* sp., unripe, ripe, fruits

Session VI - Microbiota Community in postharvest

KEYNOTE SPEECH Engineering the fruit microbiome for biological control of postharvest diseases

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Harvested commodities should be considered as a dynamic system with complex interactions between microbial communities and the harvested commodity. The vast majority of microorganisms (endophytic and epiphytic) are not pathogenic, however, their role and function in fruit physiology, quality, and disease resistance before and after harvest is largely unknown. In recent studies, the complexity of fruit microbiome was demonstrated as significant differences in diversity were observed in different portions of the fruit (peel, stem-end, calyx-end, and wounds). Taking into consideration 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. Although several biocontrol products, based on single antagonist have been developed, their efficacy under commercial conditions has been inconsistent and fallen short of industry requirements. Thus, a more comprehensive understanding of the dynamics and function of the fruit microbiome is needed to design better biocontrol systems. Although a great deal of fundamental knowledge needs to be acquired, empirical investigations can be pursued, keeping the “whole” system in mind when designing novel biocontrol strategies. In a recent effort to characterize the apple microbiome, a global effort was used to identify the existence of a core microbiome that could be utilized to select a consortium of microorganisms for postharvest biocontrol of apple. Such a consortium may provide distinct advantages in terms phenotypes/functions, such as optimal colonization of surface wounds and utilization of available nutrients, enhanced ability to induce resistance, microbes that can colonize intact surfaces and/or special niches, production of secondary metabolites, proteases, and fungal cell-wall-degrading enzymes, etc. Another approach that is being examined is the application of genome-wide modeling to provide information that could be used to establish and sustain beneficial microbial communities on fruit surfaces. Characterization and analysis of microbial networks is being used to predict the beneficial effects of specific microbial genera or species and design ways to specifically manipulate their population through the use of nutrient amendments.

Keywords: Biocontrol, postharvest diseases, microbiome

S-VI-O1 Impact of primers on metabarcoding analyses of phyllosphere fungal communities

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One of the current challenges facing mycobiome researches is the use of primers that are able to detect the highest number of microbial taxa while avoiding DNA from plants and other non-target organisms. In the present work, we evaluated the performance of 5 selected primer sets targeting the ITS1 or ITS2 region of the rDNA, by analyzing the fungal community associated to the phyllosphere of four plant species (olive, wheat, orange, and grape). Two primer sets targeting the ITS1 region and a set targeting the ITS2 region were highly specific since the amplification of plant DNA was almost completely avoided. Whereas, around 30% of the reads amplified by the other two primer sets were of plant origin. Regardless of the specificity, a similar taxa coverage (number of OTUs) was achieved with the 5 primer sets. However, the community composition changed significantly according to the sets. Several taxa were preferentially or exclusively detected by certain primers and this association was consistent on different plant hosts. We also showed that some primers were more suited to certain plant species than other although none of them enabled the recovery of the whole fungal diversity. On average, each set detected around 50% of the total community detected by all primers. This percentage was increased to 70-80% when data from two primer sets were combined. Our results highlighted the importance of the selection of primers according to plant hosts and purpose of analyses but also indicated that whatever the choice, a consistent fraction of the actual microbial diversity will remain undetected.

Keywords: Phyllosphere, metabarcoding, mycobiota, primers, internal transcribed spacer, rDNA

S-VI-O2 The apple fruit microbiome: influence of orchard management, variety, storage time and storage atmosphere

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Microbial spoilage in commercial apple storage facilities can lead to food loss of up to 30% during the storage period. While some of the causal pathogens such as *Penicillium* spp. and *Botrytis* spp. are well characterized, others such as Neofabraea spp. and *Marssonina* spp. are less known due to difficulties in culturing under laboratory conditions. Metagenomics allows the screening of apples for the abundance and dynamics of pathogens and the microbiome as a whole in a culture independent way. Here we aimed at characterizing the total microbiome on the apple fruit after harvest and to elucidate the influence of the growing season, apple variety, orchard management practices, storage atmosphere conditions on the microbiome by means of in vitro cultivation and metagenomics. The results allow for the characterization of infection levels of different pathogens at harvest and, to some extent, the prediction of post storage symptom development. Additionally, information about the community composition allows for the identification of main factors driving the composition of the microbiome, the change in diversity during the storage period and the identification of beneficial microorganisms that may eventually be applied as biocontrol agents in the future. The diversity of the microbiome was shown differ significantly between orchard management conditions, variety and growing season. The results show a potential to be applied in the development of novel and improvement of existing infection models, educate breeders on how the host genotype interacts with the microbial community and inform researchers on how microbial communities change over time. Therefore, metagenomic characterization of the microbiome may provide a valuable tool to inform practitioners and researchers on disease risks and prevent post-harvest losses in the near future.

Keywords: Apple microbiome, metagenomics, postharvest pathogens, *Neofabraea*, food loss

S-VI-O3 The effect of waxing and low-temperature storage on the microbiota of different tissues of apple and the survival of foodborne pathogens

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Abstract body text:

Previous studies have revealed distinct spatial and temporal differences in the composition of the microbiota of harvested apples (Horticultural Research. 2016. 3). In that study, differences were also observed in the microbiota that were related to management practice (organic vs. conventional). In the present study, the impact of waxing and low-temperature storage on the microbiota of calyx-end, stem-end, and peel tissues of 'Royal Gala' apples was examined over a six-month period. In addition, the survival of *Listeria* was also examined. Results indicated distinct spatial and temporal changes in the composition and diversity of the microbiota in response to washing, washing-waxing, in conjunction with low-temperature storage. The greatest impact was attributed to washing with smaller differences between washed and washed-waxed apples. The magnitude of the differences, however, was tissue-specific with the greatest impact occurring on peel tissues. Temporally, the largest shift occurred during the first two months of low-temperature storage. In general, bacteria were impacted more than fungal taxa by sanitation practices, especially the epiphytic microflora of peel tissues. Coating fruit with a commercial wax favored the survival of foodborne pathogens (*Listeria*) that had been applied prior to waxing. This study is part of a comprehensive analysis of the apple microbiome including the identification of a 'core'apple microbiome based on an analysis of the harvested microbiome of harvested 'Royal Gala' apples from 2 – 6 orchards in eight countries (USA, Canada, Uruguay, Turkey, Israel, Spain, Italy, Switzerland). In-depth analysis of the waxing study and core microbiome study will be presented.

Keywords: Apple, waxing, *Listeria*

S-VI-O4 Cultivars and geographic location influence the epiphytic microbiota associated with mangoes

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In Reunion Island, mango is the second largest fruit produced after pineapple, and like many other subtropical fruits, mango (*Mangifera indica* L.) is subject to various pests and diseases which can significantly reduce yields. Losses due to fungal deterioration are the main cause of fruit damages and post-harvest decay in mango. A link between fruit epiphytic microbial communities and the occurrence and/or development of fungal diseases (such as mango anthracnose) on surface is suspected. But, so far, there is no data supporting this evidence. This is why we decided to explore epiphytic microbial communities associated with mango surface by using culture dependent and metabarcoding approaches. Both richness and abundance of the microbiota can be affected by different parameters, such as agricultural practices, climatic conditions (temperature and relative humidity), cultivars and terroir. In our study we focused on bacterial and fungal communities associated to "Cogshall" and "José" mango cultivars. Various climatic and agronomic factors such as the position and orientation of the fruits on trees, the position of the trees in an orchard, were taken into account in this study. A total of 193 fruits were sampled from two distant orchards and analyzed. Data obtained from bacterial and fungal communities will be presented and discussed.

Keywords: Metagenomics, epiphytic microbiota, mangoes, cultivars, geographic location

S-VI-O5 Exploration of microbial communities associated to fruitlet core rot (FCR) disease in 'Queen' pineapple from Reunion Island

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Abstract body text:

In Reunion Island, 'Queen' pineapple is the first fruit production. But this production is facing losses due to several diseases, including Fruitlet Core Rot (FCR), a postharvest disease which develops in pineapple upon maturity. FCR disease has a significant impact on both local and export markets because there are no visible external symptoms. It is mainly due to the development of phytopathogenic fungal species from *Talaromyces* and *Fusarium* genera in the fruitlets that cause black spot in the fruit flesh. The occurrence of FCR disease can be linked to different parameters, such as climatic conditions, agricultural practices and fruit composition. However, the causes of fungal development in the fruitlets remain poorly understood. Pineapple fruitlets could be colonized by a variety of microbial (bacterial and fungal) communities but their role in FCR disease development has not been investigated yet; this is why we decided to explore microbial communities associated to pineapple fruitlets. For this purpose, molecular and conventional microbiology techniques were used in order to study and identify the different microbial communities present in healthy and diseased fruitlets. The study was performed on about 120 fruitlets samples originating from 20 production sites with various climatic conditions (altitude, humidity, rainfall) and agricultural practices. We aimed at linking production factors to variations in microbial communities and identifying microbial markers associated with FCR disease. The data obtained from bacterial and fungal communities, as well as candidates for microbial markers of the FCR disease will be presented and discussed.

Keywords: Pineapple, fruitlet core rot, fungal disease, microbial communities, Reunion island, Queen cultivar

S-VI-O6 Postharvest and on-field microbial community changes caused by root rot in sugar beet

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Abstract body text:

Sugar beets (*Beta vulgaris* L.) are grown in temperate regions primarily for sugar production. Due to limited capacities of the sugar refineries, sugar beets are stored after harvest for up to 60 days. Microbial degradation leads to sugar decrease during this time. To investigate disease impact on microbiome level, the bacteriome and mycobiome of field grown as well as stored sugar beets were compared. Using a barcoded amplicon sequencing approach, complemented with cultivation-dependent methods, community dynamics of healthy and diseased samples from both sampling locations were assessed. Moreover, signature taxa of healthy and diseased sugar beets were identified. The microbiome of beets affected by root rot in the field as well as in storage showed broad overlaps. Root rot was accompanied by loss in microbial diversity as well as the replacement of Plectosphaerella and Vishniacozyma, as predominant species in healthy roots, with *Penicillium*, Candida and *Fusarium* sp. Furthermore, the Gram-positive *Lactobacillales* were predominant in rotting beets. Along with taxonomic changes also a trophic specialization of the mycobiome was observed. The overall findings can be implemented in new postharvest strategies following a microbiome-driven approach for biological treatments.

Keywords: *Beta vulgaris*, bacteriome, mycobiome, health indicator species

S-VI-O7 Functional characterization of apple fruit epiphytic microbiome in Belgium

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Abstract body text:

Microbial communities (microbiota) at the surface of apple fruit have been the source of the majority of biocontrol agents (BCAs) and can influence the fruit quality during storage. However, the use of BCA in commercial application is limited by low or non-reliable efficacies in comparison to chemical fungicides. Indeed, once applied on the fruit surface, a BCA faces a complex microbiota where ecological interactions (parasitism, mutualism, commensalism) occur, thus affecting its efficacy. To address this concern, Massart et al. (2015) suggested the use of microbiota to improve BCA efficacy by the selection of helper strains. Apple fruit samples of fifteen varieties grown in four disease management practices (DMP) (never treated, light organic, organic and conventional) have been collected. Their epiphytic microbiota were harvested and their efficacy to raise the biocontrol of *Pichia anomala* strain K against *Botrytis cinerea* were tested. Amplicon (16s and ITS) high throughput sequencing allowed to decipher the bacterial and fungal populations of the microbiota. Results of the taxonomic profiling a huge diversity and differential abundance of microorganisms (FDR-$p < 0.05$), influenced by DMP (ADONIS test $p < 0,05$). The apple core microbiota, which represents the OTUs shared in 90% of all samples, also showed a diversified profile including 60 bacterial OTUs and 10 fungal OTUs at genera level. Results of the biological assay reveal an interaction between the concentration of the microbiota and the different types of microbiota ($p < 0,001$). Some apple microbiota can either raise up to 100%, or reduce to 17% the biocontrol of the strain K against *B. cinerea*. Co-clustering analysis have help to detect interesting beneficial OTUs to be tested for their ability to significantly raise the efficacy of strain K.

Keywords: Apple, microbiota, biocontrol, *Pichia anomala* strain K, helper strains, *Botrytis cinerea*

S-VI-O8 Probiotic bacteria and yeasts as novel biocontrol agents of postharvest pathogens

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Abstract body text:

Numerous microbial antagonists (yeasts and bacteria) of postharvest pathogens have been identified in both laboratory, semi-commercial, and commercial studies. Several of these antagonists reached advanced levels of development and commercialization. Early investigations of potential biocontrol agents adopted the same strategy used for finding biocontrol agents against foliar and soil-borne diseases where the isolation and screening program was designed to identify single potent antagonists. This approach, however, neglected the fact that the introduced antagonist was not the only "player" present on the harvested commodity. The successful wide-spread use of biocontrol products based on a single antagonist, however, remains limited. This is for several reasons, among which are the inconsistency, and variability in the efficacy of the product under commercial conditions, as well as the lack of understanding of how these antagonists interact with the existing natural microflora on intact and wounded fruit surfaces. In attempt to overcome the shortcomings of existing biocontrol strategies for managing postharvest pathogens, we have begun to investigate the microbiome of a variety of fermented foods in an attempt to identify probiotic, natural microbial consortia capable of exhibiting robust and consistent biocontrol efficacy against a wide range of postharvest pathogens. The composition of the microbiota of different dairy and vegetable-based fermented foods, will be presented and the potential use of synthetic microbial consortia for biocontrol will be discussed.

Keywords: Biocontrol, postharvest diseases, probiotic

P075 Postharvest microbiome dynamics of mango fruit stem-end

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Abstract body text:

Stem-end rots (SER) develop in harvested mangos during ripening and cause significant losses. SERs are caused by pathogenic fungi that endophytically colonize stems during fruit development in the orchard and remain quiescent until ripening. This work was conducted to characterize the endophytic microbiome in mango fruit stem-end tissue and study the effect of various conditions on community composition. Microscopic analysis showed that quiescent fungi colonize the phloem of the stem-end. After switching to pathogenicity they expand into fruit parenchyma, causing SER. Interestingly, fruits subjected to high light in the orchard developed less SER after storage; they accumulated anthocyanins leading to red peel color, which was correlated with resistance to anthracnose and SER. The bacterial and fungal microbiomes in stem-end of red and green mango fruit stored at different temperatures were examined. Bioinformatic analysis showed that community compositions were significantly modified during storage, in response to different storage temperatures and in response to high light in the orchard. For example, *Pleosporaceae* (*Alternaria*) was the most abundant fungi in green (susceptive fruit) that were not exposed to sunlight or during storage (fruit ripening). This change in fungal composition was accompanied by increased occurrence of SER. Soon before the development of SER, the increased amount of fungi was correlated with the increase in abundance of chitin degrading *Chitinophagaceae* bacteria. Recently, we found that mango fruits harvested with longer stem (1 cm) are more resistant to SER than fruits harvested without stem. Preliminary results showed that fungal community in both treatments is similar at harvest but develops during storage to be more pathogenic in fruits with no stem. Collectively, our results show that pre and post-harvest treatments/conditions modify the microbial community in the stem-end and could be associated with reducing postharvest SERs.

Keywords: Microbiome, stem end rot

Session VII - Postharvest food safety

KEYNOTE SPEECH *Listeria monocytogenes* in fresh fruits: the occurrence and potential mechanisms of contamination

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Listeria monocytogenes is estimated to cause over 1,600 illnesses and 250 deaths annually in the United States, making it one of the leading causes of death from bacterial foodborne diseases. Most listeriosis outbreaks have historically been linked to ready-to-eat meats and dairy products; however, fresh produce-associated listeriosis outbreaks are increasingly recognized. Whether the emergence of produce as a vehicle for listeriosis represents a true increase in produce-associated illnesses or just an improvement in outbreak detection is unclear. The 2014-2015 multistate listeriosis outbreak associated with contaminated caramel apples, the 2014 recall of stone fruits due to *L. monocytogenes* contamination, the 2014-2015 Food and Drug Administration surveillance findings of *L. monocytogenes* in whole fresh avocados serve as a reminder that the historical absence of outbreaks linked to a particular low-risk product does not imply an absence of risk. Contamination of tree fruits remains a complex issue because many of the conditions that promote the contamination and persistence of this pathogen in the environment and in planta are not known. A better understanding of the ecology, distribution and survival of *L. monocytogenes* in the tree fruit production continuum is paramount to developing efficient prevention and control strategies. This lecture will highlight latest findings on the *L. monocytogenes* prevalence of the tree fruit production environments as well as present research on identification of high-risk postharvest practices, potentially facilitating contamination and survival of *L. monocytogenes* in fruits.

Keywords: *Listeria monocytogenes*, fresh fruits, postharvest, foodborne, outbreak

S-VII-O1 Behavior of *Listeria innocua* on cut cantaloupe during sanitization and refrigerated storage

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Abstract body text:

Outbreaks of *listeriosis* and *salmonellosis* linked to contaminated cantaloupes have been the cause of several deaths since 2017. Pathogenic contaminants are generally found on the melon surface and internalized during the process of peeling and cutting the fruit for consumption. As the market for fresh cut produce expands, industry members are seeking solutions to offset the risk of bacterial pathogen contamination on this low acid product. Cantaloupe melons sourced from retail outlets were peeled and diced to uniform size before inoculation on cut surface with *Listeria innocua,* a non-pathogenic surrogate for the virulent *Listeria monocytogenes*. Inoculated cantaloupes were treated by spray application of water or aqueous sanitizers (chlorine, peroxyacetic acid or sequential combinations of these) on a pilot-scale produce conveyor. Treated samples were subjected to refrigerated storage for up to 48 hours. Population of *L. innocua* was monitored throughout this process using cultural techniques. Inoculated melon cubes bore an average of 5.3 log CFU/cm^2 of *L. innocua* before treatment. Physical removal of inocula (as represented by water spray control) resulted in a significant initial population decrease of 1.1 log CFU/cm^2. Although no sanitizer combination was able to decrease population significantly more than water alone, the sequential application of chlorine (200ppm) followed by peroxyacetic acid (80ppm), resulted in the greatest inactivation of the target. An initial decrease in population as the result of refrigeration was observed in all treatments, notably, this trend was, without exception, followed by a population increase of as much as 1.0 log CFU/cm^2 over the course of the subsequent 48 hours. Results suggest that surface characteristics of cut melon discourage the effectiveness of aqueous sanitization. In order to provide safety assurance in product produced at large scale, alternative methods for pathogen inactivation should be investigated.

Keywords: Melon, fresh cut, *Listeria*, sanitizer

P076 Evaluation of a food safety training for farmers in the U.S

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Abstract body text:

The United States Food and Drug Administration (FDA) has created new regulations that will dramatically affect the food industry. The purpose of the Food Safety Modernization Act (FSMA) is to minimize the risk of foodborne diseases in the U.S. food system. As part of the Produce Safety Rule (PSR), at least one person per farm will be required to complete a day-long food safety training. So far there is only one compliant training, created by the Produce Safety Alliance (PSA), available. To evaluate the efficacy of this training, we used a pre-test post-test methodology. The test was composed of 25 questions and was delivered to attendees before and after training. Participation was voluntary and anonymous. In this preliminary evaluation phase of the training, 64 participants took the pre-test and 67 participants the post-test. The average increase in correct answers was 16%; from 72% to 88%. Since the average initial score was already good (72%), the increase was not pronounced, potentially indicating a ceiling effect. Indications of such effect can be observed in questions with pre-test scores over 95%. These questions covered basic concepts such as hygiene and the primary goal of the training. Examples are “Which of the following should guide risk management actions?” (Answer Scientific evidence; scores from 91% to 91%); “What practice should be done before starting work, before putting on gloves, and after a break?” (Answer Handwashing; scores from 98% to 100%). Nonetheless, the training had a pronounced and positive effect on some questions. Examples are “Which of the following is used as an indicator of fecal contamination of a water supply?” (Answer Generic *E. coli*; scores from 45% to 95%); “Which packinghouse zone poses the greatest concern for cross-contamination of produce?” (Answer Zone 1; scores from 50% to 99%); “Which of the following statements regarding cleaning and sanitizing is true?” (Answer Surfaces that have not been cleaned cannot be sanitized; scores from 61% to 94%); and “What is the first step in developing a Farm Food Safety Plan?” (Answer Assess risks; scores from 61% to 88%). This preliminary evaluation shows that the current training is successful in increasing knowledge, even if the overall increase in correct answers is not as large one would like. The small increase in scores could be due to the fundamental nature of the subject of some of the questions, where farmers already possessed knowledge. On the more applied subjects, the increase in scores was higher. The continuous evaluation of the training, with more participants taking the tests in future offerings, will allow a better evaluation. In summary, most farmers know the basics already and are learning the more advanced subjects, which is a clear indication of the success of the training.

Keywords: Food safety, training, FSMA, Extension

P077 Safety assessment in a recirculating hydroponic system and packaged lettuces

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Abstract body text:

Fresh lettuce is a major component in most salads. It is mostly eaten raw and therefore warrants a high level of safety. Hydroponic lettuce is known to confer less risk of microbial contamination relative to soil lettuce production due to reduced contact of the edible portion with soil or substrate. Substrates used for anchorage in hydroponic systems can retain nutrients with a potential of breeding microbes. Most harvested hydroponic lettuce, however, are packaged with intact, unsanitized substrates. The purpose of this study was to assess the transfer of microbes from the substrate to different sites on the lettuce and to determine how sanitization and modification of packaging technique could reduce the microbial count on the harvested lettuce. A 4x3 factorial experimental design was used to carry out this experiment. Factor 1 was the application of sanitizer; comprising peroxyacetic acid (PAA, ~80 ppm), chlorine (200 ppm), sterile water or no sanitization (control). Factor 2 was the modification of packaging, comprising “lettuce inversion” and “no inversion.” Marketable size lettuces were harvested, and the intact substrate was dipped 3 times into sanitizers and packaged. Treated lettuce leaf, root, and substrate samples were culturally enumerated for aerobic mesophiles (AMC) and coliforms. Identification of *Listeria* spp. was conducted by selective enrichment with isolation on MOX and PALCAM media. Data were subject to ANOVA and Tukey’s test for mean separation. The control treatment had the highest AMC on all samples with a load of 5.17 log CFU/g on the leaves. Among the sanitizers, PAA significantly lowered the AMC on the leaves. The “no inversion” treatment also lowered AMC on leaves. The combination of PAA and no inversion gave the best result with a microbial load reduction of 2.37 log CFU/g on leaves. The coliform count was highest in the substrate. Among the portion of lettuces analyzed, coliforms were significantly reduced in leaves and root with no significant effect on the substrate. However, coliforms were significantly higher on leaves when lettuces were inverted during packaging. *Listeria* spp. was not detected in any sample. Significance: Data suggests that the levels of microbial count can be reduced by the addition of a PAA treatment and modification of packaging technique.

Keywords: Lettuce, hydroponic, safety, *Listeria*, coliforms

P078 Expiring date limitations is a challenge for storage and safety of ready-to-eat salads in different seasons and vegetable type

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Abstract body text:

Ready-to-eat salads of leafy vegetables are quite popular among minimally processed vegetables sector. However, these products are considered highly perishable and thus the investigation of aspects related to their safety, quality and shelf-life is essential. The aim of this study was to examine the microbial load, physicochemical attributes of ready-to-eat salads and their correlation with product shelf-life during chilled-storage as affected by season and vegetable type. A total of 144 ready-to-eat salads samples were randomly collected from retail outlets in Cyprus in two seasons (72 samples during winter and 72 during summer) and analyzed to determine the microbiological quality and safety along with their physicochemical attributes. The results indicated an increase of microbial load (especially in total viable count of Enterobacteriaceae, coliforms, yeasts and molds) along with the increase of CO_2 production in the package leading up to the expiration date of the product. It is noteworthy that *Salmonella enterica* was absent in all samples, whereas *Listeria monocytogenes* was detected in eight samples (5.56%) that were collected during spring.

Keywords: Antioxidants, food quality, food safety, foodborne pathogens, ready-to-eat salads

P079 Application of Ultraviolet C light as alternative sanitation technology for keeping safety of fresh raspberries

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Abstract body text:

Berries have been associated with outbreaks in both North America and Europe, and have caused numerous serious illnesses. The challenge for raspberry decontamination exists because fresh market raspberries are not washed. Thus, the aim of this work was to study the application of ultraviolet C light (UV-C) as new sanitation technology alternative to limit the potential microbial risk. Fresh raspberries were inoculated with three foodborne pathogens (*Listeria inocua, Salmonella enterica subspp. enterica* and *Escherichia coli*). Fifty mL of 10^7 cfu.mL^{-1} of inoculum were pulverized on the surface of raspberries in order to simulate the contamination. Inoculated raspberries were dried for 8 h. After that, inoculated berries were treated with different doses of Ultraviolet -C (UV-C) light (D1= 2 KJ and D2= 3,5 KJ). Control batches were included: non- UV-C treated raspberries inoculated with pathogens, non-inoculated raspberries treated with UV-C and raspberries non-treated nor inoculated as negative control. Pathogens and microbial counts, firmness and percentage of disorders were measured for each batch at day 0 and after 4 and 6 days of cold storage at 5°C. Raspberries with *L. inocua, S. enterica* and *E. coli,* treated with D2 experienced the highest decreases of the counts of pathogens, with mean counts of 3,7; 2 and 3,8 log cfu.g-^{1}, respectively, whilst raspberries inoculated and not treated with UV-C reported pathogens mean counts between 5 and 6 log cfu.g^{-1}. Moreover, the microbial flora of the fruits also experienced a reduction of 1 log for mesophilic bacteria, whilst the reduction of molds was less pronounced. Reading Firmness, the application of UV-C involved a slight decrease of the firmness values, even if no significant differences were detected. Thus, the application of UV-C light at doses of 3,5 KJ enables the reduction of microbial and pathogenic counts, being a suitable sanitation alternative for berries.

Keywords: Sanitation technologies, pathogens, berries, UV-C

P080 Antioxidant capacity of fermentation broth of fresh-cut fruits and vegetables scraps and its application as a detoxifying agent

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Fresh-cut fruits and vegetables have been popular by consumers because of their freshness, convenience, hygiene and health. However, the fresh-cut industry produces a large amount of waste, which pose serious pollution risk to the environment. Recycling or downstream processing of this waste to produce fermentation broth has the meaning of turning waste into treasure. In this study, waste such as peeled fruit cores produced by fresh-cut apples and vegetables are used as raw materials, which are pulverized into a certain particle size. The chinese honeylocust fruit and fresh wastes dregs were taken and equal weight of each mixed. The mixtures were mixed with brown sugar and water to carry out natural anaerobic fermentation at room temperature. The traditional fermentation broth contained only fresh-cut dregs, brown sugar and water. The antioxidant capacities of the raw material and the obtained fermentation broth were investigated, the abilities of the fermentation broths to remove pesticide residues was determined, as well as high-throughput sequencing technique was used to studied the microbial diversity in the fermentation broths. The results showed that the activities of superoxide dismutase in the fermentation broth containing Chinese honeylocust fruit and traditional one were 76.1 and 5.5 times higher compared with the raw materials, respectively. The fermentation broth containing Chinese honeylocust fruit possessed amylase, cellulase and lipase activity that can be used as detergent builders, which were not present in raw material. The effect of removing the pesticide residue after soaking in 1/100 dilution of multiple fermentation broth containing Chinese honeylocust fruit for 30 min was obviously better than domestic famous brand detergent for fruits and vegetables and traditional fermentation broth. In addition, the bacteria and fungi were lower in the fermentation broth containing Chinese honeylocust fruit than that of the traditional fermentation. The results also indicated that microbial populations differed greatly in two broths.

Therefore, as a biological detoxification agent, fermentation broth of fresh-cut fruits and vegetables waste along with Chinese honeylocust fruit has the characteristics of safety, environmental protection and remarkable effect, and has broad application prospects.

Keywords: By-products of fresh-cut fruits and vegetables; fermentation broth; antioxidant capacity; microorganism; environment friendly

Session VIII - Advances and applied research in handling packaging, transport and distribution to reduce postharvest losses

KEYNOTE SPEECH Advances in applied research in handling, packing, transport and distribution to reduce postharvest losses - embracing the 4th industrial revolution

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Abstract body text:

Taking advantage of the 4th industrial revolution in postharvest science may provide practical real time solutions for harvesting, handling, packing, transport, storage, distribution and point of sale to possibly reduce waste and losses. Technological advances may contribute to addressing some of the United Nations Sustainable Development Goals; 1 No poverty, 2 End hunger, 3 Good health and well-being, 7 Access to sustainable energy, 8 Inclusive sustainable economic growth, 11 Sustainable cities, 12 Sustainable consumption patterns, 13 Combat climate change, 16 Promote peace and 17 Revitalise global partnerships. The 4th revolution offers a merging of technologies that is erasing the boundaries between digital, physical and biological technologies often referred to as cyber-physical systems. Postharvest pathogens have evolved and adapted to modern harvesting, packing, transport and cold chain systems to contribute to greater losses at the market or consumer end of the supply chain. The traditional definitions of pathogenicity, host specificity and virulence or aggressiveness often do not fit modern fresh produce supply chain systems with losses and waste shifting to the market and customer end. This presentation will address the challenges within the modern fresh produce supply chains reflecting on 20 years of research on citrus, subtropical, pome and stone fruit and the fusion with novel technologies such as artificial intelligence, block chain, 3D printing, quantum computing, nanotechnology, robotics, autonomous vehicles and other biological technologies that can be used to reduce waste and losses for a food secure world.

Keywords: Technological advance, food waste, postharvest losses, SDG's, food security

S-VIII-O1 Comparison of the shelf life and surface mold population of Hungarian *Prunus cerasus* cultivars following different pre- and postharvest treatments

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Abstract body text:

Hungary is among the three largest producers of *Prunus cerasus* in the European Union, and also the world's largest fresh tart cherry exporter. There is a lack of information about the postharvest losses, primarily caused by postharvest diseases in this crop. The optimization of the storage and the shelf-life conditions of the fruits could provide longer availability period of fresh fruit with high nutritional value. The aim of our research was to compare the effectivity of different pre- and postharvest treatments on three Hungarian tart cherry varieties (‘Érdi bőtermő’, ‘Újfehértói fürtös’ and ‘Petri’) harvested from the same orchard. Fungicide (Luna Privilege) and biofungicide (Serenade ASO) were applied two weeks before harvest. Harvested fruits were stored for 6 weeks at 0°C, either in normal or in modified atmosphere packaging (MAP), using StePac Xtend (cherry). Surface mold population changes were compared by determining colony forming unit (CFU) counts and the morphology based identification after harvest and storage. Shelf-life was monitored, and disease incidence was calculated during one week both before and following storage. Molds were isolated from rotten fruits during shelf-life studies and identified based on morphological and molecular characters. Fruits from the different cultivars showed differences both regarding the shelf life and the surface mold CFU. The effectivity of the preharvest treatments were also influenced by the cultivars. Disease incidence was higher following cold storage compared to non stored fruit. Consequently, six weeks cold storage decreased the shelf life of sour cherry. Weight loss and the percentage of decay were significantly reduced by MAP and cold storage. *Penicillium* sp. *Alternaria* sp., *Fusarium* sp. and *Rhizopus* sp. were the most frequent fungi isolated the surface of the fruits. Potting can be decreased by MAP in some cases.

Keywords: MAP, Luna Privilege, Serenade ASO

S-VIII-O2 Salicylic acid and chitosan retained strawberry fruit quality and phytochemical contents and decreased decay extension during cold storage

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Abstract body text:

Effect of salicylic acid (SA) (at 0, 1 and 2 mmol.L-1) and chitosan (at 0, 0.5 and 1%) on postharvest life and quality of Selva strawberry fruit during storage at 2.5 °C at 85–95% RH for 7 and 14 days was studied. Total phenolics, total antioxidant activity, ascorbic acid content and fungal decay incidence were evaluated during storage. Chitosan at 1% and SA, at all concentrations, significantly decreased decay incidence and maintained fruit marketability during 14 days of cold storage. 1 mmol.L-1 SA in combination with 1% chitosan significantly increased ascorbic acid content and total antioxidant activity during first week of cold storage. Total phenolics significantly decreased during cold storage but edible coating of 0.5% chitosan with 1 mmol.L-1 SA reduced the rate of decrease in phenolics. SA and chitosan, as nonchemical and safe compounds, show a good potential in increasing postharvest life of strawberry fruit.

Keywords: Chitosan, decay incidence, phenolics, strawberry, salicylic acid, total antioxidant activity

S-VIII-O3 Pre -and post-harvest factors determining carrot storability

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Abstract body text:

Carrot (*Daucus carota* L.) is the most important root vegetable in Norway. Due to short growing season roots may be stored for up to 8 months in wooden crates (400 – 800 kg) with perforated plastic liners. Storage temperature is aimed at stabilizing at 0°C – 0.5°C. Storage performance is though variable and an average loss on 30 % is common. The losses are largely due to diseases caused by fungal pathogens. In Norway the main storage disease is caused by soilborn pathogens liquorice rot (*Mycocentrospora acerina* (Hartig)) and crater rot (*Fibularhizoctonia carotae* (Rader). In recent years, a yet not understood damage in the root tip of carrots, developing into rot during storage, has caused large losses (Assalf et *al.* 2018). A number of abiotic and biotic factors are known to influence the severity of loss during storage. Both root age, soil conditions, infestation in the soil and not least, storage conditions affect storage performance. In this presentation, data from a number of experiments on pre – and post-harvest factors affecting storage performance of carrots in Norway are presented: i) effects of mechanical soil compaction/soil loosening ii) field infestation with liquorice rot/ crater rot and carrot age & iii) mapping/survey on how different storage types affect storage performance in carrots. Furthermore, response related to variety are presented. Preliminary results showed that the mechanical soil compaction applied affected the percentage of: fresh roots, roots with *Fusarium* and tip rotting. Infestation with liquorice rot/ crater rot in field increases infestation in the roots, and older roots have a higher infection rate then younger roots. Storage performance varies with root age and variety and storage type influence the storage performance of carrots and regional differences are found.

Keywords: Soil compaction, soil loosening, storage type, variety, root age

P081 Good post-harvest practices for better control of banana fungal diseases

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Abstract body text:

Currently, post harvest control of banana fungal diseases mostly involves chemical fungicides. However, this approach has been found to be hazardous for workers and the environment, and it seems that the development of fungus resistance is making this approach increasingly inefficient. In this work, we propose to highlight the impact of each step from harvest to consumer that impacts positively or negatively the severity of banana fungal diseases, and especially the development of crown rot. In particular, recontamination steps and the negative impact of delatexing in a water bath are clearly shown. Lastly, the use of a modified atmosphere as a trigger for better anthracnose control is described. This work, thus, provides a list of good practices starting from the banana packing house up to the shipping and storage stages that could potentially make it possible to control banana fungal diseases without using chemical fungicides. In an organic production context, this preventive approach will be essential for producing fruits that respect the requirements of the demanding food chain.

Keywords: Post harvest, banana, good practices, fungal diseases, packing house

P082 Hot water treatment and modified atmosphere packaging reduce decay of 'tainung no.2' papaya (*Carica papaya* L.) fruits during low temperature storage

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Abstract body text:

Anthracnose and stem-end-rot diseases are major causes for the postharvest loss of papaya 'Tainung No.2' during storage. Polyethylene film (0.01, 0.03, 0.05, and 0.1mm of thickness) packaging delayed and reduced the decay incidence of papaya fruit during storage at 12°C. Weight loss and loss of firmness of fruit were also prevented. Combination of modified atmosphere package (MAP) and hot water treatment (HWT) at 57°C for 90 sec, inhibited the incidences of anthracnose and stem-end rot, delayed fruit softening as well as the rate of fruit coloring of papaya fruit during storage for 3 weeks at 12°C and 3 days shelf life at 25°C. No off-flavor development was induced in the package after 3 weeks storage at 12°C. Use of hot water treatment with MAP showed a benefit to reduce postharvest decay and maintained the quality of papaya during storage at 12°C and shelf life period.

Keywords: Papaya, HWT, MAP, postharvest decay

P083 Comparison of sanitation systems on air and fruit quality during cold storage of white currant, red currant and blueberry

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Abstract body text:

In order to limit postharvest fruit decay, it is necessary to control pathogen diseases during storage, especially with highly perishable products. In this regard, a number of control methods have been proposed to reduce fruit losses based on different sanitation systems and chemical or biological approaches. In this work, we have tested two different sanitization technologies (Ionization and Ozone) in comparison with untreated industrial standard under CA storage conditions of red currant, white currant and blueberry produced in Trentino Alto Adige region (Italy). The investigated sanitation technologies reduced the presence of yeasts, moulds and bacterias on the air of the cold room after 7 days of storage. Sanitation technologies were compared to the results obtained with two different untreated industrial storage methods (Untreated and the storage using a bin passive permeation cover) for the main quality control parameters, fruit shelf-life and physiopathology grading after 34 days.

Keywords: Postharvest decay, Pathogens, Sanitization, Currant, Blueberry

P084 Aqueous ozone treatment decreased degradation of cell-wall polysaccharides in fresh-cut apple during cold storage

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Abstract body text:

The influence of aqueous ozone on the relevant indices of degradation of cell-wall polysaccharides in fresh-cut apple during cold storage was studied. The effects of aqueous ozone treatments (1.4 $mg.L^{-1}$) for 2, 5 and 10 min on the firmness, the variations of polysaccharides content in cell wall and activities of cell wall degrading enzymes were investigated. Results showed that aqueous ozone treatments for 2, 5 and 10 min delayed degradation of cell-wall polysaccharides in fresh-cut apple during cold storage. The content of water-soluble pectin (WSP) increased more slowly, while the protopectin content, 4% KOH-soluble fraction (4KSF) and cellulose content decreased at a lower rate in aqueous ozone treated fresh-cut apples compared with the control. However, no significant influences were shown on 24% KOH-soluble fractions (24KSF). Aqueous ozone treatments promoted the increase of pectin methylesterase (PME) activity, but could distinctly inhibited the increase of β-galactosidase (β-Gal) and α-arabinofuranosidase (α-L-Af) activities during storage. The changes of polygalacturonases (PG) and cellulase (Cx) activities were not affected by aqueous ozone. Therefore, aqueous ozone maintained the intactness of cell walls through regulating β-Gal and α-L-Af activities in cell walls of the apple, thereby reducing loss of textural quality in fresh-cut apple during cold storage. Moreover, aqueous ozone treatments for 5 and 10 min were better than that for 2 min in delaying loss of textural quality of fresh-cut apples, and aqueous ozone treatments for 5 min was more suitable for industrial production efficiency and cost requirements.

Keywords: Aqueous ozone; fresh-cut apple; softening; cell-wall polysaccharides; cell wall degrading enzyme

P085 Apple fruit deterioration by fungal decay as a function of temperature during post-storage period

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Abstract body text:

This study describes the deterioration rates of 'Gala' and 'Fuji' apples fruit during 30 days after controlled atmosphere storage period (ACAS). It was simulated handling periods of 11 days at packinghouse (PH), 7 days at shipping and distribution center (S&DC) and 12 days at retail and consumer home (R&C). Apple fruit harvested from commercial orchards in Brazil, were stored in commercial CA rooms at 0.7^{o}C. 'Gala' apples from orchards 1, 2 and 3 were stored for 5, 7 and 8 months while 'Fuji' apples from orchards 4, 5 and 6 were stored for 5, 6 and 8 months, respectively. Fruit were sized and graded in a commercial sorting plant one day ACAS. Six samples of 25 unblemished fruits (category 1, 135.5 ± 7.5 g) were selected for each treatment, cultivar, orchard and date of assessment. At pre-shipping period (PH), the fruit were kept at 10^{o}C between the 2nd and 4th day ACAS simulating the sorting and packaging periods, and then at 0.5^{o}C between the 5th and 11th day ACAS, simulating storage of sorted or packed apple (0.5^{o}C). The treatments were four temperature regimes applied from 12th to the 30th day ACAS: 1) continuously at 0.5^{o}C; 2) continuously at 22^{o}C; 3) 0.5^{o}C from the 12th to the 18th day (S&DC) and 22^{o}C from the 19th to the 30th day (R&C); 4) 22^{o}C from the 12th to the 18th day and 0.5^{o}C from the 19th to the 30th day. Fruit deterioration was affected by post-storage temperature, cultivar and orchard-length of CA storage factor. Fungal decay was the main disorder developed ACAS period and the limiting factor of marketing period. The maximum incidence of decayed fruit was 7% and 25% for 'Galas' and 10% and 34% for 'Fujis' kept continuously at 0.5^{o}C and 22^{o}C, respectively. Low temperature from 12th to 18th day was more effective than low temperature from 19th to 30th day to delay appearance of fungal decay symptoms and to increase marketing period. However, low temperature from 19th to 30th day resulted in higher incidence of decayed fruit on 30th day ACAS than low temperature from 12th to 18th day. Low temperature following CA storage also delayed development of flesh browning and loss of firmness in 'Galas' apples.

Keywords: *Malus domestica*, quality, rot, shelf life, flesh browning

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