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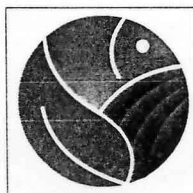
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SESSION 1 (S1)

RIPENING PHYSIOLOGY IN CLIMACTERIC AND NON-CLIMACTERIC FRUITS



S1-01**GENOMICS APPROACHES TO UNDERSTANDING RIPENING CONTROL AND FRUIT QUALITY IN TOMATO.**Giovannoni J.^{1,*}, Alba R.², Vrebalov J.², Fei Z.², Liu Y.²¹USDA-ARS and Boyce Thompson Institute for Plant Research, ²Boyce Thompson Institute for Plant Research, USA.

*Presenter (jjg33@cornell.edu)

As part of the National Science Foundation (NSF) supported Tomato Genome Project our laboratory has and continues to participate in the development of tomato genomics resources. Project participants (S. Tanksley, G. Martin, R. Wing) in collaboration with The Institute for Genome Research (TIGR) have created over 150,000 tomato EST sequences from 23 different tissue samples. We are exploiting this EST collection develop microarrays which we employ for gene expression profiling to gain more depth in our analysis of fruit development and ripening. Ten stages from 6 days post-anthesis through late ripening have been selected for expression analysis and the expression profile of normal fruit development has been compared. A current focus is on novel transcription factors associated with ripening and discovered through this analysis. A user-friendly Tomato Expression Database (TED) has also been developed as a means to transfer the resulting expression data to the research community (<http://ted.bti.cornell.edu/>).

The laboratory is also directing considerable effort toward characterization of developmental, hormonal and environmental (esp. light) signal transduction systems impacting maturation and quality characteristics associated with ripening through characterization and analysis of available tomato mutants. Positional cloning efforts resulting in isolation of the RIPENING-INHIBITOR (NOR) and NON-RIPENING (RIN) genes involved in developmental regulation of ripening indicate the NOR product is required for RIN gene expression. Progress toward positional cloning of additional tomato fruit mutants impacting quality (high-pigment-1) and abscission (jontless2) will be summarized.

S1-03**DYNAMICS OF GAS EXCHANGE AND BIOCHEMICAL CHANGES DURING SHELF LIFE OF EUROPEAN PLUMS (*Prunus domestica* cv. Hauszwetsche) Neeraj B.^{1,*}, Lippert F.¹**¹Dept. of Horticulture, Bonn University, Germany.

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The rate of respiration and ethylene production in combination with storage temperature are considered as vital processes determining the post-harvest life of fruits. The ripening behaviour of European plum fruits is a climacteric type as recently characterized. This makes them highly perishable as the tissues rapidly undergo profound changes in texture and quality resulting in short storage period.

The aim of present study was to obtain a continuous profile of gas exchange processes and related changes in biochemical composition of plum fruits at 20°C. Rate of oxygen consumption, carbon dioxide production, ethylene and acetaldehyde evolution were monitored on a daily basis. Changes in total soluble solids, acidity and carbohydrates were also studied.

Rate of respiration decreased after an initial rise where as respiratory quotient was found increasing in later stages of storage period. A continuous increase in acetaldehyde evolution was observed. It was interesting to observe a very less change in concentration of total sugars during the period of shelf life study. The results obtained indicate the presence of alternative energy reservoir in plum fruits to support the metabolic processes. Possible role of stimulated ethylene levels in fruit senescence and cell structure break down is hypothesized.

S1-02**THE ROLE OF METHYL JASMONATE IN ETHYLENE BIOSYNTHESIS AND FRUIT RIPENING IN STRAWBERRIES.**Mukun L.¹, Zora Singh^{1*}¹Horticulture and Viticulture, Muresk Institute, Division of Resources and Environment, Curtin University of Technology, Perth, Western Australia.

*Presenter (Z.Singh@curtin.edu.au)

The role of methyl jasmonate (MJ) in 'Pajaro' strawberry fruit ripening was investigated by monitoring endogenous MJ levels at various stages of fruit ripening including white, half ripe and at fully ripe and with its exogenous application. Endogenous MJ was quantified in fruit at zero, three and six days after harvest. The effects of MJ on ethylene biosynthesis were tested by incubating strawberry discs (2 cm diameter, 3 mm thickness) at white, half ripe and at fully ripe stage in petri dishes containing 20 mL mannitol (0.4 M) with 0, 10 and 50 mM MJ for 24 or 48 hours, followed by transfer of discs to MJ-free petri dishes. Ethylene production, ACC synthase and ACC oxidase activities were measured at zero, one, two, and three days after treatment. Trans-methyl jasmonate was detected in strawberry fruit using GC-MS at white, half ripe and at fully ripe stages. The concentration of endogenous MJ was significantly higher in the white fruit (31.7 – 162.2 ng g⁻¹) and decreased sharply in half and fully ripe fruit. Higher concentrations of endogenous MJ at the white stage of strawberry fruit followed by a decline during fruit ripening indicate that MJ may play an important role in modulating fruit ripening. Significantly increased ethylene production was recorded in strawberries when MJ was applied to white, half ripe and at fully ripe fruit. The application of MJ (50 µM) resulted in significantly highest ethylene production and increased activities of ACC synthase and ACC oxidase as compared to all other treatments. The effects of exogenously applied MJ on ethylene production, ACC synthase and ACC oxidase activities was dependent on concentration of MJ and fruit developmental stage.

In conclusion, MJ appears to play an important role in modulating strawberry fruit ripening.

S1-04**DOWN-REGULATION OF AN AUXIN RESPONSE FACTOR IN THE TOMATO ALTERS PERICARP TISSUE ARCHITECTURE AND CELL WALL POLYSACCHARIDE.**Lahaye M.^{1,*}, Guillon F.¹, Bouchet B.¹, Devaux M.F.¹, Frasse P.², Bouzayen M.³¹INRA-URPOI, Nantes, France; ²INRA/INP-ENSA, UMBMF, Castanet-Tolosan, France; ³INRA/INP-ENSA, UMBMF, Castanet-Tolosan, France.

*Presenter (lahaye@nantes.inra.fr)

The understanding of fruit texture elaboration markedly benefit from studies of transgenic plants affected in the expression of enzymes and proteins responsible for cell wall (CW) polymers remodelling during ripening. The latter event is mainly orchestrated by hormones such as ethylene through the intervention of transcription factors. In tomato, down regulation of an auxin response factor (DR12) regulated by ethylene resulted in a pleiotropic phenotype including enhanced fruit firmness and blotchy ripening (Jones et al. 2002, Plant J. 32: 603-613). To uncover the molecular basis of this enhanced firmness, biochemical and structural characterisations of the pericarp CW polysaccharides from DR12 MG and RR transgenic fruits were carried out and compared to WT fruits. Acetyl-esterification (DA) of polysaccharides was higher in DR12 fruit compared to WT at both ripening stages. Methyl esterification (DM) of pectins in DR12 was slightly higher for the MG and lower for the RR stages. CW polysaccharide composition showed a decrease in pectin DM and galactan in RR DR12 and WT fruits. An increased water and oxalate extraction of pectins was observed for RR DR12 and WT fruits. However, endopolygalacturonase degradation and competitive ELISA assays of the water and oxalate pectins differed between WT and DR12. Quantitative microscopic analysis showed that on an area basis, 9% of the DR12 outer cortical region corresponded to cells of $\phi \leq 50$ µm compared to 7% in WT. Immunocytochemical analyses using monoclonal antibodies against different pectic epitopes supported the physico-chemical data.

Thus, DR12 down-regulation does not impair pectin de-assembly during ripening but seems to affect cell division, pectin methyl esterification and polysaccharide acetyl esterification. Whether the latter correspond to hemicelluloses is still to be elucidated. The increased firmness of the RR mutant fruit appears to involve increased pectic CW interactions and peculiar tissue architecture.

S1-05

COMPARING THE PHYSIOLOGICAL CHANGES IN APPLES AND PEARS DURING SHELF-LIFE MEASURED BY FLUORESCENCE IMAGING.

Huybrechts C.¹, Valcke R.^{2*}¹Laboratory of Molecular and Physical Plant Physiology, Limburgs Universitair Centrum, ²Dept. S.B.G., Belgium.*Presenter (christy.huybrechts@luc.ac.be)

The physiological state of plants can be determined by red-light chlorophyll fluorescence induced after excitation with UV or blue light. Smillie et al. (1987) showed that two major changes affect the level of chlorophyll fluorescence emission during fruit ripening and senescence. Fluorescence decreases due to loss of photosynthetic competence per unit chlorophyll leading to reduced PSII activity or due to a decrease in chlorophyll content associated with fruit ripening and senescence.

Research has shown that fruit quality (Nedbal et al., 2000), storage potential (Huybrechts et al., in press) and the incidence of physiological disorders (Ciscato et al., 2001; Huybrechts et al., 2002) during storage can be predicted by means of chlorophyll fluorescence imaging. In this experiment, a transportable chlorophyll fluorescence imaging system was used to study physiological changes in "Jonagold" apples and "Conference" pears during shelf-life. Fruit was bought in a local store and measured during consecutive days at room temperature in order to detect physiological changes during this period. During shelf-life a decrease of the maximal fluorescence intensity and changes in the homogeneity of the images is observed although there appear to be little or no visual changes. This allows us to study the physiological changes associated with fruit ripening and senescence in apples and pears.

S1-06

DFD, A NEW TOMATO MUTANT THAT PROMPTS A REEVALUATION OF THE KEY DETERMINANTS OF TOMATO FRUIT SOFTENING AND POSTHARVEST DETERIORATION.

Saladie M.^{1*}, Watkins C.², Labavitch J.M.³, Shackel K.³, Rose J.K.C.¹¹Department of Plant Biology, Cornell University, Ithaca; ²Department of Horticulture, Cornell University, Ithaca; ³Department of Pomology, University of California, Davis, USA.*Presenter (ms252@corn4ell.edu)

Fruit softening is a complex physiological event that a major determinant of postharvest fruit quality. Attempts to understand the molecular basis of softening have focused on cell wall metabolism and it is now generally believed that fleshy fruits soften as a consequence of polysaccharide degradation in the primary cell wall and middle lamella. Tomato has provided the principal model system for these studies and yet efforts over the last ten years to substantially reduce softening in transgenic tomato lines by suppressing the expression of genes encoding cell wall degrading proteins, such as polygalacturonase (PG), pectin methylesterase (PME) and expansin, have been largely unsuccessful.

We have recently identified a tomato line, that we named the did (delayed fruit deterioration) mutant, which promises to provide a new perspective of the key molecular determinants of softening and other postharvest quality traits. The two major characteristics of did are substantially reduced fruit softening and complete resistance to postharvest disease, which collectively result in a remarkable shelf life. Unlike other well known ripening-related tomato mutants such as rin (ripening inhibitor) and nor (non-ripening), did fruits undergo essentially normal climacteric ripening while attached to the plant, with all the organoleptic characteristics and quality properties that are essential for commercialization, such as color, aroma and accumulation of sugars. However, the did fruits also maintain a firm texture for a dramatically extended period of time after harvesting and can be stored with no further treatment at room temperature for more than seven months with no signs of deterioration. Moreover, after more than one year, intact and untreated did tomatoes show no signs of microbial infection.

The physiological, molecular and biochemical characterization of the did mutant will be presented, together with a new model of the key features that underly tomato fruit softening and tissue disintegration.

S1-07

THE RESPONSE OF THE 'CARABAO' MANGO TO CONTROLLED ATMOSPHERES.

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Earlier attempts to apply controlled atmosphere (CA) systems to delay ripening in the 'Carabao' mango (known in trade as the 'Manila Super' mango) have not been successful. This is mainly due to its susceptibility to fermentation at reduced oxygen, exhibiting internal breakdown (IB) even at 7% O₂. This susceptibility is affected by maturity, temperature and growing conditions.

In a study conducted to document the response of 'Carabao' mangoes to low O₂, fully mature, sound fruits were held at varying O₂ levels with or without added CO₂. Fruits were observed to respond favourably to 5% O₂ at a temperature of 12.5°C, if harvested at the fully mature stage. Carbon dioxide at 12.5% or 25% did not significantly affect fruit response to low O₂. As this cultivar starts producing ethylene even before full harvest maturity is attained, the timing of low oxygen treatment is critical.

Susceptibility to disorders evidently depends also on adaptive physiological mechanisms that occur under low O₂. In the absence of such mechanisms, fruits exhibit symptoms typical of hypoxia: elevated acetaldehyde and ethanol levels leading to tissue death and lesions referred to as spongy tissues. As with other cultivars, the success of CA holding also depends on pre- and postharvest disease control measures, particularly in growing areas where existing environmental conditions favour disease development. With appropriate measures to control disease, CA can extend the marketable life of 'Carabao' mangoes to as long as 33 to 40 days.

S1-08

EFFECTS OF 1-METHYLCYCLOPROPENE ON STONE FRUITS.

Lurie S.^{1*}, Weksler A.¹¹Department of Postharvest Science, Volcani Center, ARO, Bet Dagan 50250, Israel.*Presenter (w_asia2002@yahoo.com)

1-Methylcyclopropene (1-MCP) is an ethylene action inhibitor, which prevents plant tissue from perceiving and responding to ethylene. It is generally effective in concentrations of 1 micromolar or less, and can retard many ripening processes that depend on ethylene for their induction. These processes include softening, color development, loss of titratable acidity and increase in volatile compounds. The active compound is a gas (as is ethylene) and the treatment is given after harvest. The effect of 1-MCP on apricots, cherries, nectarines, peaches and plums has been investigated.

Apricots responded to 1-MCP by slowing their softening, peel color change and loss of titratable acidity. However, ethylene production and respiration were not affected, and the treatment with 1-MCP enhanced internal flesh browning. Cherries are a non-climacteric fruit and treatment with 1-MCP had no effect on their postharvest life. Peaches and nectarines responded to 1-MCP treatment in a similar manner to apricots by slower softening, color change and loss of titratable acidity, with only minor inhibition of ethylene production. However, after storage, fruit which had received a 1-MCP treatment developed more flesh disorders, particularly bleeding, than untreated fruit. Plums, both European and Japanese, responded positively to 1-MCP. Ethylene production was inhibited, as was softening, color change and loss of titratable acidity. There were fewer storage disorders, such as internal browning and gel breakdown in 1-MCP treated than non-treated fruit.

The use of this compound can help to elucidate the role of ethylene in the development of physiological storage disorders and in regulation of ethylene biosynthesis in different types of stone fruit.

S1-09

PATTERNS OF TEMPORAL mRNA EXPRESSION AND ENZYME ACTIVITY OF PECTOLYTIC AND NON-PECTOLYTIC CELL-WALL DEGRADING ENZYMES IN GROWTH AND RIPENING OF APPLE FRUITS.

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Textural changes that lead to softening of apples are accompanied by enzymatic degradation and loss of neutral sugars of the pectic polysaccharides of the cell wall. Recently, it has been suggested that the process is the result of the combined action of several cell wall degrading enzymes. This work aims to establish a temporal sequence of the action of cell wall degrading enzymes during apple growth and ripening.

A cDNA library enriched with mRNA isolated from over-ripe fruits was constructed and screened to clone an endo-1,4-beta-glucanase (EGase), two xyloglucan endotransglycosylase/hydrolase (XTH), an expansin, an alpha-L-arabinofuranosidase (AFase), a pectin methylesterase (PME), and a pectate lyase (PL) full-length cDNAs encoding late isoforms. These clones were characterized and their accumulation during fruit growth and ripening was examined by semi-quantitative RT-PCR analyses. Expression of beta-galactosidase and polygalacturonase (PG) mRNAs previously reported was also included in the analyses. Transcripts of all enzymes, except PME, could be detected in fruits at harvest. However, transcripts of EGase were more abundant at fruit set and both expansin and pectate lyase had their highest expression before ripening. The strongest expression in over-ripe fruits was observed for beta-galactosidase and PG clones. RT-PCR analyses were also conducted in flowers, peduncles, young and expanded leaves and senescent petioles, and the results showed that the cloned cDNAs are not fruit-specific.

The activity for each enzyme was also monitored in fruits at the same stages as for the mRNA accumulation. Comparison of the patterns of enzyme activity with mRNA expression suggests the presence of isoforms acting in fruit growth and ripening-specific isoforms or post-transcriptional regulation. Furthermore, the results indicate that the pattern of softening of apple fruits is different from the model plant tomato.

S1-11

DIFFERENTIAL EXPRESSION OF THE CHILLING-INJURY INDUCED PHYSIOLOGICAL DISORDER OF WOOLLINESS IN PEACHES AND NECTARINES.

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Expression of the chilling injury disorder known as woolliness or mealiness is common in peaches and nectarines exported from Chile, as they are submitted to prolonged exposure to cold temperatures during transport to the markets.

A project has been initiated to study aspects of functional genomics as related with induction and expression of the disorder in a number of varieties of peaches and nectarines selected according to presumed differential susceptibility to the problem.

Differential expression of woolliness within each variety has also been attained by submitting the fruit to different storage periods and temperatures, with a temperature not resulting in chilling injury, i.e. 10°C, and two temperature levels leading to subsequent problems, using 0°C and 4°C to induce and to attain maximal expression, respectively. Thus, the different varieties of peaches and nectarines did actually show differences in propensity to the physiological disorder, leading to characterization of expression of the lack of juiciness in fruits attaining the ripe stage by using the objective free-juice method (Crisosto and Labavitch, 2002) and correlating such results with subjective determinations as normally performed in similar studies.

S1-10

IMPORTANCE OF HORMONAL PROFILE ON THE ONSET OF RIPENING IN GRAPE BERRIES *Vitis vinifera* L.

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Grape berry is classified as a non climacteric fruit which accumulates acid abscissic (ABA) at the beginning of ripening. It seems that this phytohormone is an activating signal of ripening. We propose to have a global view over the hormonal equilibrium.

As a part of this investigation, we have realized treatments during the stage 81 of development (1% veraison). We have treated grape berry with ABA and the fungal toxin fusaric acid, which is known to have an ABA antagonist effect on plant tissues.

We first observe that both treatments induce a delay in the increase in berry weight. The exogenous application of ABA results in an advance of the change of colour, by faster decreasing chlorophyll levels. The hormonal profile is modified during the veraison: ABA levels are enhanced and acid indole acetic acid (AIA) levels are decreased in the berry. This treatment seems to advance ripening process. Application of fusaric acid to berry deletes the chlorophyll degradation. This is accompanied by a decrease of ABA levels compared to the control.

These results show that exogenous treatments with ABA modify the hormonal profile and the ripening process. The roles of ABA and AIA are discussed in relation with expression of some genes involved in the ripening process.

S1-14

THE INFLUENCE OF HARVEST MATURITY AND STORAGE TEMPERATURE ON QUALITY AND POSTHARVEST LIFE OF PERSIAN MUSKMELON FRUIT (CV. SEMSORY).

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Fruit of Persian muskmelon (*Cucumis melo* L. Reticulatus group cv. Semsory) harvested at mature green and or at first stages of yellow color development on fruit skin were stored at 2.5°C and or 5.5°C with 85-90% RH for 33 days followed by one day at 20°C. Then quality evaluations were conducted. Factors, storage temperature and fruit maturity at harvest, significantly affected fruit attributes. Fruit harvested at first stages of yellow color development stored at 2.5°C had high taste and flavor, high pH number and marketability value in comparison to other fruit at the end of storage period, and their sugar content was much higher than others. Fruit harvested at mature green stage and kept at 2.5°C were firmer, but they had not good flavor and marketability value because they had low sugar content and yellow color. No damage to fruit was observed at 2.5°C.

Skin yellow color development and flesh taste & flavor improvement that in fruit harvested at first stages of yellow color development, was the reason for high marketability for these fruits, whereas since mature green fruits had not good flavor and yellow color and had low pH then were not marketable.

S1-15

RESPONSES OF TWO PLUM (*Prunus salicina*, Lindl) CULTIVARS TO POSTHARVEST ETHYLENE TREATMENT.

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Climacteric and non-climacteric fruits differ in their responses to postharvest treatment with ethylene, or with other gases of equivalent activity. In climacteric fruits, these treatments accelerate the ripening process, the respiration rate and the auto-catalytic ethylene production. Non-climacteric fruits do not present these effects. On the basis of this, the objective of this work was to study the responses of two plums (*Prunus salicina*, Lindl) cultivars (Golden Japan and Santa Rosa) to ethylene treatments, and to evaluate their postharvest quality. Fruit were harvested at different stages during consecutive two weeks. Ethylene gas was applied at 1.0 and 10.0 ppm for 24 hours in closed containers. Measurements were made on ethylene production, skin color, texture, acids and total soluble solids content. The results indicated that 'Santa Rosa' plums behaved as a climacteric fruit, where ethylene treatments stimulated the production of auto-catalytic ethylene, and the changes in colour and texture, and the effects were less notorious at the advanced stages of fruit ripening. 'Golden Japan' plums behaved as a non-climacteric fruit, where ethylene treatments caused no stimulation in the production of auto-catalytic ethylene nor other indices related to fruit ripening, and only accelerated changes in fruit colour.

S1-16

INTERACTION OF ETHYLENE AND ALTERNATIVE RESPIRATION IN CLIMACTERIC AND NON-CLIMACTERIC FRUITS.

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Ethylene is considered to be the agent that triggers climacteric activity and fruit ripening. Ethylene stimulates respiration by stunting the flow of electrons in respiratory electron transfer chain from the conventional cytochrome to an alternate cyanide resistant oxidase. Even though the evidence seems compelling that respiratory stimulation by ethylene calls for the generation of cyanide-resistant electron transport, the degree of participation of latter in ethylene-stimulated respiration is an open question. The alternative pathway of respiration in higher plant mitochondria was first a thermogenic curiosity observed during anthesis and recognized as part of plants ability to regulate its energy/carbon balance responses to a changing environment. In spite of its wide occurrence, role in fruit ripening and senescence was not studied in detail. Hence, the present studies were taken up to study the interaction of Ethylene and alternative respiration in climacteric and Non-climacteric fruits.

To study the interaction of ethylene with alternative respiration during ripening and senescence of climacteric fruits and non-climacteric fruits experiments were conducted at ambient and low temperatures. Banana, a typical climacteric fruit, and grape, a non-climacteric fruit was selected for experimentation. Alternative oxidase inhibitors (Propylgallate) and polyamine (Spermine) were the treatments. At regular intervals ethylene levels and alternative respiration were monitored. Propyl gallate and spermine improved shelf life by delayed respiratory climacteric (in banana), reduced alternative respiration, and reduced ethylene.

The results suggest there is an interaction of ethylene and alternative respiration during ripening and senescence of climacteric fruits and senescence of non-climacteric fruits.

S1-17

DIFFERENT TRANSCRIPTION FACTORS ARE EXPRESSED DURING GROWTH AND RIPENING OF FRUITS.

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A peach EST collection representative of pre-climacteric RNA was prepared in our laboratory. A number of cDNAs coding for different transcription factors could be singled out by a computational analysis of the collection.

The expression profile of the transcription factors encoding genes has been analyzed in fruits at different stages of development in order to ascertain their possible involvement in the ripening process. Expression analyses have also been made with hormone treated fruits.

Transcription factor encoding cDNAs orthologous to those obtained from the peach library have also been isolated from a strawberry cDNA library, and their possible role in the ripening process has been analyzed both in fruits at different stages of development and in hormone treated fruits.

Comparisons will be presented between results obtained by studying both a climacteric (peach) and a non-climacteric (strawberry) fruit belonging to the same Rosaceae family.

S1-18

CHANGES OF CELL WALL HYDROLASES IN RELATION TO FINGER DROP IN 'HOM THONG' AND 'NAM WA' BANANAS.

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'Hom Thong' (Musa AAA group) and 'Nam Wa' (Musa ABB group) bananas were treated with ethephon and ripened at 25°C (~85% RH). Finger drop of 'Hom Thong' banana rapidly reached 100%, whereas 'Nam Wa' banana did not show finger drop 7 days after treatment. The rupture force and fruit firmness of both bananas decreased while ripening advanced and finger drop increased. 'Nam Wa' banana had greater rupture force and fruit firmness than 'Hom Thong' banana. Polygalacturonase (PG) activity in the pedicel adjacent to rupture area was higher than that in the peel of both 'Hom Thong' and 'Nam Wa' bananas. PG activity in the pedicel adjacent to the rupture area of 'Hom Thong' banana was higher than that of 'Nam Wa' banana. In contrast, pectinesterase (PE) activity in the pedicel adjacent to the rupture area of 'Nam Wa' banana was higher than that of 'Hom Thong' banana. It is concluded that PG activity may be involved in finger drop of ripening bananas.

S1-19

RETAIN™ MAINTAINS 'PINK LADY' FRUIT QUALITY DURING LONG TERM STORAGE.

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'Pink Lady' apples were harvested from two growing regions (South Australia and Victoria) and at two harvest maturities (early and late). Fruit were treated with aminoethoxyvinylglycine (AVG, ReTain™) at two different times in the orchard (7 and 21 days before harvest). Fruit were harvested according to maturity and stored at 0°C in controlled atmosphere storage (2% O₂ and 1% CO₂) or regular air storage. Fruit quality (internal ethylene concentration, firmness, background colour, starch, soluble solids content etc) were assessed at two monthly periods for up to 10 months storage. Fruit were subject to a two week shelf life at 20°C after six months storage, where aroma production was also measured using SPME/GC. All air stored fruit were removed at six months storage. The ReTain™ treatment significantly reduced ethylene production across all treatment and storage regimes, compared to the untreated control. Ethylene production was also lower in the ReTain™ treatments during the 14 days shelf life at 20°C after six months storage. Flesh firmness (measured by penetrometer) was generally higher in the fruit stored in CA and in the ReTain™ treated fruit. This effect was maintained during the entire storage period. The interactions between harvest maturity, growing region and timing of the ReTain™ treatments will be discussed in more detail in the full paper.

S1-21

VARIABILITY OF APRICOT STORAGE POTENTIAL IN RELATION TO POSTHARVEST ETHYLENE PRODUCTION.

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Apricot specie is characterized by a large variability in fruit quality and specially in ripening duration. Some apricots ripe in less than 8 days and some others in 3 weeks. In relation with this trait, the ethylene production varies a lot among ripe apricot fruits, from 5 to 6000 µL h⁻¹ kg⁻¹. After harvesting, the fruits put in air at 23°C ripe faster than the fruits let on trees. Firmness decrease is always higher but colour change is quite similar, dependent of varieties and harvesting stages.

For ethylene production, great differences are observed. For most of studied varieties, postharvest ethylene production is multiplied by 10 to 100. This fact would be in relation with the storage potential of apricots. Indeed, apricots like Bergeron which can be stored for 3 weeks is one of the varieties producing low ethylene level after harvesting. Pre-treatment with 1-MCP before low temperature storage gives interesting results on Bergeron and it could be extended to these low potential varieties.

S1-20

THE RELATIONSHIP BETWEEN SUGAR ACCUMULATION AND DEVELOPMENT OF WATERCORE IN APPLE FRUIT.

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It has been reported that the accumulation of sorbitol might be related to the development of watercore in apple fruit. To confirm it, we measured the sugar concentration of apoplastic and symplastic solution of mesocarp tissues during ripening of apples. Fruit of 3 cultivars, 'Yoko', 'Orin' and 'Fuji', were used in this study. Fruit were harvested in 2002 in a commercial orchard near Yamagata (Japan) at 10-day intervals over a 1-month period during ripening. Mesocarp tissues were sampled and centrifuged (1000 g for 20 min). This effluent was regarded as apoplastic solution. After collecting apoplastic solution, tissues were frozen with liquid nitrogen, allowed to thaw at room temperature and centrifuged (1000 g for 20 min) again. This effluent was regarded as symplastic solution. Sugar composition of both solutions was analyzed using HPLC.

Watercore occurred during ripening in 'Fuji' 30 days before the optimum harvest time, and developed during ripening. It was not observed in 'Yoko' and 'Orin' throughout experimental period. Concentrations of glucose and fructose in both apoplastic and symplastic solutions did not change significantly during ripening in all cultivars. Concentration of sucrose in both solutions increased in 'Yoko', 'Orin' and 'Fuji' did not show a significant change in sucrose concentration throughout ripening. Sorbitol concentration increased during ripening in both solutions of all cultivars. This increase was remarkable particularly in apoplastic solution of 'Fuji' where the concentration at optimum harvest time was 4 to 5 times higher than those of 'Yoko' and 'Orin'. In addition, sorbitol concentration in apoplastic solution was significantly higher than that of symplastic solution in 'Fuji' throughout experimental period. These results indicate that sorbitol might be related to the development of watercore in apple fruit.

S1-22

EFFECT OF HARVEST DATE AND STORAGE ON ANTIOXIDANT SYSTEMS IN PEARS.

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In many fruits the ripening process is characterised by an increase in oxygen consumption related to the climatic rise. The enhanced oxidative metabolism could generate an excess in active oxygen species (AOS) that, if not effectively detoxified by the cell defence systems, leads to a peroxidation of biomembranes, to a damage of cell compartmentation and, ultimately, to tissue senescence and general disorders. Studies on some components of the system of enzymatic and non enzymatic antioxidants involved in the protection of cells from oxidative damage, are reported.

Pears (*Pyrus communis* cv. Passa Crassana) were picked at 3 different stages of ripening: immature, commercial ripe and fully ripe. Commercially ripe fruits were stored for 3 and 4 months at normal atmosphere (T: 1.5°C; R.H.: 95%). Ethylene production rates were measured and the activity of the scavenging enzymes as superoxide dismutase (SOD), ascorbate peroxidase (AP) and glutathione reductase (GR) were evaluated. The levels of the antioxidant ascorbic acid (AA) and of malondialdehyde (MDA), a marker of lipid peroxidation, were also determined.

Ethylene levels were barely detectable at all 3 harvest dates and increase progressively during storage. The ripening stage did not affect SOD activity, whereas first APX and then GR activities increased during the harvesting period. The activities of SOD and APX decreased significantly during storage and that of GR was enhanced. AA reached the highest level in commercial ripe fruit. Furthermore, storage had a negative effect on AA content and caused a gradual, marked decrease. MDA did not change in fruits of different ripening stages, while in pears after storage the levels were significantly higher.

These results suggest that principally during storage defence mechanisms against AOS fail to provide adequate protection and oxidative stresses occur.

RELATIONSHIPS BETWEEN ETHYLENE AND CARBOHYDRATE METABOLISM IN PEACH FRUIT.

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It is generally accepted that sucrose is the major carbohydrate used in assimilate partitioning, its utilization in terminal sinks being dependent on cleavage into fructose and glucose. In plants this reaction is catalyzed by two enzymes with different properties: invertase and sucrose synthase. The relative importance of each may vary between species, in relation to tissue and organ development, and plays an important role in determining sink strength. During the final phases of growth, peach fruit accumulates high level of sucrose, and this is accompanied by changes in the expression pattern of genes encoding proteins involved in sucrose metabolism and transport. It has been pointed out that cross-talk between sugars and hormones signal transduction pathways may be involved in the coordination of metabolic activity in the fruit, and, therefore, in assimilate partitioning and allocation in sink tissue. In order to verify this possibility, peach fruits were treated during the final phases of growth with substances able to interfere with ethylene metabolism and action. Particularly, an inhibitor of ethylene biosynthesis (AVG) and an ethylene releasing molecule (CEPA) were adopted to impair the hormone's action, and to verify the possible consequences on enzymes of sugar metabolism and fruit quality. In fact, despite the huge amount of research on the relationships between ripening and ethylene, little is known about the possible regulation exerted by the hormone on assimilate accumulation. Data allowed the hypothesis of a role played by ethylene, at least during the last phases of fruit growth, in the regulation of the expression of genes related to sugar metabolism. The regulatory mechanisms seem to be related to a shift in the ripening process.

STUDY ON EXPRESSION OF GENES INVOLVED IN ETHYLENE BIOSYNTHESIS AND FRUIT SOFTENING IN APPLE AND NECTARINE.

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Fruit texture and long storage life are relevant features defining eating-quality apple. Fruit firmness as combined crispness, hardness and slow softening traits, is strictly related to the ripening physiological process, especially to the cell wall disassembly of fruit flesh. It has been widely demonstrated a relationship between cell wall disassembly enzymes and ethylene production in climacteric fruit.

In order to study this physiological correlation in apple, a comparison through a semi quantitative RT-PCR technique has been carried out on apple differing in firmness and ethylene production. Allele-specific primers were designed on apple homologues ripening specific sequences for ACO and ACS gene members involved in ethylene biosynthesis, and for isoforms of expansin and polygalacturonase playing a key role on fruit softening.

It has been observed a different expression of ACO and ACS genes according to the ethylene production in those samples; expansin and polygalacturonase level agree with the general model of softening in two times: an early stage (expansin-dependent) and a late stage (polygalacturonase-dependent), proposed by Bennet (2002) and Rose et al. (1997) for climacteric fruit. The same primers, used for analysis on apple samples tested were effective also on nectarine, sharing a genetic similarity among the two species.

EFFECT OF ETHYLENE TREATMENT ON FRUIT FIRMNESS AND POLYGALACTURONASE ACTIVITY IN STONY HARD PEACH.

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The texture of peach fruit is the basis for the melting-flesh (MF) and no melting-flesh (NMF) classifications. MF fruit is the common table peach that loses firmness rapidly during ripening, while NMF lacks the rapid loss of firmness during the late ripening stages and is commonly used for processing. The rapid loss of firmness in MF fruit has been shown to be related to the activity of endopolygalacturonase (endoPG). Levels of endoPG activity are greatly reduced in NMF peaches compared to MF fruit, while the levels of exopolygalacturonase (exoPG) activity were similar for the two fruit types. Stony hard-flesh is another important flesh texture trait that is characterized by low ethylene production in the fruit without the loss of firmness during ripening. However, ethylene treatment causes stony hard-fruit to lose firmness and soften to a melting-like texture.

In this study, we analyzed the enzymatic activity of endoPG and exoPG in stony hard peach cv. 'Manami' with and without ethylene treatment to confirm the role of PGs in peach fruit softening. The 'Manami' fruit without ethylene treatment remained firm during a 5-day treatment period, while the treated 'Manami' fruit began to lose firmness after 24 h of ethylene treatment and then rapidly softened in 2 or 3 days. The endoPG and exoPG activity began to increase in ethylene treated 'Manami' fruit after 24 h of treatment and the increase was closely related with the rapid loss of fruit firmness. In 'Manami' fruit without ethylene treatment, the activity levels of both endoPG and exoPG were low and remained unchanged during ripening. These results indicated that both endo- and exo-PGs were induced by ethylene treatment in 'Manami' fruit. This increase in the activity of PGs may be related to peach fruit softening.

THE EFFECT OF JASMONATES ON THE EXPRESSION OF RIPENING RELATED GENES IN TOMATO FRUIT DISKS.

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Jasmonates are lipid-derived compounds regarded as "non traditional" plant hormones which exert numerous effects on plant growth and development. In recent years, it is well known that jasmonates are important as a mediator of wound- and stress-induced signal transduction and induce expression of a variety of genes involved in defensive response. And it also has been revealed that jasmonates plays an important role in fruits ripening. In some fruits, It is reported that the endogenous concentration of jasmonates increases during the onset of fruits ripening, and that the application of exogenous concentration of jasmonates stimulates ethylene production and colour change.

To determine if jasmonates affect the expression of the genes involved in ripening, such as ethylene biosynthesis, we examined the change of the mRNA levels encoding these genes. Treatment of breaker stage tomato pericarp disks with methyl jasmonate promoted the accumulation of mRNA for 1-aminocyclopropane-1-carboxylic acid (ACC) oxidase, but ACC synthase 4. And the results of macro-array analysis will be showed.

S1-27

FLESH SOFTENING AND PHOSPHORYLATION OF SOLUBLE POLYPEPTIDES IN RELATION TO ETHYLENE PRODUCTION IN PEACH FRUITS WITH DIFFERENT RIPENING PATTERNS.

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In peaches, it is desirable to individuate simple biochemical/physiological parameters, genetically determined and thus useful for Marker-Assisted Selection to obtain improved genotypes for what concerns flesh firmness (Melting/Non-Melting). The expression of enzymes involved in cell wall loosening/degradation, such as expansins (Exp) and endo-polygalacturonases (endo-PGs) has been studied in peach fruits of a few M, NM, Slow-Ripening genotypes available in Italy.

In M fruits, the expression in the flesh cell walls of an endo-PG-like polypeptide was relevant and increased with ripening. The polypeptide was expressed at very low extent in NM fruits. A similar pattern was observed for expansins (assessed with anti-LeExp1 antibodies kindly supplied by dr. J.K.C. Rose). NM fruits produced more ethylene than the M ones. The Ca²⁺-dependent phosphorylation pattern of a soluble polypeptide (Mr 52 kDa) from the fruit flesh showed differences related to ripening stage and phenotype. It decreased with ripening in NM fruits whereas it remained constant in the M ones. In slow ripening genotypes, with mutated ripening pattern, the phosphorylation of the 52 kDa soluble polypeptide was detectable only in those fruits which, though not achieving the normal size, produced ethylene, expressed the endo-PG-like polypeptide and softened their flesh.

These data suggest that the degree of phosphorylation of the 52 kDa soluble polypeptide may be involved in the modulation of ethylene signal and may possibly be linked to a higher sensitivity to ethylene in M fruits.

S1-29

EXPRESSION ANALYSIS OF RIPENING-RELATED GENES IN STRAWBERRY FRUITS WITH ALTERED AUXIN METABOLISM.

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Strawberry is a false fruits with a non-climacteric ripening habit and it is well known that auxin does control some aspects of fruit ripening. By altering the endogenous content of auxin in the ovules, the DeH9-iaaM gene triggers the formation of parthenocarpic fruits in Solanacea. Furthermore, DeH9-iaaM strawberry and raspberry plants grown under standard cultivation conditions show a drastic increase in fruit productivity. In all three Rosaceae species tested, *Fragaria vesca*, *Fragaria x ananassa* and *Rubus idaeus*, the weight and size of DeH9-iaaM transgenic fruits was increased. Moreover, DeH9-iaaM plants have an increased number of flowers/fruits per inflorescence and an increased number of inflorescences per plant.

We have started to investigate if the increase in auxin contents, already observed in young developing fruits of DeH9iaaM clones of *F. vesca* (cv. Alpina) and *F. x ananassa* (a breeding selection AN93.231.53), can in some way alter the ripening syndrome. Since the softening is a very important quality trait of the strawberry fruits, we have studied possible effect of the transgene on this process by analyzing the expression of genes encoding cell wall degrading enzymes.

Northern analyses were carried out on total RNA extracted from fruits at different stages of development and ripening. Of the different genes tested, FaEG1 shows an earlier expression in fruits of the DeH9iaaM clone of *F. x ananassa*, compared to the control ones. This difference was not detected between the Control and GM clones of *F. vesca*, probably because of the shorter period of fruit growth and size in comparison with *F. x ananassa*.

Since it was previously observed that the FaEG1 gene is negatively regulated by auxin, a discussion will be presented on the possible causes of such an anticipation of the softening in the transgenic strawberries.

S1-28

INHIBITION OF ETHYLENE BIOSYNTHESIS IN PEAR FRUIT BY CARBON DIOXIDE: THE MODE OF ACTION.

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High CO₂ can inhibit ethylene production of pear (*Pyrus communis* L.). The mode of CO₂ action is still unknown. In several experiments it was shown that CO₂ inhibits ethylene production other than through inhibition of ethylene perception. In these experiments, 1-MCP was used to block the ethylene receptor binding site. (1) in climacteric pears, the reduction of ethylene production by CO₂ was similar for 1-MCP treated and untreated pears; (2) in the case of pears that had been stored for a period of 25 weeks, CO₂ only had a clear effect after 1-MCP treatment, and (3) ethylene production of pre-climacteric pears was stimulated by 1-MCP, but unaffected or inhibited by CO₂.

The effect of CO₂ on ethylene production of pear depended on the applied CO₂ level and the duration of exposure. Elevated CO₂ initially stimulated ethylene production, which may reflect a fast direct effect on ACC oxidase. Later, CO₂ inhibited ethylene production which points to a relatively slow indirect effect of CO₂ regarding inhibiting properties, for instance, an effect on gene regulation.

Differences in ethylene production in response to various CO₂ partial pressures were not accompanied by differences in respiration.

In conclusion, the ethylene receptor binding site is not the primary site at which CO₂ inhibits ethylene production. Inhibition of ethylene production by CO₂ cannot be explained via an effect of CO₂ on respiration. The most likely action site of CO₂ is the conversion of SAM to ACC catalysed by ACC synthase.

S1-30

RESPONSE OF PAWPAW FRUIT TO COLD STORAGE TEMPERATURE AND DURATION.

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Pawpaw [*Asimina triloba* (L.) Dunal] is a highly perishable climacteric fruit, softening rapidly once ripening commences which may limit its marketability. Preliminary cold storage studies indicated it may be stored for 1 month at 4°C and ripen normally upon removal to ambient temperature.

The objective of these studies is to determine the optimum cold storage temperature and maximum storage life of the fruit. Fruit were stored at -2, 2, and 6°C for 1, 2, 4, 8 and 12 weeks, and were then ripened upon removal to ambient temperature. Through 4 weeks, fruit exhibited adequate firmness upon removal from cold storage, but at 8 and 12 weeks fruit held at 2 and 6°C were very soft. Irrespective of storage temperature, at 8 weeks fruit showed a delay in a climacteric-like respiratory increase, and by 12 weeks a respiratory climacteric was not apparent. An ethylene climacteric was evident by fruit from all temperature and storage periods except those held at 6°C for 12 weeks.

The results suggest that common cold storage at -2 to 2°C will maintain pawpaw fruit quality and ripening potential for 4 weeks, but that such storage for longer periods is questionable.

S1-31

SYMPTOMS OF COLD STORAGE INJURY OF PAWPAW FRUIT.

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Postharvest strategies for maintaining pawpaw [*Asimina triloba* (L.) Dunal] fruit quality are currently being studied. While storage at 2°C for 4 weeks seems possible, significant symptoms of injury were found following postharvest storage for longer periods. The symptoms developed after the fruit had been moved to ambient temperature for ripening after 8 weeks of 2°C storage. While fruit stored for 4 weeks subsequently ripened normally, those held 8 weeks exhibited a delayed respiratory climacteric. Although not obvious from the surface appearance, fruit held 8 weeks exhibited flesh browning within 48 h of moving to ambient temperature.

A change in fruit aroma volatile profile suggests injury might have been developing by 4 weeks of cold storage even though other symptoms were not evident. Immediately after harvest, methyl octanoate was the dominant volatile ester followed by methyl hexanoate. By 4 weeks of postharvest cold storage, ethyl hexanoate was the dominant ester followed by ethyl octanoate, but methyl octanoate production was still substantial. At 8 weeks, volatile ester production was generally lower with ethyl hexanoate the major volatile followed by ethyl octanoate. If these symptoms are due to cold storage temperature and/or duration, postharvest storage strategies need to be developed that minimize or eliminate the problem.

S1-32

USE OF AVG AND HEAT TREATMENT TO SUSTAIN 'LODI' APPLE FRUIT QUALITY IN COLD STORAGE.

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Summer apples tend to maintain quality poorly in cold storage in contrast to cultivars that are harvested later in the season. To determine if summer apple storage life can be extended, the effects of aminoethoxyvinylglycine (AVG) and heat treatment, alone or combined, on ripening traits and postharvest storability of the summer cultivar 'Lodi' are being studied.

An aqueous solution of AVG was applied to 'Lodi' apple trees 4 weeks before harvest at 124 g ha⁻¹ a.i. Control and AVG-treated fruit were heated at 38°C for 4 days. Fruit were ripened at ambient temperature immediately or after storage at 4°C for 30 days. During ripening at ambient temperature, respiration rate increased immediately after harvest with a peak at 4 and 9 days after harvest for control and AVG fruit, respectively. Respiration was always higher in control than AVG-treated apples, but the difference was greater after harvest than after retrieval from cold storage. AVG reduced ethylene production, even after cold storage for 30 days. AVG-treated apples were firmer immediately after harvest, but the effect was not apparent after cold storage. Post-storage respiration rate of control and AVG-treated fruit was negatively affected by heat treatment. In contrast, ethylene production was equal or greater by heated compared to non-heated apples. After cold storage, fruit firmness was lower than pre-storage values in all treatments, although AVG-treated and heated apples were the most firm. During cold storage, 'Lodi' apples developed cracks and/or bruises, with control fruit suffering the most (73%) damage and fruit receiving AVG plus heat the least (15%) damage.

In general, the combination of AVG and heating improved the storability of 'Lodi' apples by reducing cracking and bruising incidence and loss of firmness.

S1-33

PHYSICO-CHEMICAL MODIFICATION OF NETTED MUSKMELON DURING LOW TEMPERATURE STORAGE.

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Lipoxygenase activity and membrane lipid composition were assayed on netted muskmelon (cv. Earl's Favourite). These were known related to chilling induced softening and cell membrane integrity. Fruits were stored at 2 and 15°C for 4, 8, 12, and 16 days, then transferred to 20°C for 2 days. Lipoxygenase activity was increased in hypodermal tissue, but absent in inner-mesocarp tissue. Whereas fruit softening was mainly progressed in inner-mesocarp tissue. Electrolyte leakage was increased not in hypodermal tissue but inner mesocarp tissue. There was no relationship between lipoxygenase activity and cell membrane integrity in melon fruit. The major fatty acids of cell membrane were linolenic acid and linoleic acid. The ratio of unsaturated to saturated fatty acid also obtained during storage. After rewarning, ethylene and acetaldehyde production were sharply increased as decomposition products of fatty acid hydroperoxide. However, visible external symptoms of chilling injury were not observed.

S1-34

RELATION BETWEEN HORMONAL BALANCE AND POLYGALACTURONASE ACTIVITY IN GRAPE BERRY.

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Grape berry (*Vitis vinifera* L.) is considered as a non climacteric fruit. It exhibits a double sigmoid pattern of growth. The first phase correspond to cellular multiplication and growth. Ripening occurs concomitantly with the second growth phase and involves significant changes. Sugar accumulation and colour change are well known. Softening involves variations in properties of cell wall polymers but the implicated mechanisms are still unclear.

The free acid abscissic (ABA) content of whole berry and separated pericarp increases during veraison and the ABA accumulation is concomitant with a peak in the acid indole acetic level. Our results indicate that the pulp loses its ABA during ripening. At contrary, ABA increases in the skin. Calcium ions evolve in the same way. In the opposite the skin tissue water decreases. ABA may involved protein synthesis such as cell wall-modifying enzymes. Polygalacturonase (PG) activity is detected during the change of colour and is seemed to be correlated with ABA levels in the berry. We observe two kinds of evolutions : in several cultivars, the berries show an increase of PG activity during veraison whereas this activity appears earlier, at the beginning of veraison for other Bordeaux cultivars. This results are also well correlated with free acid galacturonic levels in berry must.

S1-35

POSTHARVEST CHANGES OF MANGOSTEEN FRUITS AFFECTED BY DIPPING IN PARAFFINIC OIL.

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Wilting and lose of green colour of stalk and sepals in mangosteen fruit (*Garcinia mangostana* L.) after harvest are an aspect to determine shelf life for export market.

To extend mangosteen shelf life, whole fruits were dipped in paraffinic oil or only stalk and sepals of fruits were sprayed. After treatments fruits were kept in a cold room at 18°C. and 80% relative humidity. Delay of wilting and colour changes of stalk and sepals was observed as the concentration of dipping increase. On the other hand that delay was not occurred when stalk and sepals were sprayed. After storage for 17 days, weight loss and soluble solids of fruits which were dipped in 0, 1, 2, 4 or 8 % of paraffinic oil were 8.0, 6.8, 6.9, 5.3 or 5.4 % and 18.2, 17.3, 16.0, 15.0 or 14.0 %, respectively. While weight loss and soluble solids of fruits which stalk and sepals were sprayed by 0, 1, 2, 4 or 8 % of paraffinic oil were 8.2, 7.0, 8.0, 6.9 or 6.9 % and 15.3, 16.4, 17.0, 16.1 or 17.0 %, respectively. Changes of peel colour from the stage at colour break to violet and tritrate acids in fruit juice were not affected by dip or spray treatments.

Appearance and eating quality of pulp in every treatment were marketable accepted after 17 days of storage. Shelf life of the control was 12 days and was not different from those of spray treatments while the shelf life of dip treatment at 8 % of paraffinic oil was 16 days. The results showed that dipping with paraffinic oil could delay the ripening of mangosteen fruits and ripening had a major effect on the senescence of stalk and sepals.

S1-37

ETHYLENE BIOSYNTHESIS OF QUINCE DURING STORAGE.

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In order to determine changes in some physiological and quality parameters, quince fruits of Cukurgobek and Esme cultivars, were harvested just after climacteric minimum in respiration rate occurred and transferred to the storage rooms having 2±1°C temperature and 85-90% relative humidity during two years. After each month, fruits were transferred to the ripening rooms having 20°C temperature and 85-90% relative humidity conditions.

Internal ethylene concentration and external ethylene production, 1-aminocyclopropane-1-carboxylic acid (ACC) oxidase activity, respiration rate, sugar (sucrose, glucose and fructose) and organic acid (citric and malic acid) contents, weight loss, fruit taste, flesh browning were analysed with monthly periods for cold storage and with weekly periods for ripening conditions. For the first year, internal ethylene concentration, external ethylene production and ACC-oxidase activity of Cukurgobek and Esme fruits changed between 0.9-4.7 $\mu\text{L L}^{-1}$, 0.0-5.2 $\mu\text{L L}^{-1}$, 0.010-0.030 $\text{nmol kg}^{-1} \text{s}^{-1}$, 0.001-0.034 $\text{nmol kg}^{-1} \text{s}^{-1}$, 0.5-1.5 $\mu\text{L L}^{-1}$, 0.3-1.0 $\mu\text{L L}^{-1}$, respectively. These values were recorded as 0.1-0.4 $\mu\text{L L}^{-1}$, 0.5-2.3 $\mu\text{L L}^{-1}$, 0.001-0.017 $\text{nmol kg}^{-1} \text{s}^{-1}$, 0.006-0.030 $\text{nmol kg}^{-1} \text{s}^{-1}$, 0.4-2.4 $\mu\text{L L}^{-1}$, 0.3-2.3 $\mu\text{L L}^{-1}$, in the second year respectively. Otherwise a sharp increase in these parameters could not be observed during storage trials. These parameters showed fluctuations during ripening periods. Although flesh firmness and fruit colour hue values were tended to moderately decrease in both cultivar and year, sugar and organic acid content of fruit juices showed unstable changes. Fructose and malic acid were determined as dominant sugar and organic acid for both cultivars.

S1-36

EFFECTS OF DIFFERENT CALCIUM LEVELS IN THE FRUITS ON THE POSTHARVEST PHYSIOLOGY OF 'Prunus domestica' L.

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Plum fruits (*Prunus domestica* L.) were grown in a calcareous soil (more fertile) and in a xiste soil (less fertile) with two different type of rootstocks, a more vigorous and a less vigorous one. It is studied the influence of different rootstocks in the calcium concentration of plum fruits. More vigorous rootstocks produced fruits with lower calcium content than less vigorous rootstocks. This effect is more evident in more fertile soils. It was studied the postharvest behaviour of fruits with higher and lower calcium content. Changes in texture and chemical composition of pulp fruits (% acidity, sugars, organic acid and production of ethylene) during cold storage (0-2°C) were investigated. Ethylene production rate was studied in the fruits after cold storage (10, 17, 24, 31, 38 days).

Fruits with a higher calcium content showed a higher firmness as compared with fruits with a lower calcium content. After cold storage fruits exhibited a lower ethylene production rate which decreases for longer storage periods. After 38 days of cold storage the ethylene production rate decreased about 1/3.

S1-38

INFLUENCE OF TEMPERATURE AND LIGHT IN FRUIT COLOR DEVELOPING OF A. macrosperma.

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Actinidia macrosperma is a species characterized by a bright orange colour of the flesh of ripe fruits. The colour can change on the vine or during the post-harvest period. The colour change is due to chlorophyll degradation and new synthesis of carotenoids. Different storage conditions, as temperature and light can influence the colour of the flesh of the fruits of this species.

To demonstrate this hypothesis, green fruits were collected and stored at low temperature and different light regimes (continuous light or dark), while other fruits were stored at room temperature under the same light. The fruits maintained at room temperature turned orange quickly, independent of light exposure. Fruits maintained at low temperature colored slowly, and their colour never became bright orange (hue angle 65.8), but it changed to white/pale green (hue angle 105.2) instead. On the other hand, fruit maintained at room temperature quickly turned to bright orange. In conclusion, during post-harvest the fruit colour seems to be more influenced by temperature than light. From these results it is possible to hypothesize that carotenoid biosynthesis is directly influenced by storage temperature. In fact, while temperature always affects chlorophyll degradation at different rates, related to the temperature values reached, carotenoid biosynthesis is completely blocked at the temperature normally used in cool storage conditions.

S1-39

THE EFFECT OF CALCIUM TREATMENTS ON ASPECTS OF CELL WALL METABOLISM IN APPLE CV 'BRAEBURN'.

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'Braeburn' apple is appreciated because its 'crispy' texture and acid taste but it is very susceptible to several storage disorders- mealiness included-, because its low calcium content. Many attempts are in progress to improve cation flesh concentration and thus its keeping quality. Aim of the present work is to study the capability of field and postharvest treatments in keeping fruit quality during cold storage.

'Braeburn' apples field or postharvest treated with diverse Calcium formulae and additives, were examined for quality (total soluble solids; titratable acidity; flesh firmness; starch content), calcium contents and cell wall biochemical (cellulose; total, soluble and insoluble pectins; neutral sugars) traits at harvest and after 7 months of controlled atmosphere cold storage (ULO). Field and postharvest calcium treatments did not affect quality traits both at harvest and after storage, nevertheless they influenced calcium contents in fruit flesh and they modified cell wall.

All field treatments increased fruit calcium content up to 10-60% according to the type and timing and the effect lasted till the end of storage; postharvest treatments increased cation level (8-60%) at the end of storage. Cellulose contents increased for both treatments and the effect lasted during storage. Field supplies seemed to stimulate pectin biosynthesis also after harvest for long time, while postharvest treatments did not increase pectin biosynthesis but were very effective in preventing pectin solubilization. Cell wall rhamnose was reduced by field treatments, thus reducing the side chain number of polygalacturonic acid to which ascribe the flesh crispness of this apple cultivar. Galactose, a basic component of pectin chains, is positively affected by field supplies and its high level is maintained along the storage period. Postharvest calcium treatments did not increase galactose content, but were very active in saving its level. This results confirmed the influence of calcium on cell wall metabolism.

S1-40

RIPENING AND SENESCENCE OF THE NON-CLIMACTERIC SOUR CHERRY (*Prunus cerasus* L.)Perlaki R.¹*, Kovács E.², Szöllösi D.², Kállay T.³¹Budapest University of Technology and Economics, Budapest, Hungary;²Central Food research Institute; Budapest, Hungary; ³Research Institute for Fruitgrowing and Ornamentals Budapest; Hungary.

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Maturity at harvest is the most important factor that determines storage life and final fruit quality. All fruits, with a few exceptions reach their best eating quality when allowed to ripen on the tree or plants. Sour cherry is an important non-climacteric fruits. The aim was to investigate the increase of fruit size, coloration and correlation with the activity of polygalacturonase. Sour cherries were investigated as a function of ripeness (I-VI. stages – green, breaker/pit hardening, pink, light red, red and dark red) (1st experiment). A part of fruits were stored at 4°C, 90% RH for 35- 40 days (2nd experiment). All samples were tested for fruit size (d1; d2; m), pH, °Brix and color (L*, a*, b*). 1st experiment: the stages of ripeness were characterized by the color of fruits (CIELAB L*, a*, b*). The size of fruits increased with ripening continuously, while in next year the size of fruits increased mostly between ripeness stages IV-VI. It seemed that the growing seasons have influenced not only of the size of fruits but the rhythm of increase, too. The cultivar has also an effect of fruit size. In case of Pándy 279 only slightly increase was observed as a function of ripeness, these fruits reached the full size relatively in an early ripeness stage. The values of °Brix and pH changed as a function of ripeness in both cultivars. The activity of PG was low and a slightly changed during ripeness. It is seemed that it has not remarkable role of PG during ripening. 2nd experiment: during storage around 10-11% weight losses were found in both cultivars. After harvest, during the first 10 days the PG activity of sour cherries decreased, than increased as a function with the storage time.

S1-41

GENE EXPRESSION OF ASCORBIC ACID-RELATED ENZYMES DURING TOMATO FRUIT DEVELOPMENT AND RIPENING.

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Tomato fruit ripening has been described as an oxidative process during which production of reactive oxygen species (ROS) is balanced by their removal by antioxidant systems. Ascorbic acid (AA) in the apoplast is proposed to be involved in these oxidative processes and a change in AA redox to a more reduced state is observed as ripening progresses.

To further elucidate the role of AA in ripening, the expression profiles of GDP-mannose 3"5" epimerase and L-galactono-1,4-lactone dehydrogenase (GalLDH), enzymes that participate in ascorbate biosynthesis, and ascorbate oxidase (AO) and ascorbate peroxidase (APX), have been investigated in vegetative tissues and during tomato (*Lycopersicon esculentum* Mill. Cv. Ailsa Craig) fruit development and ripening. GalLDH transcript was present in all green and floral tissues but it was not detected in seeds and roots. In fruit, GalLDH transcript accumulated early on and at the later stages of ripening. Furthermore, expression of GalLDH was induced 3 hours after exposure of mature green fruit to ethylene with levels dropping thereafter until 48 hours post-treatment. GDP-mannose 3"5" epimerase was highly expressed in all green tissues with lower levels detected in flowers, whereas transcript was present in all fruit developmental and ripening stages. AO transcript was detected only in stems, petioles, apices and flowers. Thylacoid-bound APX mRNA was accumulated in all vegetative and fruit tissues. During ripening, APX transcript abundance increased progressively to a peak at the pink stage and slightly decreased thereafter.

Our results indicate that genes participating in ascorbic acid metabolism are differentially expressed during tomato fruit development and ripening suggesting a dynamic role of AA in this process.

S1-42

POSTHARVEST BEHAVIOUR OF *Solanum muricatum* AIT. FRUITS.Galletti L.¹*, Lizana L.A.¹, Berger H.¹, Tapia M.¹¹Centro de Estudios Postcosecha (CEPOC) Universidad de Chile, Chile.

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Pepino fruits "cachun" (*Solanum muricatum* Ait.) were harvested at two maturity stages: mature green and ripe and stored at 18°C during 4 weeks. Postharvest respiration rate, ethylene production, pulp firmness, soluble solids, titratable acidity was measured daily during this period. Results confirm the non climacteric type of respiratory activity during postharvest period, ethylene was not detectable. Nevertheless fruits showed an evolution from green stage to normal ripe.

SESSION 2 (S2)

HANDLING, PACKAGING AND SHIPPING TECHNOLOGY



S2-01**HANDLING, PACKAGING AND SHIPPING: RESEARCH AND REALITY.**Yahia E.M.^{1*}¹Universidad Autónoma de Querétaro, México.

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There has been significant research on postharvest in the last decades that led to the development of a diversity of appropriate technologies in several countries, which greatly improved the handling and quality of horticultural crops. Unfortunately, in the majority of the world - especially in Developing Countries - great quantities of horticultural crops are lost every year, and quality deterioration is still a major problem.

The problem is very complex in nature, and not due only to technical reasons. From the technical side there are diverse problems related to "unavailability of adequate technologies", "unfamiliarity of the availability of adequate technologies", "inadequate use or difficulties in the adaptation of available proper technologies", or even the "refusal of using available proper technologies, due to different reasons".

In this presentation, some of the "technical" problems related to handling, packaging and shipping of horticultural crops (especially in Developing Countries) will be pointed out, their nature and possible cause will be discussed, and possible solutions (either through research or education) will be suggested. Research is a very important activity (and should be significantly increased in Developing Countries), but extension/education is as important and should be improved significantly.

S2-03**ACTIVE PACKAGING DEVELOPMENT TO IMPROVE 'STARKING' SWEET CHERRY POST-HARVEST QUALITY.**Serrano M.^{1*}, Martínez-Romero D.², Guillén F.², Castillo S.², Valverde J.M.², Valero D.²¹Dept. Food Technology, University Miguel Hernández, EPSO-Orihuela, Alicante; ²Dept. Applied Biology, University Miguel Hernández, EPSO-Orihuela, Alicante, Spain.

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'Starking' sweet cherry is considered a late season cultivar in Alicante (Spain) with several problems for commercialisation mainly due to incidence of decay and a fast loss of sensory quality, both for fruit and green stem. Based on this issue, an active packaging has been developed based on the addition of 1 mL eugenol (essential oil from oregano) to trays and then sealed with polypropylene bags to generate a MAP. Also, cherries in MAP (without eugenol) and non-packaged fruits were selected and served as controls. Both, bags and non-packaged cherries were stored during 16 days at 2 °C and 90% RH. Samples were taken after 2, 6, 9, 13 and 16 days in which the internal atmosphere composition, weight loss, colour, °Brix-titratable acidity ratio, firmness and visual aspect of the stem were evaluated.

Steady state atmosphere was reached after 9 days of cold storage with 2-3% of CO₂ and 10-11% of O₂ with no significant differences between treated and control. When fruit quality parameters were determined, those treated with eugenol showed a significant reduction in weight loss compared with control, either under MAP or not. Contrarily, colour parameter L* and fruit firmness remained significantly higher during storage in treated cherries than in controls, under MAP or not, while no significant differences were obtained in relation to °Brix-titratable acidity ratio. When the stem was evaluated, this remained green in cherries stored in MAP, while they became brown in control. Finally, the microbial analysis showed that eugenol treatment reduced yeast, mould and total aerobic mesophylic colonies 2 and 3-log CFU compared with control under MAP or not, respectively. In conclusion, the use of MAP in combination with eugenol is an effective tool on maintaining cherry fruit quality and reducing the occurrence of decay.

S2-02**A NEW APPROACH TO MEASURE AIR DISTRIBUTION THROUGH HORTICULTURAL CROP PACKAGES.**Vigneault C.^{1*}, de Castro L.R.², Cortez L.A.B.²¹Agriculture and Agro-Food Canada, Canada; ²State University of Campinas, SP, Brazil.

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The air flow distribution through a porous medium such as a mass of fruit or vegetable is of great challenge. The development of a method allowing the measurement of the air velocity or distribution would be of great interest for the scientific milieu. Different possibilities of measuring air velocity inside a container during precooling were discussed.

The correlation between the cooling rate of produce simulators and the air approach velocity permitted to develop a new approach consisting of indirect measurement of air velocity. The produce simulators consisted of sixty-four thermo-instrumented spheres (balls) used to represent packed spherical horticultural produce during forced-air cooling. These simulators were strategically distributed in an orthogonal matrix along with 448 other plastic spheres.

This matrix follows a column stacking pattern where the simulators were used to verify the homogeneity of cooling process. The specific heat capacity and a cooling rate index of each plastic spheres were measured. The cooling rate of the spheres were measured using still air and five approach velocities.

A regression analysis demonstrated that 98.6% of the variation of the cooling rate of the spheres could be explained by the variation of the air approach velocity and their cooling rate index. The system was evaluated in terms of its capacity to determine the airflow pattern through the ball matrix. This system is an excellent tool to evaluate various forced-air cooling parameters and the results may therefore be used to enhance the design of new packages used for handling, transportation and processing of horticultural crops.

S2-04**EFFECTS OF FILM PACKAGING AND COLD STORAGE ON POSTHARVEST QUALITY OF 'TOMMY ATKINS' MANGOES.**Vidigal de Castro J.^{1*}, Pfaffenbach L.B.¹, Carvalho C.R.L.¹, Rossetto C.J.²¹Instituto Agronômico, Campinas, Brazil; ²Apta Noroeste Paulista, Votuporanga, Brazil.

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Brazil is one of the ten mango world producers and the second exporter country of this tropical fruit. Mango fresh fruits are perishable and their shelf life cannot surpass one week at room temperature. After harvest the main problems are fruit overripening and disease development. Refrigeration and modified atmosphere can improve fruit shelf life with additional benefits besides the ones of cold storage but for mangoes there are controversial points of improved quality. The effects of modified atmosphere for plastic film associated with cold storage on 'Tommy Atkins' mango fruits were studied. Mangoes were packed in low density polyethylene bags (LDPE) with and without potassium permanganate absorber, and PVC bags and stored at 12 °C and 90% RH. Every week, the bags were removed and mangoes were transferred to 25 °C conditions to simulate marketing. Quality parameters (TSS, acidity, firmness, flesh and peel colour) and losses (weight and rots) were evaluated immediately after cold storage and when the mangoes ripened at room temperature, after cold storage. The polyethylene film reduced fruit weight loss during cold storage. For mangoes packed in LDPE with absorber, decay incidence was completely controlled for up to 21 days of refrigerated storage and the fruits remained firmer. At room temperature there were no residual effects of packaging on peel colour development and on disease incidence. For all packages studied, when the mangoes ripened, they reached the ideal consumer quality conditions.

S2-05**EXTENSION OF THE STORAGE LIFE OF PLUMS USING CONTROLLED ATMOSPHERE SHIPPING.**Maré L.¹, Truter A.B.², Kemp A.T.², Dodd M.C.³, Holcroft D.M.⁴, Huysamer M.^{1*}¹Department of Horticultural Sciences, University of Stellenbosch, Matieland, South Africa; ²Transfresh Africa, Howard Place, South Africa; ³Alacer Aer Technologies, Table View, South Africa; ⁴Dole Fresh Vegetables, Salinas, USA.*Presenter (huysamer@sun.ac.za)

South Africa is an important supplier of stone fruit to the northern hemisphere in the months of November to March. The voyage by sea to the main markets in the UK and Continental Europe necessitates production of cultivars that are able to maintain an acceptable eating quality for a period of at least 4 weeks from the time of harvest. Four Japanese plum (*Prunus salicina* L.) cultivars were examined with the view to extend their storage life under regular atmosphere (RA) conditions at -0.5°C following either RA or controlled atmosphere (CA) shipping, using either the commercial dual temperature (-0.5°C, +7.5°C, -0.5°C) or a single high temperature (+7.5°C) regime. The cultivars included the locally bred 'Sapphire', 'Songold' and 'Laetitia' as well as 'Angeleno' which is well-known in plum producing countries internationally. Storage life of all four cultivars could be extended for an additional two to three weeks under RA conditions at -0.5°C without adverse effects on quality. Storage life of CA was applied during the shipping phase, either under dual or single high temperature regimes. Fruit firmness was best retained under CA (dual temperature) conditions. These fruit also showed lowest respiration rates, ethylene production rates and internal ethylene content. Skin colour development was better under single high than under dual temperature conditions, and also better under RA than CA shipping. These results will be discussed with reference to commercial application in the South African plum export industry.

S2-07**EFFECTS OF DIFFERENT COMPOUNDS ON THE MICROBIAL POPULATION OF CUT SHIRAZ NARCISSUS VASE SOLUTION.**Jowkar M.M.^{1*}¹Azad University, I.R., Iran.*Presenter (mjowk@yahoo.co.uk)

One of the important factors causing life reduction and cut flower deterioration is the disruption of cut flower water relation due to microorganism growth and proliferation in the vase solution. This experiment was conducted to find the most suitable compound for controlling the microorganism population in the vase solution of cut 'Shiraz' Narcissus, one of the bulbous native cut flowers of Iran which is cultivated most extensively in Shiraz. Thus, the stems of 'Shiraz' Narcissus cut flowers were exposed to 17 treatments; samples of vase solution were taken at the start of the experiment, 2, 4, and 6 days after placement in the treatments. After decimal dilutions, samples were plated on nutrient agar. The number of microorganisms were counted by the standard plate count method and the kinds of microorganisms were determined. Treatments were Tap water as control, Sterilized Distilled water, Citric acid (150, 300, and 450 mg L⁻¹), 8-Hydroxyquinoline citrate (200, 300, and 400 mg L⁻¹), Calciumhypochlorite (400, 600, and 800 mg L⁻¹), Sodiumhypochlorite (400, 600, and 800 mg L⁻¹), and Aluminiumsulphate (100, 200, and 300 mg L⁻¹). The most effective compound for controlling microbial growth and proliferation were 8-Hydroxyquinoline citrate treatments which did not contain any microbes even after 6 days. After which the 800 mg L⁻¹ Calcium and Sodiumhypochlorite was placed. These two compounds did not contain any microbes until the fourth day. Aluminiumsulphate was the least effective compound. Yeasts were the most spread microorganisms in the cut 'Shiraz' Narcissus vase solution after which *Bacillus* were placed. Shrinking and browning of the proximal end, bleaching of the soaked part, yellowing and abortion of buds were the side effects of 8 HQC, Sodiumhypochlorite and Aluminiumsulphate treatments respectively.

S2-06**VAPOR PRESSURE DEFICIT AND WATER LOSS PATTERNS DURING SIMULATED AIR SHIPMENT AND STORAGE OF BEIT ALPHA CUCUMBER.**Laurin E.¹, Nunes M.C.N.², Emond J.P.³, Brecht J.K.^{2*}¹Laval University, FSAA-SGA, Quebec City, Canada; ²Center for Food Distribution and Retailing, Horticultural Sciences Department, University of Florida, IFA, Gainesville, USA; ³Center for Food Distribution and Retailing, Agricultural and Biological Engineering Department, Gainesville, FL, USA.*Presenter (emiliela@ufl.edu)

Harvested commodities lose moisture by transpiration, with the rate affected by environmental factors such as temperature (T), relative humidity (RH), and atmospheric pressure (P). Commodities are commonly exposed to high T, low P, and large vapor pressure deficit (VPD) during air shipment, which can increase their transpiration rate and result in undesirable loss of moisture. The objective of this work was to understand the VPD and water loss patterns of Beit Alpha cucumbers under combined flight conditions (T, RH, P) in airtight and open containers. To simulate flight conditions, cucumbers were stored for 6 hours at 0.7 atm, 20°C, and initial RH of 70% in airtight or open containers with an air-flow rate of 0.415 L s⁻¹, and with 1.0 atm controls. After the air flight simulation, fruit were transferred to 1.0 atm cold rooms at 20°C and 70% RH or 7°C and 90% RH for 7 days. The VPD was monitored during flight simulation and weight loss was evaluated after harvest, after flight simulation, and daily for 7 days. Exposure of cucumbers to 0.7 atm in either airtight or open containers increased moisture loss compared with 1 atm. The VPD was higher in open containers, enhancing transpiration, and leading to greater moisture loss during the simulated air shipment as well as throughout the storage period. The atmosphere in airtight conditions was quickly water-saturated, limiting transpiration rate and moisture loss during the air shipment simulation. Loss of moisture from the cucumbers exposed to 0.7 atm in airtight containers was significantly greater throughout the storage period compared with fruit in 1.0 atm airtight containers. These latter results suggest that low P during air transport may induce physiological stresses on cucumbers, especially in the water diffusion pathway through the epidermis.

S2-08**EFFECT OF POSTHARVEST ILLUMINATION OF LAMB'S LETTUCE (*Valerianella locusta* L.) ON SUGAR METABOLISM AND KEEPING QUALITY.**Enninghorst A.^{1*}, Lippert F.¹¹Dept. of Horticulture, Bonn University, Germany.*Presenter (andy.enninghorst@uni-bonn.de)

Few publications have shown that postharvest illumination of fresh produce can improve quality of leafy vegetables by extending their shelf-life. As an easy method to prolong the period for marketing, postharvest light application is expected to be welcomed and introduced for food retailers. While cooling is one of the most powerful tools to extend shelf-life by reducing catabolic processes and transpiration, photosynthesis is an anabolic process and can still take place after harvest, especially in leafy vegetables. Hence, lamb's lettuce (*Valerianella locusta*) was used as model plant to quantify the influence of illumination on quality maintenance during storage.

The lamb's lettuce was kept in the dark and in light for 3 weeks at 10°C and flushed with constant 2% CO₂, 20% O₂ and 78% N₂ in humidified air. Rates of weight loss were lower in the dark variant, caused by closed stomata. Leaves, which were illuminated, showed extended keeping quality because of delayed decrease in sugars concentrations. The result obtained underlines previous findings where the sugar status went along with quality.

S2-09

BIOPOLYMERS USED AS EDIBLE COATING TO LIMIT WATER TRANSFERT, COLOUR DEGRADATION AND AROMA LOST IN MEXICAN FRUITS.

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Low preservation of typical fruits in countries with warm weather represents a limitation to export. A recently proposed method to increase shelf-life of fresh guava, is the application of biopolymers as edible coatings. This research involves the use of biopolymers of microbial origin obtained with low cost nutrients, to prepare edible coatings applied on Mexican guava and apricot.

Dextrans obtained by fermentation with *Leuconostoc mesenteroides* isolated from a typical Mexican beverage named "pulque" (cactus juice fermented).

Dextrans were purified by precipitation with methanol and dispersed in purified water. This mechanism was repeated 3 times to eliminate carbohydrates other than dextrans. The functional properties of dextrans were compared with four highly purified biopolymers: xanthan gum, potato starch, sodium alginate, carboxymethylcellulose and tragacanthin.

Dextran production gave 30% of transformation sugar-dextran in a liquid medium. Dextrans showed better properties as gas barrier compared to the other polymers. However, coatings based on dextran showed poor water retention on fruits at room temperature. The best efficiency found for dextrans was when fruits protected were preserved at 4°C, increasing guava characteristics (size, colour, aroma, water content) by three times.

Results have shown differences on functional properties between the biopolymers studied. Dextrans could be a good option to preserve fresh fruit, if water retention is not the main purpose. A combination of biopolymers (multi-layer coating) or their application in an emulsified way could improve their performances.

S2-11

IMPROVING QUALITY OF PERISHABLE PRODUCE USING OZONATED WASHING WATER.

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Ozonated water is used to sanitize fresh cut and other produce. In a series of laboratory-scale experiments the efficacy of dissolved ozone to reduce pathogens below critical levels was proved. Initial trials were on microbial solutions of *Escherichia coli*, *Listeria monocytogenes*, *Salmonella choleraesuis*, and *Bacillus cereus*. These experiments performed with reasonable reductions of 4 and more logarithmic units. In the case of *B. cereus* a 100% reduction could be achieved. In further series we inoculated different lettuce species and varieties with the same variation of microbes either as monocultures or in mixtures. As it is expected reduction of these microbes is less effective on natural surfaces than in solution. But in general satisfying efficacy of ozonated washing water could be achieved with reductions of approximately 2 logarithmic units on average. If microbes were applied as mixture additional effects of competition between species occurred. The reduction of the other species led to an increase of *L. monocytogenes* or *E. coli*, depending on lettuce species.

S2-10

RE-WARMING OF STONE FRUITS AFTER COLD STORAGE.

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Generally, extension of shelf life can be obtained by manipulation of reaction rates due to temperature decrease. However, cooling requires a re-warming step commonly leading to condensation of water at the produce surface at temperatures below the dew point. The amount of condensate is a function of the produce surface temperature and of the surrounding conditions which are strongly affected by the packaging system used. The temperature equilibrium is often obtained not before several hours. If the water remains at the sample surface for a long time period while temperature increases, unwanted microorganisms are able to grow under certain conditions resulting in produce deterioration and reduced shelf life.

The objective of this study was to minimize condensation effects by controlling the air flow conditions close to the produce surface. Cherries and plums in various open packaging were warmed after the cold storage using different flow conditions. The time-dependent amount of condensate was calculated using a certain heat and mass transfer model for the produce in the packaging unit. The data clearly show that low air convection results in small amounts of condensate persisting on the product surface in the packaging during extended periods (up to 10 h). Furthermore, reaching the temperature equilibrium demands for a relatively long time. When increasing the air velocity higher amount of water vapour condensates, but remaining on the produce surface for shorter time. Compared to low convection rates, here the temperature equilibrium is reached much faster. Applying equal air velocities and air flow conditions against and around the packaging resulted in increased water loss of the fruit samples when packed in plastic containers. The presented data point up the effect of air flow condition, packaging and temperature on the postharvest behaviour of stone fruits, resulting in strategies for improved post-cold storage handling.

S2-12

THE USE OF NATURAL AROMATIC ESSENTIAL OILS HELPS TO MAINTAIN POST-HARVEST QUALITY OF 'CRIMSON' TABLE GRAPES.

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'Crimson' table grape clusters were packaged on trays and then sealed with polypropylene bags to generate a modified atmosphere. Hence, a sachet impregnated with either 0.5 mL of thymol or 0.5 mL of menthol was included outside the tray. Thus, evaporation substances were released to the headspace package acting as active substances. Then, packages were stored at 1 °C and 90% RH for 42 days. Samples were weekly taken for analytical determinations: atmosphere composition inside the bags, weight loss, °Brix-titratable acidity ratio, colour evolution and fruit firmness. Also, the visual aspect of the rachis and enumeration of both total yeast and mould and mesophilic aerobic were performed.

Steady state atmosphere was reached at day 21 of storage with 1.2-1.3% of CO₂ and 13-14% of O₂, with no significant differences between treatments and control. However, both treatments showed significant lower weight loss and °Brix-titratable acidity ratio than controls during storage. These different conditions of packaging and storage did not affect the colour changes and fruit firmness. Thereafter, the microbial analysis showed that both essential oils reduced yeasts, moulds and total aerobic mesophilic colonies by 3-log CFU, and improved also the visual aspect of the rachis.

These natural compounds could be an alternative to the use of SO₂ in table grapes, since showed improvements of the fruit shelf life in terms of quality and incidence of decay, one of the most important problems during commercialisation of table grapes.

S2-13**EFFECT OF PLASTIC PACKAGING ON TOMATO FRUITS STORED AT DIFFERENT TEMPERATURES AND HIGH RELATIVE HUMIDITY. QUALITY ATTRIBUTES, SHELF LIFE, AND CHEMICAL PROPERTIES.**Alsadon A.A.^{1*}, Alhamdan A.M.², Obied M.A.³¹Department of Plant Production, College of Agriculture, King Saud University, Riyadh; ²Department of Agricultural Engineering, College of Agriculture, King Saud University, Riyadh; ³Department of Plant Production, King Saud University, Riyadh, Saudi Arabia.

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Two types of plastic packaging (low density polyethylene, LDPE, 50 µm and high density polyethylene, HDPE, 22 µm) and paper packaging (0.11 mm) were used to study their effect on quality attributes, shelf life and chemical properties of tomato fruits (cv, Red Gold) stored at three temperatures (5, 15, 25 °C) and 97 % RH. Percentage of weight loss, disease incidence, progress of fruit colour, TSS and PH were all evaluated during six weeks of storage. Highest and significant weight loss was found in unpacked fruits throughout the storage period. Both LDPE and HDPE treatments gave lowest weight loss. Fungal decay was significantly the highest in fruits stored at 25 °C with plastic packaging, and it increased as storage period increased. Unpacked fruits followed by paper packed fruits had less decay. Storage at 15 °C resulted in faster development of fruit colour as compared to other temperatures and at all storage periods. LDPE and HDPE resulted in faster fruit colour but no significant differences were observed between them.

No significant effects of temperature and package materials on TSS throughout the storage period. Similarly, no effects were reported on pH although the general trend was toward higher pH with increased temperature or storage period. The highest pH value was found in HDPE packed fruits at 15 °C. This study concluded that all chemical properties, quality traits and shelf life of tomato fruits should be considered when selecting packaging materials or storage temperature. Fruits can be stored for up to three weeks at 15 °C if they were packaged in low density plastic packages since colour progress is slower and shelf life is better than in fruits packaged in high density plastic or paper packages. For longer storage periods, it is recommended to store at 5 °C with either plastic packaging.

S2-14**SHEAR AND PENETRATION FORCES OF DATE PASTES OF EIGHT CULTIVARS.**Alhamdan Abdullah M.^{1*}, Hassan Bakri H.¹¹King Saud University, Saudi Arabia.

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Mechanical properties of dates paste were experimentally determined for eight popular cultivars, namely, Barhi, Khudri, Khlass, Serri, Sukkari, Suffri, Sakkie, and Nubot Saif. Date pastes were produced in the laboratory by comminuting clean pitted dates using an electrical mincer, followed by formation of uniform pastes cylinders (3 cm dia.x 3 cm length). A texture profile analyzer (TA.XT2) was utilized to determine shear and penetration parameters. Shear forces tests utilized Krait knife (HDP/BS) were determined by cutting the cylindrical date pastes samples radially and axially.

Penetration test were carried out utilizing a spherical probe (thump test) P/0.755 axially on samples. Shearing curves were characterized with a linear relationship of force versus deformation. Then, a transition of decreasing force followed by an apparent rupture point. In general, Sefri, Khudri, and Sukkari were the most resistance to shear forces. Curves of penetration experiments revealed Sefri, Khudri, and Sukkari were the highest resistance cultivars to penetrate 75% of sample height. It was observed that maximum and rupture points occurred at comparable distance.

Statistical analysis revealed significant differences among the mechanical parameters of the eight date cultivars. This may be attributed to differences in cultivars and harvesting time which consequently affects physical and chemical properties

S2-15**EDIBLE FILM FORMATION AND PROPERTIES FROM DIFFERENT PROTEIN SOURCES AND ORANGE COATING APPLICATION.**Sothornvit R.^{1*}¹Department of Food Engineering, Faculty of Engineering at Kamphaengsaen, Kasetsart University, Kamphaengsaen, Nakhonpathom, Thailand.

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Protein films were made from different sources such as whey protein, soy protein and egg white protein to determine film water vapour permeability (WVP) properties and appearances. The optimum pH to form whey protein (WP), soy protein (SP) and egg white (EW) films was 6.5-7.5, 7.0-7.4 and 12, respectively. To increase film moisture barrier, solutions were heated for 30 min at 90°C for both WP and SP and at 45°C for EW followed by adding glycerol as a plasticizer for 25-35% db. Protein films were dried at either 70 or 80°C for 2-3 hours. Glycerol content (GC), protein type and drying temperature influenced film WVP significantly ($p < 0.05$).

Increasing GC provides protein molecules moving freely and increases permeability while increasing drying temperature causes protein denaturation providing tight networks; therefore, lowering permeability. EW films imparted the highest WVP followed by SP and WP films, respectively. All films showed transparency and the gradient of yellowish appearances depending on protein type and drying temperature. WP coating on oranges reduced weight loss and lowered concentration of carbon dioxide yet increased concentration of oxygen.

These results indicate that different protein types can be formed with different conditions and providing different properties for coating applications on fruits and vegetables. Protein edible coating has potential to extend shelf-life of fruits and vegetables.

S2-16**THE BENEFITS OF MODIFIED ATMOSPHERE OF ETHANOL-TREATED GRAPES.**Lichter A.^{1*}, Zutchi Y.¹, Kaplunov T.¹, Shacham Z.¹, Aharoni N.¹, Lurie S.¹¹Department of Postharvest Science, ARO, the Volcani Center, Bet Dagan, Israel.

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Grape storage requires stringent control of decay caused by *Botrytis cinerea*. The commercial practice is dependent on SO₂ as a fumigant which is applied by various means with well known advantages and downsides. Many alternative technologies were developed over the years, most of them with limited efficacy or applicability. Modified atmosphere (MA) of table grapes suffers from a narrow threshold between efficacy and damage due to high level of CO₂ in the film.

We have demonstrated in the past that dipping table grapes in ethanol after harvest has a very pronounced effect on prevention of decay. However, ethanol is not expected to prevent latent infections from developing decay nests during prolonged storage. We now demonstrate that if we first treat grapes of cv. 'Superior' with ethanol and then subject them to MA using Xtend® films, we can achieve a synergistic effect. The advantage of the Xtend® film is mainly in its water conductance, which prevents accumulation of free water, often the limiting factor in MA. This combination can guarantee wider margins which are a prerequisite for commercial applicability. We also demonstrate that if undesired aftertaste does build up, one day exposure to ambient air is sufficient to avoid it.

S2-17**RE-COOLING OF STRAWBERRIES AFTER AIR-SHIPMENT DELAYS FRUIT SENESCENCE.**Laurin E.^{1*}, Nunes M.C.N.¹, Emond J.P.¹¹Air Cargo Transportation Research Group, Laval University, FSAA-SGA, Quebec City, Canada.*Presenter (emiliela@ufl.edu)

The objectives of this work were to evaluate the effect of temperature abuse during a simulated air-cargo shipment on the quality of strawberries and to determine the most appropriate cooling method to be used following air-shipment in order to reduce fruit quality loss. Freshly harvested 'Kent' strawberries (*Fragaria x ananassa* Duch.) were room cooled to 4°C within 4 hours immediately after harvest. Fruit were then packed in 0.47-L plastic clamshell containers and stored at 20°C and 60-70% RH for 20 hours to simulate time delays, temperature and humidity typically encountered during air-shipment. After that period, the strawberries were either forced-air re-cooled at 0°C, room re-cooled at 0°C, or held at 20°C to simulate different facility conditions available at the airports.

After re-cooling, the fruit were transferred to 0°C and 85-90 % RH and fruit quality evaluated after harvest, after air-shipment, after re-cooling treatment, after 6 and 10 days. Temperature abuse resulted in increased weight loss, darkening and toughening of the fruit, and decreased titratable acidity and soluble solids and anthocyanin contents. Results pointed out that re-cooling after temperature abuse was beneficial in maintaining strawberry quality compared to not re-cooling. Although, the use of a forced-air re-cooling treatment to re-cool temperature abused strawberries while in transit at the airport and/or after air shipment did not provide an advantage over the room re-cooling at 0°C.

S2-19**THE USE OF PLASTIC FILM (BIORENTED POLYPROPYLENE) UNDER COLD CONDITIONS TO STORAGE 'RAINHA CLAUDIA VERDE' PLUMS.**Aguilheiro-Santos A.C.^{1*}, Pacheco-Ribeiro G.², Ventura C.¹, Bernalte-García M.J.³¹Universidade de Évora; ²Escola Superior Agrária de Elvas; ³Universidad de Extremadura, Portugal.*Presenter (acsantos@uevora.pt)

To increase the consumption period of 'Rainha Claudia verde' plums with good level of quality using simultaneously cold storage and plastic film is the general propose of this research work.

Bags of Biorented Polypropylene, (Pplus®) were used for packing samples and there were also control samples without any kind of plastic bag. The fruits were stored at 2°C of temperature and 95% of R.H. At predetermined days (0, 7, 14, 21, 28, 35, 39, 42 and 49) samples (10 fruits of each) were removed from cold chambers and tested. The tests carried out were: Weight Loss, External Colour (L* a* b*), Visual Aspect of the epidermis, Epiderm Puncture Test, Mesocarp Penetration Test, Soluble Solids Content, Titrable Acidity (% Malic Acid). It was used "Statistica 6.0" program and an Anova analysis with two factors: "Storage Time" and "Packing Modality".

Biorented Polypropylene (Pplus®) is appropriate to minimize the loss of weight in the fruits storage at 2°C and 90%R.H. The textural properties and visual aspect, allow to conclude that to storage plums 'Rainha Cláudia Verde' using bags of Pplus® is very adequate however the values of SSC don't reach the level observed in the fruits from control samples. At these conditions, once more, 'Rainha Cláudia Verde' plums have shown no advantage in being stored for more than 42 days.

S2-18**TOMATO PACKING LINES STUDIES WITH AN INSTRUMENTED SPHERE IN BRAZIL.**Ferreira M.D.^{1*}, Ferraz A.C.O.¹, Franco A.T.O.¹¹FEAGRI/UNICAMP, Faculdade de Engenharia Agrícola, Brazil.*Presenter (marcos.ferreira@agr.unicamp.br)

Tomatoes for fresh market in Brazil were mainly classified and sorted by hand in field conditions. In the past five years many growers started to do those operations in packinghouses using machines. The goal of this research was to determine the levels and frequency of occurrence of impacts in commercial tomato packing lines in Brazil.

This research analyzed eight packing lines in São Paulo state, using the instrumented sphere (IS) Techmark, Inc., Lansing, 70 mm in diameter. The IS can measure and impact intensities at each of the transfer points. Impacts are measured as maximum acceleration (MA) in G (Gravity=9,81 m s⁻²) and velocity change (VC) in m s⁻¹. To analyse those packinghouses, the IS was placed on the top of plastic boxes. Subsequent transfer points on the packingline were sequentially measured until packing was finished. The IS was carried with the fruit over one or more transfer points while the elapsed time was recorded at each point using a stopwatch. Each transfer point was replicated 8 times, then the IS was removed from the packingline and the data was transferred to a portable computer. The threshold on the IS was set to record impacts from 15 to 500G. Means of the 8 maximum levels were determined for each transfer point (MA and VC) since these parameters most accurately describe impact intensities. Scatter plots of MA versus VC were made for all impacts recorded for each handling operation.

For the all the packing lines the highest G were found in the initial operations, when the operators dropped the boxes in the packingline, and in some cases get above 300G. Most of the packinglines showed to have impacts in some transfer points above 100G. Transfer points with greatest potential for causing damage were those with high drop heights.

S2-20**EFFECTS OF CHITOSAN COATING ON THE KEEPING QUALITY OF PUMMELO.**Ratanachinakorn B.^{1*}¹Department of Agriculture, Chatuchak, Bangkok, Thailand.*Presenter (benjamas@cscs.com)

Pummelo harvested at 7 month after full bloom were coated with 0, 1 or 1.5% chitosan and stored at ambient conditions (28-35 °C). The fruit coated with chitosan had less weight losses. The fruit in all treatments had no significant different in soluble solids, acidity and ascorbic acid content. All fruit had good eating quality although they were stored for 5 weeks.

S2-21

MODIFIED ATMOSPHERE PACKAGING OF MAY GLO NECTARINES.

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May Glo nectarines were over wrapped with 12.5, 14 and 16 μ thick PVC films and 15 μ thick polyolefin films and kept at 6 or 10 °C for 20 days. Percent weight loss, fruit colour (L, a, b), fruit flesh firmness (kg force), total soluble solids (%TSS), pH, acid content (g malic acid/100 ml fruit juice), physiological and fungal disorders were determined at day 4, 8, 16 and 20. 15 μ thick polyolefin film resulted in the lowest weight loss at both temperatures for 20 days. Fruit flesh firmness decreased at higher rate at 10 °C than 6 °C. Fruits packaged with modified atmosphere packaging films (MAP) maintained higher fruit flesh firmness than control fruits. Control fruits had the highest TSS content. Acid content of fruits were higher at 6 °C than 10 °C while pH was higher at 10 °C than 6 °C. Fruit packaged with 14 and 16 μ PVC film had higher pH than others. L, a, b values of peel colour was higher in fruits packaged with 12.5 and 14 μ thick PVC films.

S2-22

IMAZALIL ON-LINE CONTROL IN POST-HARVEST TREATMENTS OF CITRUS FRUIT.

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Penicillium digitatum and *Penicillium italicum* represent the main causes of post-harvest loss in citrus fruit medium and long term storage. They could be controlled using fungicide as Imazalil, and fruits are generally treated on-line in the packing line. One of the more effective treatment is the fruit immersion in a tub located on the packing line after the fruit dumping. However at the present the fungicide concentration during the whole day related to the amount of fruit packed in the line is not controlled. Due to this happen that fungicide is often overdosed on the fruit or due to the reduction of fungicide concentration in the washing tub an insufficient fungicide protection during the storage results.

The aim of this work has been the set up of a technique to monitor the Imazalil concentration in the washing tubs used for the treatment of citrus fruits by immersion, in order to monitor and control of the fungicide concentration on line during the process. With this aim several parameters of the water/Imazalil solution have been tested, as pH, conductivity and redox potential, but they have shown no correlation with the Imazalil concentration. Then the spectrophotometry has been used to assay the Imazalil concentration: sample solutions (0.5 to 150 ppm) have been exposed to ultraviolet (UV) and near infrared (NIR) wavelengths.

The tests performed have shown that NIR gives good correlation between Imazalil and the prediction model: the standard error of correlation (SEC) is 0.59 and the standard error of validation (SEV) is 3.65, such errors are acceptable both for the quick analysis method and for the minimum measurable concentration. Then UV has been successfully employed for the quick determination of the Imazalil concentration (SEC= 0.015, SEV= 0.683).

S2-23

INFLUENCE OF OZONATED WATER ON THE STRUCTURE AND ON SOME QUALITY PARAMETERS OF WHOLE STRAWBERRIES IN MODIFIED ATMOSPHERE PACKAGING (MAP).

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The effect of ozonated water on the structure and some postharvest quality parameters of strawberries was evaluated.

Strawberry fruits (*Fragaria x ananassa* Duch. cv. Darselect) were submerged in ozonated water (1.66 ppm) for 5 minutes, packed in air and in modified atmosphere (65% N₂O, 25% Air, 5% O₂, 5% CO₂) and stored at 4°C for 20 days. SEM analysis of the surface cells of the fresh product and after treatment was performed. Ethylene production, CO₂ and O₂ concentrations in the package headspace, pH, titrable acidity, soluble solids content, colour and texture modifications during storage were assessed. Ethylene production was low during all the storage period for all samples. Colour evaluation of surface of the fruits showed a rapid increase of saturation (C*) and red index values (a*) during storage, in particular for the control sample (not treated, packed in air). The image analysis on sepal colour indicated a preservative effect of the ozonated water treatment.

The images obtained with SEM of the cell walls close to the fruit surface of untreated and treated samples, showed an irregular shape of the cells in ozonated-water treated strawberries, in comparison to those untreated. The dynamometric results, obtained with texture analyzer, did not show significant differences in the decrease of maximum firmness between samples. However, the work needed to penetrate the surface layer (5 mm close to the surface) of different strawberries samples differed significantly, indicating a more pronounced superficial softening in the samples treated with ozonated-water. Moreover, fruits packed in MA showed, in comparison to control samples, higher firmness values. Excluding sepals colour, ozonated-water treatment did not appear to improve quality maintenance of strawberry fruits in MAP.

SESSION 3 (S3)
FRESH CUT PRODUCE



S3-01**CONSUMER-ORIENTED APPROACH FOR KEEPING QUALITY OF MINIMALLY FRESH PROCESSED VEGETABLES.**Artés F.¹*, Allende A.¹¹Postharvest and Refrigeration Group, Department of Food Engineering, Technical University of Cartagena, Cartagena, Murcia, Spain.

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In order to reduce losses and provide safer and higher quality of minimally fresh processed products in its broadest sense the industry needs that food engineers and scientists develop a multidisciplinary, consumer-oriented approach. To attempt this objective, the critical points throughout all the steps of the industrial production chain and commercial shelf-life must be well defined and new efficient preservation techniques must be introduced. In particular, wide efforts and resources must be dedicated for developing and operating Good Hygienic and Manufacturing Practices, Sanitation Standard Operating Procedures, environmental microbial testing programmes and Hazard Analysis Critical Control Point Programs (HACCP). As alternative to conventional preservation techniques for improving the overall quality and keeping longer the shelf-life of minimally fresh processed vegetables, ozone, hydrogen peroxide, hot water treatments, superatmospheric O₂ atmospheres and UV-C radiation, have been recently developed.

In addition to this, more complete strategies on fresh-cut products safety must be adopted by sanitary authorities, particularly throughout distribution and retail sale, by combining compulsory temperature limits and equipment performance testing. New approaches including audit of HACCP systems, risk communication and consumer information should be also implemented.

S3-03**BROWNING INHIBITION AND FIRMNESS RETENTION IN FRESH-CUT MANGOSTEENS (*Garcinia mangostana* L.).**Manurakchinakorn S.¹*, Nuymark P.¹, Phooupouk P.¹, Poohern P.¹, Chamnan U.¹¹School of Food Technology, Institute of Agricultural Technology, Walailak University, Nakhonsithammarat, Thailand.

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Maintaining quality of fresh-cut mangosteens by combinations of antibrowning agents, calcium chloride and modified atmosphere packaging (MAP) was investigated. Dipping solutions containing 4-hexylresorcinol (0.005 M) or sodium erythorbate (2%) or N-acetylcysteine (0.05%), used as antibrowning agents, and calcium chloride (0.2%), used as an agent for maintaining firmness, were tested. MAP with different levels of O₂ (5-10%) and CO₂ (9-15%) were evaluated.

Changes in color (L*-value), flesh firmness and sensory acceptance were monitored during 10 days storage under MAP at 4°C. Fresh-cut mangosteens dipped in the solution consisting of sodium erythorbate and calcium chloride, prior to storage under MAP (5% O₂ and 9% CO₂), resulted in best overall retention of lightness, firmness and sensory quality.

S3-02**BIOCHEMICAL EFFECTS ON FRESH-CUT FRUIT QUALITY.**Lamikanra O.¹*, Watson M.A.¹, Bett-Garber K.L.¹, Ingram D.¹¹Southern Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, USA.

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Fresh-cut produce is the fastest growing food category in the supermarket. Most of the increase in sales has been in cut-vegetables. A factor that limits the development of the fresh-cut fruit industry is the rapid decrease in product quality caused by physiological and biochemical changes that accompany processing and storage. Our research objective is to identify these changes and to develop processing and handling methods that improve cut fruit storage quality.

We have: (1) established a number of biochemical and microbial base line information for cut fruit. This includes the relationship between storage conditions and quality parameters such as sugars, amino acids, organic acids and microorganism growth. Production of lactic acid/Gram (+ve) bacteria appears to be a useful indicator of temperature abuse during storage; (2) utilized a rapid, solid phase micro-extraction gas chromatography-mass spectrometry (SP-ME GC-MS) method developed to determine the nature of phytoalexins in fresh-cut fruit. UV simulated biological stress caused significant reduction in aliphatic ester compounds concurrently with production of phytoalexin terpenes and sesquiterpene compounds; (3) demonstrated that wound-stress induced loss of volatile esters is a contributing factor to loss of freshness that occurs during refrigerated storage of cut fruit; (4) demonstrated the ascorbate nature of peroxidase in most fresh-cut processed fruits. This defined the role of the enzymes as wound oxidative stress induced and facilitated studies of oxidative stress as indicators of potential product shelf life; (5) defined roles of key enzymes (esterase, pectin methyl esterase, and lipase) that affect fresh-cut fruit shelf life. These are being used to assess the effects of processing methods and treatments on product shelf life; (6) established the beneficial effect of mild heat treatment on fresh-cut fruit sensory quality and shelf life. This research will be reviewed and discussed.

S3-04**APOPLASTIC LEVELS OF HYDROXYL RADICALS IN FOUR DIFFERENT APPLE CULTIVARS ARE ASSOCIATED WITH SEVERITY OF CUT-EDGE BROWNING.**Toivonen P.M.A.¹*, Stan S.¹, Hampson C.¹¹Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, Canada.

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Past research has shown that severity of cut-edge browning in apples used to make fresh slices is highly dependent on the cultivar. 'Ambrosia' and 'SPA343' are resistant to browning, while 'Delicious' and 'Spartan' are very susceptible. Prior experiments have shown a relationship of browning severity with superoxide dismutase/peroxidase activity ratios and peroxide contents in the apoplast. However, peroxides themselves are not sufficiently active to cause lipid peroxidation and membrane degradation. Lipid peroxidation and membrane degradation are the processes that lead to the intermingling of phenolics and polyphenol oxidase, thus leading to the initiation of browning reactions. Hydroxyl radicals can directly initiate lipid peroxidation and they are formed in vivo through the interaction of the superoxide anion with hydrogen peroxide. This research used a newly-developed method to measure hydroxyl radicals in vivo to evaluate whether hydroxyl radical accumulation in the apoplast could be associated with severity of cut-edge browning. The results clearly show that apoplastic levels of hydroxyl radical are closely related to the severity of cut-edge browning, whereas peroxide levels, water soluble antioxidants and phenols are not. A model is presented to explain the results.

S3-05

DEVELOPMENT OF NEW HEALTHY PRODUCTS: FRESH PROCESSED POMEGRANATE SEEDS.

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The pomegranates have been cultivated over the whole Mediterranean region since ancient times. This fruit presents unique organoleptic and nutritional properties which have been always appreciated. However, its consumption is still reduced due to the difficulty in obtaining the delicious arils. Therefore, the enormous potential of this cultivar in the Mediterranean area has not been completely achieved yet. A possible answer could be the development of a new product: minimally fresh processed pomegranate arils. The objective of the present work was to study the different behaviour of two clones of the Mollar cultivar (Mollar of Elche and Mollar of Orihuela), their suitability to fresh processing as well as to determine the best gas composition to keep longer the fresh properties of this product.

Once the arils of the pomegranates were extracted from the fruit, they were fresh processed (washed, rinsed, dried and packaged) and stored at 5 °C for 11 days. 125 g of pomegranate arils were packaged in polyethylene baskets and sealed with bioriented polypropylene of 40 mm (PPB40) to generate a passive and an active modified atmosphere (MA) inside the package. The control was obtained by storing the product in a macro perforated film. Several analyses were carried out during the shelf life of the product: microbial count, sensorial quality and gas composition inside the baskets.

Differences between clones were found in the atmospheric composition inside the baskets when active MA was used. It seems that Mollar of Orihuela has higher respiration rate when stored in active MA. When the microbial growth among the two MA and the control was compared a reduction was observed by using both MA. The sensory panel determined a shelf life of 9 days for this product. In their opinion the product stored under passive MA obtained the best scores for both clones.

S3-07

INFLUENCE OF PRE-TREATMENTS ON METABOLISM AND WOUNDING RESPONSE OF FRESH CUT POTATOES EVALUATED WITH ISOTHERMAL CALORIMETRY.

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The anti-browning effects of acidificants and antioxidant substances in potatoes have been broadly studied in the literature. However, to our knowledge there is no information about their effects on the metabolism of wounded tissue. We here have studied the influence of anti-browning substances on the metabolism of fresh-cut potatoes.

Samples with different surface to volume ratios were prepared from potatoes and treated with solutions of citric and ascorbic acid. The metabolic heat production was measured in closed glass ampoules in a TAM Air isothermal calorimeter for 24 hours at 20°C and the fraction corresponding to the wounding response was evaluated. Interestingly, it is shown that ascorbic acid pre-treatment accelerates the metabolism of the wounded tissue, the shift from aerobic to anaerobic metabolism of the samples in the ampoules occurred 4 to 5 hours before the control samples or the ones treated with citric acid. The effect of different concentrations of both acids was investigated to evaluate this finding.

S3-08

INTERACTION OF OXYGEN, CARBON DIOXIDE, ETHYLENE AND 1-MCP IN CONTROLLING PHYSIOLOGICAL DETERIORATION OF FRESH-CUT LETTUCE.

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Shredded lettuce is prone to enzymatic oxidative browning (EOB), which reduces its marketing appeal and nutritional value. White tissues of the leaf base around the midrib are especially susceptible to the EOB. Modified atmosphere (MA) packaging with 0.5 to 3 kPa of oxygen is commonly used to reduce the severity of EOB. However, these conditions may lead to oxygen depletion in the package and off-flavour development. An alternative way to control EOB in fresh-cut lettuce was sought in this work.

Keeping 'Iceberg' lettuce in sealed packages containing superatmospheric oxygen concentration (above 75 kPa) was found to effectively reduce the EOB in cut lettuce tissues without the risk of oxygen depletion. At the same time, these conditions increased the incidence of dark discoloration in small primordial leaves of lettuce, most probably due to the damaging effect of elevated carbon dioxide accumulation which reached 10 to 25 kPa, depending on storage temperature. Absorption of carbon dioxide from the high-oxygen atmosphere by calcium hydroxide surprisingly resulted in the appearance of severe russet spotting, another physiological disorder of lettuce firmly associated with ethylene effect. It might be suggested that synthesis and/or effect of ethylene were enhanced in the absence of carbon dioxide, which is well known as ethylene antagonist. Application of 1-MCP durably blocks the effect of ethylene, alleviates russet spotting in lettuce and therefore can reduce the negative effect of CO₂ absorption in high-oxygen MA.

The combined effect of 1-MCP treatment, high oxygen atmosphere and carbon dioxide absorption improved the appearance of shredded 'Iceberg' lettuce. Possible physiological mechanisms of the interaction will be discussed.

S3-08

EFFECT OF A PARTIAL DRYING PRETREATMENT ON THE RESPIRATION ACTIVITY OF FRESH-CUT APPLE.

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Preliminary experiments were performed in order to evaluate the effect of a partial drying on the respiration and on the metabolic activity of fresh-cut apples.

Fresh-cut apple segments (cv Golden Delicious) were dried up to a water loss of 10%, 20%, 30%, 40% and 50% in an air dryer set at a constant temperature of 50 °C. Partially dried apple segments were checked for the respiration (rate of O₂ consumption and CO₂ production in a sealed container until 24 hours), ethylene production (amount of ethylene produced in one hour in a sealed container until 24 hours), water activity (aw), total soluble solids, titratable acidity and pH.

The results showed some changes of the chemical indexes (aw, total soluble solids, acidity and pH) which were related to the level of the partial drying. The fresh-cut apple segments maintained the respiration even at 50% weight loss. After 24 hours, the oxygen percentage decreased to 19.55, 19.60, 18.65, 19.39, 19.20, 19.96% and carbon dioxide increased to 1.50%, 1.40%, 2.40%, 2.05%, 1.5% and 0.85% in, respectively, untreated samples, 10%, 20%, 30%, 40% and 50% weight loss. Ethylene production showed a trend to increase in all the samples but the amount varied noticeably. Untreated samples showed a peak after 7 hours. The 50% dehydrated samples showed the minimum amount of ethylene production (22 ppm kg⁻¹ h⁻¹), while the highest amount was showed by the 30%, 20% and 10% dehydrated apple segments (respectively 109.5, 90.3 and 78.9 ppm kg⁻¹ h⁻¹ after 24 hours).

The experiments demonstrated that the respiration is not completely inactivated by partial drying even at 50% water reduction and that the drying parameters can have some influence on the respiration rate.

S3-09

SODIUM HYPOCHLORITE AND HYDROGEN PEROXIDE DESINFECTION OF MINIMALLY PROCESSED AMERICAN LETTUCE

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This investigation aimed to evaluate the effectiveness of different concentration of sodium hypochlorite and hydrogen peroxide on microbiological control of minimally processed American lettuce. The presence of fungi, yeasts and coliforms at both 35 °C and 45 °C in the raw material after sanitizing was investigated. American lettuce was minimally processed, included: head defoliation, stem cutting, leaves selection, washing with potable water, cutting strips and finally washing with potable water.

After that, fresh cut product was divided into five parts, each one washed with: potable water (control), a solution with 100 ppm of sodium hypochlorite, another one with 150 ppm, and the others with 2 and 4% of hydrogen peroxide solution. The products were centrifuged, packed into plastic bags and stored at 2 °C for a nine days period. All treatments were effective on reducing the number of microorganisms present on samples of the lettuce cultivar studied. However, samples treated with hydrogen peroxide at 2 % and sodium hypochlorite at 150 ppm showed better overall appearance during the storage period.

S3-11

EVALUATION OF HYDROGEN PEROXIDE AS AN ALTERNATIVE TO THE USE OF SODIUM HYPOCHLORITE IN FRESH-CUT 'PÉROLA' PINEAPPLE. Antoniolli L.R.¹, Benedetti B.C.^{1*}, Souza Filho M.S.M.², Borges M.F.², Garruti D.S.²

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The purpose of this research was to evaluate the potential of hydrogen peroxide (H₂O₂) as an alternative to the use of the sodium hypochlorite (NaOCl) in the disinfection and sanitization of fresh-cut 'Pérola' pineapple. Fruits were washed and separated in 4 groups. One of them was kept as control and the others were disinfected with NaOCl (200mg L⁻¹) or H₂O₂ (200 or 1000mg L⁻¹) solutions for 2 minutes. After approximately 24 hours of cold storage, fruits were mechanically peeled and manually sliced. Slices were dipped in pure water (control) or in NaOCl (20mg L⁻¹) or H₂O₂ (20 or 100mg L⁻¹) solutions for 30 seconds. The liquid in excess was drained and the slices were placed in polyethylene teraphthalate packages and stored at 4 ± 1 °C. The parameters: pH, peroxidase activity, pulp colour, carbon dioxide concentration, total soluble solid, total, reducing and non-reducing sugars, total titratable acidity and ascorbic acid content were evaluated every 2 days, for 10 days. Fresh-cut pineapple was evaluated for residual taste. Microbiological analyses were made every 3 days, during 12 days for mesophile aerobic, moulds and yeasts counts. The determination of total and fecal coliforms was made only on day 0. Although the sanitation agents have not interfered in physical, chemical, biochemical and sensorial characteristics of fresh-cut pineapple, they were inefficient in the reduction of mesophile aerobic and moulds and yeasts endophytic populations. Therefore, new studies must be carried for evaluation of the potential of hydrogen peroxide as a sanitation agent.

S3-10

DESIGN OF A PROTOCOL FOR THE SYSTEM DEVELOPMENT TO PACKING OF FOOD PERISHABLE PRODUCTS FOR COMBINED METHODS.

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A model of evaluation and classification of the variables which affect the conservation processes for a fresh product is shown. Using tools taken from the administrative processes, to the solution of technological problems with integral sense, it is applied to the design a conservation process of Hawaiian papaya to standardize a fresh product, with which the custom finds satisfaction on having obtained a fruit, that under conditions of manipulation and transport: be palatable, innocuous and eatable during all his shelf life and that in addition, not that displays undesirable collateral effects. There are designed strategies that allow prolonging the useful life of the fruit using the following sequence: recognition and categorization of variables, evaluation of the technical feasibility of the control of these variables in the industrial climbing, application of methodologies of conservation to the increase in the life of shelf managing to duplicate the useful life of the fruit.

S3-12

EFFECT OF FILM PACKAGING ON PHYTOPATHOLOGICAL AND PHYSIOLOGICAL PROCESSES OF FRESH-CUT WHITE ASPARAGUS (*Asparagus officinalis* L.) DURING POSTHARVEST.

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Quality assurance from soil to consumer is one of the predominant requests for a consumer oriented chain management. Recently, the impact of food safety and hygienic aspects has increased, specifically for pre-prepared fresh convenience-products, such as peeled asparagus (*Asparagus officinalis* L.). These commodities are known for their rapid physiological deterioration and contamination with microorganism. Development of pathogenic fungi is being promoted by mechanical damages and inappropriate climate regimes during postharvest handling procedures. Therefore, the appropriate use of film packaging in respect to product physiology and phytopathology is an essential tool for food safety strategies. In the present investigation the effect of different film packaging and postharvest temperature regimes on the occurrence and distribution of pathogenic microorganism and their interaction with postharvest physiological processes in wrapped peeled asparagus spears was studied during postharvest.

At the time of harvest, peeled asparagus spears were contaminated with *Microdochium bolleyi* (30%), *Verticillium* spp. (1.7%), *Cladosporium* spp. (1.7%), *Penicillium* spp. (3.3%) and *Fusarium oxysporum* (1.7%). After three days of storage (20 °C) the development of fungi was inhibited and only *Microdochium bolleyi* occurred to 13.3% and 6.6% in P-Plus-film and PP-film wrapped spears, respectively. Oxygen concentration within the packaging unit decreased from 21% to 8.5% in P-Plus-film and to 0.2% in PP-film. During storage, glucose (mg g⁻¹ DW) decreased to a larger extent in PP-film packaging. It is concluded that the development of pathogenic microorganisms was inhibited by the gaseous composition within the film packaging unit and/or by the limited source of carbohydrates. Furthermore, it is assumed that *Microdochium bolleyi* revealed a better adaptation to varying physiological conditions in postharvest.

S3-13

EFFECTS OF CUTTING AND OF MATURITY STAGE ON LYCOPENE CONTENT OF FRESH TOMATOES DURING STORAGE.

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Tomatoes (cultivar Belissimo) were harvested in three maturity stages, corresponding to the following colour scales of the CBT (Centraal Bureau van de Tuinbouwveilingen): I = grade 3; II = grade 5 and 6; III = grade 8. Within each maturity stage groups of six fruits as uniform as possible regarding visually observed colour, size and shape were selected. Three in each group were sliced before storage and the other three were stored intact. The fruits to be stored as slices were sliced in 7-mm thick transversal slices. Both intact and sliced fruits were stored at 5 °C. The initial content of lycopene for stages I, II and III was respectively 0.12 ± 0.02 , 0.24 ± 0.04 and $0.70 \pm 0.07 \mu\text{g mg}^{-1}$ dry weight. Both cut and whole fruit showed a similar behaviour during storage. After 9 days storage, the lycopene content of fruits at stage I and II hardly changed compared to the initial content, for both intact and sliced fruits. The same was observed for stage III after 5 days storage, although in this case a slight decrease was observed in fruits stored intact, after 9 days. These data indicate that minimal processing does not change the accumulation of lycopene in fruits stored at 5 °C, compared to fruits stored intact. For sliced tomatoes the effect of storage temperature was studied as well, using a model that incorporates a synthesis and a degradation pathway. The following temperatures were used: 2 °C, 5 °C, 8 °C, 12 °C, and 16 °C. No major changes were observed, but small increases were observed at high temperatures, while small decreases were observed at low temperatures. Different maturity stages responded slightly different with respect to this temperature effect. The results indicate that depending on the conditions net degradation or synthesis of lycopene can occur in sliced tomatoes.

S3-14

NITROGEN FERTILISER RATE AFFECTS THE N-FRACTIONS OF CELERY PETIOLES FOR THE FRESH PROCESSING INDUSTRY.

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Studies for several vegetable crops have shown that the level of fertiliser applied during the growing season affects the nutrient content of the product. However, knowledge about the effect of the level of nitrate fertiliser on the N-fractions of celery is scarce. The objective of this research was to study the effect of two N fertiliser rates on the protein, nitrate and ammonia contents of celery stalks used as raw material for the minimal fresh processing industry. Celery plants (cv. 'Istar') were grown on an inert substrate in a plastic greenhouse where, after the first month, two treatments were applied: a control (NC) with the commonly applied N concentration and a 25% reduction in N concentration (NR). Remaining nutrients were kept at the same level for NR and NC. Plants were hand harvested and the following fractions were prepared: leaves, petioles, bud, basal disc and roots. Total N, N-protein, N-nitrate and N-ammonia contents were analysed. The protein content of the petioles (fraction used by the industry for producing celery sticks) was not affected by the level of fertiliser. However, a positive correlation was found between the rate of N fertiliser and the nitrate and ammonia concentration. Since the ingestion of excessive amounts of nitrate can cause adverse effects on health, celery grown under 25% lower N supply could be considered as safer from the nutritional point of view and, at the same time, with an adequate level of proteins. Organoleptic properties were not affected by the rate of fertiliser.

S3-15

INHIBITION OF MUSHROOM BROWNING.

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Browning of harvested mushrooms is a rapid process, resulting in decreased commercial value. The process may be initiated by enzymatic oxidation of phenols such as tyrosine, to form brown pigments (melanin) or by non-enzymatic oxidation induced by different factors, including bacteria. Natural extracts and their active constituents, possessing potent tyrosinase inhibitory activities, previously isolated in our group, were tested for their ability to inhibit mushroom browning.

Cut mushroom cups were treated with different concentrations of licorice root extract, or with 3-(2,4-dihydroxyphenyl) propionic acid -DPPA (isolated from fig leaves), with or without pretreatment with H_2O_2 , and then stored at 200 °C for two days. Browning was inhibited with IC₅₀ of 0.1 PPM for liquorice extract and 1 mM for DPPA. Treatment of whole mushrooms with either liquorice or DPPA did not prevent browning, whereas treatment with 5% H_2O_2 prevented whole cup browning for 10 days at 4 °C. This treatment caused an immediate decrease by three orders of magnitude in colony forming units number (CFU), from 491 to 0.37 CFU/Cm². In conclusion, increased shelf life of mushroom might be achieved by initial treatment with H_2O_2 followed by treatment with liquorice extract or DPPA for cut mushrooms.

S3-16

EFFECTS OF FRESH-CUT ONION PROCESSING AND STORAGE ON HEALTH-PROMOTING BIOACTIVE COMPOUND QUERCETIN.

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White, yellow or red onions are known to contain a large amount of flavonoids mainly quercetin (flavonol), conjugated with sugars as glucose. Onions are recognized as the major dietary source of quercetin (aglycon or O-glycosylated derivatives) related with certain benefits to human health which include anticarcinogenic properties, antiplatelet activity, antithrombotic activity. Nowadays, the consumer demand for healthy, safe, free-additives, natural, fresh-like food, requires only minimum amount effort and time for preparation. That has led to the introduction of ready-to-eat foods prepared by mild or minimally processing methods. One type of minimally processed fruits and vegetables consist of raw fresh cut produce, which have undergone a minimal processing such as peeling, slicing or shredding, washing with 80-200 ppm of sodium hypochlorite solution, packed under modified atmosphere (MAP) in sealed pouches or trays of polymeric films and then storage at refrigerated temperature.

The present research was undertaken in order to clarify the impact of minimally processing (cutting, washing with 60 ppm sodium hypochlorite solution, MAP, refrigerated storage at 4 °C for 30 days) on the quercetin content of a common used yellow onion-bulb cultivar in Spain, Grano de Oro. Total quercetin content in raw material was 557.2 mg Kg⁻¹ f.w. No significant statistical differences in total quercetin content were shown between products packed under vacuum and MAP, at the end of 30 days at 4 °C. No significant statistical differences in total quercetin content were shown between water-washing and hypochlorite solution-washing products at the end of 30 days at 4 °C, packed under vacuum or MAP. Only slight significant differences in total quercetin content were shown between whole onion and cut onion product, in all the treatments assayed. Minimal processing seems not modified significantly the quercetin content in onion products.

EFFECT OF SANITATION TREATMENTS WITH HEATED, CHLORINATED WATER ON THE MICROBIOLOGY OF FRESH-CUT THAI MANGOES.

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Studies were conducted to investigate the effects of fruit sanitation treatments on the microbiology of fresh-cut Thai mango (cv. Chokanun). Washing in warm (50°C) or cold (12°C) chlorinated water (100 mg L⁻¹) for 5 min significantly ($p \leq 0.05$) reduced total microbial populations on the skin and stem end of mangoes. Yeast and mold populations were particularly sensitive to the effects of heat. Brushing did not significantly ($p \leq 0.05$) improve the removal of microorganisms from the fruit surface at either temperature.

Microbial populations on fresh-cut mango slices prepared from unwashed fruit were significantly ($p \leq 0.05$) higher than those prepared from washed fruit. Chlorinated water washes at both temperatures were equally effective in moderating the transfer of microorganisms from the fruit surface to the flesh. After 7 days in storage at 5°C, microbial populations on slices prepared from unwashed fruit were significantly higher ($p \leq 0.05$) than those measured on slices prepared from washed mangoes. Brushing had no effect on the microbiology of the stored mango slices.

Washing and brushing treatments did not alter chemical indices (pH, total acidity, soluble solids) or headspace gas composition (CO₂, O₂) in stored mango slices.

RESPIRATORY AND STORAGE BEHAVIOR OF FRESH CUT 'TOMMY ATKINS' MANGO.

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The respiratory and storage behavior of fresh cut 'Tommy Atkins' mango ripened naturally or with use of ethylene were studied.

Fruits were selected, washed and disinfected (200mg Cl L⁻¹) and stored for 12 hours at 10°C. After this period, they were processed under hygienic conditions at 10°C, packaged in polyethylene terephthalate trays or in styrofoam trays recovered with stretchable polyvinyl chloride film and stored for up to 15 days at 3°C. The products were evaluated regarding the evolution of internal atmosphere in the packing (O₂ and CO₂), development of weight, appearance and shelf life. The respiratory rate was measured before and after processing at each two hours.

The yield of 'Tommy Atkins' mango to produce fresh cut product was 48.09 ± 0.95%. Was verified increasing on the respiration rate of both mangoes, one hour after the preparation (naturally=17.75 mL CO₂ kg⁻¹ h⁻¹; with ethylene=28.29 mL CO₂ kg⁻¹ h⁻¹) followed stabilization at 3.76 and 8.07 mL CO₂ kg⁻¹ h⁻¹, respectively. The percentage of O₂ in packages was maintained stable in all treatments, 15-20% in PVC trays, 18-20% in PET tray. The percentage of CO₂ was stable around 1.5-2.5%. The products lost fresh mass during the storage, from 0.06% to 0.30% for PET trays and from 0.15% to 1.61% for trays covered with PVC. The appearance was considered adequate for commercialization until 13th day, wherein product from mangoes ripened with application of ethylene was for 11 days, presenting browning in the external surface. The control of hygienic conditions during de production and storage was satisfactory and with safety for until 10 days, with values <10-3 of mesophilic bacteria and no fecal coliform bacteria.

USE OF CARAMBOLA (*Averrhoa carambola* L. cv. FWANG TUNG) FRUIT AT TWO STAGES OF MATURITY FOR FRESH-CUT PRODUCTS.

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Consumption of fresh-cut horticultural products has increased in the last few years, mainly due to demand for vegetables offering convenience and safety. The biggest appeal for using carambola (*Averrhoa carambola* L.) in the fresh-cut market is the star-shape the fruit presents after a transverse cut. The star-shape slices have great potential for use in salads and fruit salads. This study was aimed at determining the most suitable stage of maturity to produce fresh-cut carambola products and to evaluate postharvest changes.

Carambola fruit (cv. Fwang Tung) were picked from the orchard of Estação Experimental de Citricultura de Bebedouro, Brazil, at two stages of maturity: mature-green (50% yellow) and mature (100% yellow). Fruit were washed with water, dipped in NaOCl solution (200 mg L⁻¹ for 5 minutes), and stored over night at 10°C. Fruit were sliced manually in to pieces of approximately 1 cm thickness. Slices were rinsed with NaOCl solution at 20 mg L⁻¹, drained for 3 minutes, and packaged in polyethylene terephthalate (PET) trays provided with a fit cover (Neoform N94). Packages were stored at 6.5°C and 85% RH for 9 days, and samples taken every 3 days for chemical, biochemical analysis, respiration, and internal atmosphere composition. Immediately after cutting, slices at both stages of maturity showed a wounding response with a 5-fold increase in respiration rate. Polygalacturonase (PG) and polyphenol oxidase (PPO) activity did not differ between stage of maturity. Despite the less mature stage being less preferred at the sensory evaluation owing to its greenish peel, the best stage of maturity for carambola fresh-cut production was mature green, due to a higher resistance to cutting, and presenting a better colour and appearance maintenance for up to 9 days.

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EFFECT OF WHEY PROTEIN-BEESWAX EDIBLE COMPOSITE COATING ON COLOR CHANGE OF FRESH-CUT PERSIMMONS CV. ROJO BRILLANTE

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Persimmon fruit cv. Rojo Brillante is an astringent variety. Application of high CO₂ concentrations allows the removal of the astringency and maintains the fruit firmness, which it makes possible to commercialized the fruit as a fresh-cut commodity. However, the commercial success is limited mainly due to enzymatic browning. The main approach to inhibit browning is the use of antibrowning agents. Recently, edible coatings have been shown to improve self life of fresh-cut fruits.

The objective of this work was to study the effect of whey protein concentrate (WPC)-beeswax (BW) edible composite coating on colour change of fresh-cut persimmons cv. Rojo brillante.

WPC-BW coatings were prepared with sodium ascorbate incorporated as antioxidants at 0%, 0.5%, 1% and 1.5% content. Persimmons were cut, immersed in citric acid and sanitized in sodium hypochlorite. Samples were dip-coated either in the WPC-BW-Ascorbate coatings or in ascorbate solutions at 0.5%, 1% and 1.5% content. Finally, samples were stored 9 days at 5°C in open or sealed trays. Texture, weight loss and colour (CIE L*a*b*, and browning index) was measured during storage.

Coating application improved texture and reduced weight loss compared to the control and ascorbate-dipped samples in open conditions. However, when samples remained closed, coatings did not improve texture and weight loss. The use of ascorbate increased L*, and reduced browning index compared to the control. Application of the coatings significantly reduced browning of the fresh-cut persimmons compared to the application of ascorbate solutions alone. Ascorbate concentrations above 1% did not further reduce browning of WPC-BW-based coated persimmons. These results indicate that WPC-BW-ascorbate coatings are effective reducing browning, weight loss and texture loss of fresh-cut persimmons compared to the use of ascorbate alone.

S3-21**OXIDATION ACTIVITY IN READY-TO-CUT ORANGES.**Ingallinera B.^{1*}, Spagna G.¹, Barbagallo R.N.¹, Bognanni R.¹, Rapisarda P.²¹Dipartimento di Orticultura, Floricoltura, Arboricoltura e Tecnologie Alimentari (DOFATA), Università di Catania, Italy; ²Istituto Sperimentale per l'Agromicoltura, Acireale (CT), Italy.

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Minimally processed fresh vegetables or "ready-to-cut" or "ready-to-eat" consist of washed, peeled, sliced or shredded raw vegetables, ready for use and, generally packed in plastic bags, stored below 6°C, and sold within 8-10 days [Pretel et al., 1998]. Ready-to-cut are mainly constituted from vegetables and, only in smaller measure, from fruit; among these the oranges presents ideal characteristics for preparation as a minimally processed product [Pretel et al., 1998]. Nevertheless, in literature has not study been found relatively ready-to-cut oranges and have not been yet completely individualized the quality indexes fit to describe the qualitative profile of the ready-to-eat oranges [Senesi et al., 2003].

In this study were studies in ready-to-cut oranges the influence of some enzymatic activities degradative found in fruits (pears, apples, peaches, etc.) and in general in vegetable minimally processed vegetables. Enzymatic tests have been conducted on oranges cut to slices and packed with films of different permeability and in normal atmosphere. Particularly have been considered Polyphenoloxidase (PPO) and the Ascorbate oxidase (AAO) as indexes of oxidation and anthocyanins and vitamin C reduction.

The PPO activity was very low, probably because of oranges pH strongly acid; tied up to this low activity, is seen that the phenols and the anthocyanins didn't reductions statistically significant. Instead, the AAO activity was very tall, such activity was correlated to a reduction of the vitamin C that nevertheless didn't overcome the 20-30%.

S3-23**EXTENDING SHELF-LIFE OF MINIMALLY PROCESSED CARROTS.**Gonçalves L.¹, Beirão-da-Costa M.L.^{1*}, Moldão-Martins M.¹¹CEAA, Instituto Superior de Agronomia, Portugal.

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Recently an increasing market demand for minimally processed vegetables has been observed. Physiological and biochemical changes in such products may occur at faster rates than in intact raw commodities due to tissue damage. Accelerated quality loss, especially in colour and firmness caused by the action of endogenous enzymes and microorganisms, may occur.

The main objective of this study was to extend the shelf-life of carrots by the application of mild heat pre treatments to whole carrots "Nantes" and modified atmosphere packaging after minimally processed. In order to optimize the treatment conditions, the response surface methodology (RSM) was applied using as independent variables: water bath temperature, the exposure treatment time and storage time. Three different atmosphere conditions were tested: passive mode (20.9 O₂ - 0.03 % CO₂), active mode (1% O₂ - 10 % CO₂) and (80% O₂ - 0.1 % CO₂). Samples were evaluated for: colour (L*a*b*), texture (conducted on a TA-XT2 texturometer), pH, solid soluble contents and exudates.

Within the considered experimental conditions, carrots submitted to mild heat pre treatment at 35°C during 60 minutes were those that better preserved the quality attributes along storage period. The modified atmosphere packaging had a little effect in extending the shelf life of carrot processed. The carrot submitted to selected mild heat pre treatment, minimally processed and packed under passive mode atmosphere, showed less susceptibility to browning and dehydration.

S3-22**SHELF LIFE OF MINIMALLY PROCESSED MELON IN PROTECTIVE ATMOSPHERE.**Nicolais V.^{1*}, Maturi T.², Villani F.¹, Barbieri G.², Masi P.¹¹Department of Food Science; ²Department of Agricultural Engineering and Agronomy, Università degli Studi di Napoli, Federico II, Portici (NA), Italy.

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Physical and biological processes, due to the interactions between foods and the surrounding environment, cause food qualitative decay. Many technological trials have the purpose to stabilize the products allowing to get a shelf life suitable to distribution demands and to the marketing. In the last years it was introduced a new packaging technology that foresees the inclusion of gas in the package. Such application is named Modified Atmosphere Packaging (MAP) and has the function to preserve for a long time the initial hygienic and sensory quality of the more perishable products.

The research was turned to the application of the new packaging technologies in protective atmosphere on melon slices (*Cucumis melo* L., var. reticulata, cv. Zagar). It is a ready to eat product, that has already suffered, before the marketing phase and the distribution, some preliminary processes (washing, peel and seeds elimination, cut and packaging), that confer to the product an elevated convenience. Samples of melon were packaged in trays containing three different gaseous mixtures: A=78% N₂, 21% O₂, 1% CO₂ (control); B=90% N₂, 5% O₂, 5% CO₂ and C=85% N₂, 10% O₂, 5% CO₂. Each of these packages were stored at 4±1 °C for 10 days. During product shelf life, microbial, sensorial and instrumental analysis were effected after 4, 7 and 10 days of storage, so to get the best and more complete information on the product global quality decay, on the alteration of their sensory profile and the nature of physical, chemical or biological phenomena responsible of the possible alterations.

S3-24**EFFECT OF DECONTAMINATION BY INTENSE LIGHT PULSES ON THE SHELF-LIFE OF TWO MINIMALLY PROCESSED VEGETABLES.**Gómez-López V.M.¹, Devlieghere F.^{2*}, Debever J.²¹Instituto de Ciencias y Tecnología de Alimentos, Facultad de Ciencias, Universidad Central de Venezuela; ²Laboratory of Food Microbiology and Food Preservation, Department of Food Technology and Nutrition, Ghent University, Belgium.

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Intense light pulses (ILP) is a novel technique proposed to decontaminate food surfaces by killing microorganisms using short time high frequency pulses of an intense broad spectrum, rich UV-C light. Minimally processed vegetables (MPV) have a short shelf-life and can only be decontaminated by mild treatments that do not impair their fresh-like attributes. To this date, no report is known on the effect of ILP on the shelf-life of MPV. In this study, the effect of an ILP treatment 45 seconds/side long, at 12.8 cm distance, on the shelf-life of minimally processed white cabbage (*Brassica oleracea*) and Iceberg lettuce (*Lactuca sativa*) stored at 7°C for 9 days in equilibrium modified atmosphere (3% O₂, 7% CO₂) was studied by monitoring headspace gas concentrations, microbial populations and sensory attributes.

Respiration rates at 3% O₂ and 7°C were 16.2, 17.7, 9.2 and 16.1 ml O₂ h⁻¹ kg⁻¹ product for control and treated cabbage, and control and treated lettuce respectively. ILP treatment of cabbage reduced total aerobic psychotropic counts (TPC) with 0.44 log and yeasts counts with 0.27 log. At day 2, TPC from treated samples became higher than those from controls, and reached the acceptability limit (8 log) at day 7, when panel detected unacceptable levels of off-odour, while TPC from controls never reached 8 log; yeasts counts kept lower in treated than in control samples and never exceeded 5 logs; lactic acid bacteria were not detected (<1 log CFU g⁻¹). At day 9, treated samples were rejected due to spoiled taste and browning, while controls were never rejected.

QUALITY MAINTENANCE OF FENNELS AS A FRESH CUT PRODUCTS.

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Fennel production in Italy is quite large especially in Central Italy. Fennels can be eaten cooked or as fresh vegetable. In this last case are available at the retail market also as a minimally processed product. Freshness, nutritional content, and sensorial aspects like visual quality and taste, represent the main important characteristics.

The aim of our research was to give suggestions to prolong the shelf life of the fennels as a "ready to eat" vegetable. Sliced fennel were placed in trays packaged with two different polyester films (MAP), sliced fennel packed in perforated film served as control, and kept at 4°C (R.H. 85%) for 9 days; respiration rate, weight loss and colour changes were evaluated. Panel tests were also carried out.

Wound-induced stress due to peeling, cutting and slicing affected a lot of physiological responses like respiration rate, ethylene production, enzymatic browning and dehydration. Particularly we noted that weight loss of fresh cut fennel kept in perforated film was about 18% and 3% after 9 days at 20°C and 4°C respectively and respiration rate was 40 mg kg⁻¹ h⁻¹ and 24 mg kg⁻¹ h⁻¹ of CO₂. After cold storage fennel stored in modified atmosphere packaging showed good quality attributes, no weight loss and we didn't note off flavours.

GUAVA FRUITS (*Psidium guajava* L.) MINIMALLY PROCESSED.Durigan J.F.^{1*}¹FCAV, Jaboticabal, UNESP, Brazil.

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Guavas 'Paluma' and 'Pedro Sato', after internal quality evaluation using tomography of magnetic resonance, were used to produce fresh-cut products, by peeling or not, cut in halves and by taking out their seeds, and they were packaged in styropor trays covered with PVC film or in PET package with lid. These packages were stored for 12 days at 5°C, 10°C and environment temperature (22,6°C). The evaluations by tomography permitted to observe that impact produced an internal bruising with loss of cellular integrity and liquefied the placental tissues. The compression was more evident at pericarp and the cuts promoted superficial deformations. The storage temperature influenced the loss of fresh mass on both packages, with styropor tray allowed a greater loss. The peeling did not influence this loss. The appearance was spoiled during the storage, which was more intense in environment temperature, influencing the product's shelf life, that under refrigeration was 8 days, with low microbiological content (<103 UFC.g⁻¹) and absence of coliforms. The packages didn't influence the chemical parameters evaluated. The peeling reduced the contents of ascorbic acid and total soluble solids. The internal structure of chunks did not show modifications, observed by tomography, until the 5th day.

The use of calcium to protect the fresh-cut products was not efficient. The calcium absorption capacity of 'Pedro Sato' guavas was tested by using ⁴⁵Ca. Fruits treated with 2% CaCl₂, containing or not the radioisotope were divided in four layers (epicarp, mesocarp, endocarp and seed) and analyzed for the total and ⁴⁵Ca calcium content. Guavas presented in all four layers a greater amount of total calcium, however the autoradiograph indicate that calcium stayed in the surface of epicarp.

ANTIOXIDANT PHENOLICS IN ESCAROLE AND RADICCHIO DURING STORAGE OF FRESH-CUT 'READY TO USE' PRODUCT.

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In this study, escarole (*Cichorium endivia* L. var. *latifolium* Hegi) and radicchio rosso di Chioggia (*C. intybus* L.) were considered. Phenolic composition and content, polyphenoloxidase (PPO) and peroxidase (POD) activities and antioxidant capacity "in vitro" were assessed during the storage for nine days at 4°C of the fresh-cut product packed in polyethylene bags in air atmosphere (commercial conditions).

Both species showed to be rich in chlorogenic acid, other caffeic acid derivatives and some flavonoids (kaempferol glycosides in escarole and quercetin glycosides in radicchio). Moreover, in radicchio four anthocyanins, one of which particularly abundant (probably identified as kuromanin), were found. The total phenolic content in 'radicchio' was about 4-5 times higher than in escarole. Phenolic compounds showed the tendency to a gradual decrease during storage, followed by an increase more marked in escarole, in which it is evident after the fifth day in storage. Changes in oxidative enzyme activities were in good agreement with phenolic content variation: in particular, PPO activity had the same trend as chlorogenic acid (low initial decrease followed by an increase), whereas POD activity, initially stable, increased after the fifth day in storage, more markedly in escarole and slowly in radicchio.

Both species showed a good level of 'antioxidant potential' until the end of the commercially accepted storage period for MPV (seven days in Italy and EU countries). There was some evidence that after the fifth/sixth day in storage phenolic compound content increased due to the low temperature. So, towards the end of its shelf-life, the product tended to increase its nutritional value (with respect to the antioxidant capacity). This finding will be more important, if in the future it will be possible, due to innovative technologies, to extend by 2-3 days the shelf-life of minimally processed leafy vegetables.

FRESH-CUT PRODUCTS FROM CACTUS SPECIES.

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Various species of Cactaceae family can serve as a source of delicious and nourishing fresh products having a number of documented positive health effects. However, today their consumption is mainly limited to very specific ethnic niches. Marketing cacti as ready-to-eat (fresh-cut) products may significantly expand their consumption, on condition that quality, safety and longevity of the product would answer the demands of the market.

The present study involved a number of fresh-cut products prepared from different edible cactus species, e.g. sliced and/or peeled fruit of cactus pear *Opuntia ficus-indica*, sliced and/or peeled fruit of pitaya (dragon fruit) *Hylocereus undatus*, peeled fruit of cactus apple (koubou) *Cereus peruvianus*, sliced pads of vegetable cactus (nopalitos) *Nopalea cochenillifera*.

The lifespan of the products depended on storage temperature. Peeled cactus pear and pitaya fruit could be stored at 4°C for at least 14 days with acceptable visual, organoleptic and microbiological quality. At 8°C, storage duration of more than 10 days was accompanied by a sharp increase of yeast population. At 20°C, peeled cactus fruit could be kept for not more than 2 to 3 days before demonstrating decay signs. Packaging peeled cactus fruits in micro-perforated polypropylene film allowed better quality maintenance than in the case of macroperforated film (holes of 5 mm in diameter). Slicing markedly accelerated the deterioration of texture and flavor of cactus pears as compared to peeled non-sliced fruit.

Trial shipment of peeled cactus fruit from Israel to Europe was well accepted by marketing experts.

EFFECTS OF MINIMALLY PROCESSING AND TEMPERATURE ON RESPIRATION RATE OF CARROT (VAR. NANTES).

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Consumer's increased interest in fruits and vegetables as 'healthy' foods with zero cholesterol, low to no fat and sodium, and high levels of vitamins, minerals and fiber, has accelerated an increased effort to improve the quality of those products through the marketing system.

A new category of products, called Minimally Processed (MP) vegetables has arisen. They are intended to be presented to the consumer conveniently peeled, cored or sliced in prepared packages, with fresh-like quality and ready to be eaten, comprise a fresh convenient product, but they are highly perishable. New methods of solving degradation problems of MP products must be developed.

The respiration rate of vegetable products is an important indicator of metabolic activity allowing predicting the shelf life. The knowledge of the nutritional impact of minimal processing operations on these products will be an advantage for the producers that will possess information that will create new markets.

The aim of this work was to evaluate the influence of minimally processing operations as well as temperature on the respiration rate of carrots (var. Nantes). Minimally processing operations caused a remarkable impact on the respiration rate of carrots stored at 4°C and 20°C. Low storage temperature was a good inhibitor of the respiration rate, contributing to the improvement of shelf life.

EFFECT OF TISSUE WOUNDING ON CALORIMETRIC MEASUREMENTS OF VEGETABLE METABOLISM.

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When plant tissue is wounded, a number of protective processes start. We have made a study by isothermal calorimetry of the response of some vegetable tissue to wounding. Samples with different surface to volume ratios were prepared from carrots, potatoes and swedes (rutabaga) and the overall metabolic heat was measured in closed glass ampoules in a TAM Air isothermal calorimeter. The evaluation was made by assuming that a certain heat production rate per volume tissue was associated with the normal metabolism, and that another heat production rate per surface area was associated with the wound response.

The results showed that the wound response part was high; in some cases the major part of the heat came from the wound response and not from the ordinary metabolism. This is an important factor to take into account when making calorimetry on wounded tissue. It also shows that isothermal calorimetry can be used for the study of wound response in vegetable tissue. Measurements such as the ones shown here can be used to optimize experiments with respect to this problem.

EFFECTS OF STABILIZING TREATMENTS AND PACKAGING ON MINIMALLY PROCESSED FENNELS.

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Minimally processed vegetables are ready to eat products, with shelf-life of 5-6 days. The physical damage or wounding caused by preparation increases respiration and ethylene production within minutes, and associated increases occur in rates of microbial growth and enzymatic browning, with consequent changes in colour (such as russet spotting and brow stain), flavour, texture, and nutritional quality loss.

Among minimally processed vegetables, fennel is not a widespread product due to speed with whom enzymatic browning occurs (within 48 h). In order to extend shelf-life of fresh-cut fennels, effects of treatments with stabilizing solutions and different packaging conditions were studied. Washed and cut samples were treated with several stabilizing solutions (ascorbic acid, citric acid, ethanol, SO₂) straight before packaging; this was carried out both in modified atmosphere (75% N₂, 20% CO₂, 5% O₂) using an impermeable PET film and in ordinary atmosphere using a semipermeable film (MRX, Cryovac). During the storage at 4°C polyphenoloxidase activity, colour changes (measured as L*a*b* values) and level of main microbial groups were monitored.

Good results were obtained with SO₂ and ethanol pretreatments followed by modified atmosphere packaging and ordinary atmosphere packaging with semipermeable film, with shelf-life extension up to 8 days. Moreover it was observed that the studied cultivars are different both in terms of polyphenoloxidase activity and indigenous microflora.

EFFECT OF OZONATED WATER, MODIFIED ATMOSPHERE PACKAGING AND DIFFERENT STORAGE TEMPERATURE ON SHELF LIFE OF CUT LETTUCE (*Lactuca sativa acephala*) AND ARUGOLA (*Diplotaxis* spp.).

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Several experiment were carried out in order to assess the effect of different post-harvest treatments on quality and shelf life and in reducing microbiological spoilage during storage, of cut lettuce and arugola. Applied treatments were as follows:

-Disinfection with ozone (about 1.5 ppm) added to the washing water and storage at 5°C;

-Packaging in plastic bags with Modified Atmosphere with different O₂/CO₂ (2/5; 2/10; 5/5; 5/10; 5/14; 12/10; 15/5; 15/10) and N protoxide/O₂ (80/20; 85/15; 90/10) ratios and storage at 2 or 5°C.

Lettuce and arugola leaves were stored for 3, 5 and 15 days and O₂ and CO₂ concentrations, ethylene evolution, ethanol ed acetaldehyde production were monitored. At the end of each storage period, colour was measured and the overall visual quality (leaves and cut surface browning, wilting and rotting) was estimated adopting a visual score system. A sensory panel of trained panelists evaluated appearance, texture, turgidity, crispness, juiciness, odours of the produce after each storage period.

Ozonated water did not affect physiological and quality parameters during storage but, as a trend, reduced the oxidation of the cut surfaces. N protoxide coupled with temperature of 5°C resulted to be the best treatment to prolong shelf-life and maintain quality and visual characteristics for 15 days. High CO₂ rates, mainly when applied with the lowest O₂ concentrations, negatively affected quality parameters of both produce. Similarly to ozonated water, atmospheres containing low CO₂ concentrations (5%) appeared to reduce cut surface oxidation.

SESSION 4 (S4)

SENESCENCE AND ABSCISSION



S4-01**FRUIT ABSCISSION AS RELATED TO FRUIT QUALITY.**Ramina A.^{1*}¹Dip. Agronomia Ambientale e Produzioni Vegetali, University of Padova, Italy.*Presenter (angelo.ramina@unipd.it)

Many fruit species bear an abundance of flowers which produce a surplus of fruit that the tree is unable to support. In anticipation of this, the major fruit species developed an immature fruit physiological drop as self regulatory mechanism. From a horticultural point of view, this self regulating mechanism may be too strong or entirely insufficient. To overcome these shortcomings bio regulators are currently used. Knowing more precisely about molecular mechanism underlying natural fruitlet abscission would help in setting up more efficient control strategies.

In this context peach and apple fruitlets were assumed as study models. Fruitlet abscission is a highly coordinated event. It involves multiple changes in cell structure, metabolism and gene expression, leading to cell separation occurring in specific tissues designated as abscission zone (AZ). Anatomical, biochemical and molecular events associated with cell separation at fruit AZ level have been described. Increases of expression and activity of specific cell wall hydrolases, as well as other proteins as expansins, a metallothionein-like protein, and pathogenesis related (PR) proteins have been reported.

Ethylene and IAA regulate abscission. The general interaction between the two hormones is manifested in their antagonistic relationship, when the IAA status of the tissues controls its sensitivity to ethylene. On the other hand ethylene is a potent inhibitor of IAA, interfering with its polar transport. It has been demonstrated that the activation of fruit abscission is preceded by the stimulation of ethylene biosynthesis and the up regulation of an ethylene specific receptor. At the moment efforts are made to sort out additional abscission related genes that might be used for constructing molecular tools useful in screening new chemical thinners or in selecting self-thinning varieties.

S4-03**FUNCTIONAL GENOMICS AND BIOTECHNOLOGY OF BROCCOLI YELLOWING ASSOCIATED GENES.**Shaw J.F.^{1*}¹Institute of Botany, Academia Sinica, Taipei, Taiwan.*Presenter (bopshaw@gate.sinica.edu.tw)

Broccoli (*Brassica oleracea*) florets senesce and turn yellow rapidly after harvest. Subtractive hybridization technique was used to clone over 300 cDNAs with enhanced expression during floret senescence. These include genes involved in cell wall degradation (pectinesterase, polygalacturonase, pectin methylesterase), chlorophyll degradation (chlorophyllases), carbohydrate metabolism (fumarase, aconitase, sucrose synthase, fructose-biphosphate aldolase, pyruvate dehydrogenase), protein and amino acid metabolism (asparagine synthase, glutamine synthase, glutamate dehydrogenase, cysteine protease), nucleic acid metabolism (hypoxanthin-guanine phosphoribosyltransferase, bifunctional nuclease), lipid metabolism (beta-ketoacylthiolase, oleosin-like protein, digalactosyldiacylglycerol synthase, fatty acid binding protein), signal transduction (ethylene receptors, protein kinases, jasmonic acid regulatory protein, A. thaliana mRNA protein kinase), environmental and oxidative stress (metallothionein (MT1 and MT2), cytochrome P450, antifungal protein, catalase, 1-aminocyclopropane-1-carboxylate oxidase (ACC oxidase), drought-induced protein, 1,2-dioxygenase, GA-stimulate transcript (GAST1), gamma-glutamylcysteine synthase), and many other unknown functional genes. Some of these senescence associated genes have been cloned, expressed and characterized, including broccoli ACC oxidase, cysteine protease, caffeoyl CoA 3-o-methyltransferase, chlorophyllase, ethylene receptors (ETR1 and ERS), CTR1, metallothionein, bifunctional nuclease and antifungal protein. Some of these senescence-associated genes have been cloned, expressed and characterized, including broccoli ACC oxidase, cysteine protease, caffeoyl CoA 3-o-methyltransferase, chlorophyllase, ethylene receptors (ETR1 and ERS), CTR1, metallothionein, bifunctional nuclease and antifungal protein. An antifungal protein and chlorophyllase will be discussed.

A broccoli floret senescence-associated cDNA microarray was used to analyze the expression profile of these genes during senescence. A mutated broccoli boers-1 gene has been successfully transferred into broccoli and the floret yellowing was delayed for 3 days. Similarly, the mutated boers gene was transferred into petunia and the excised flowers remained fresh for 18 days, or five times longer than those of the control.

S4-02**PREVENTION OF BUD AND FLORET ABSCISSION IN CESTRUM CUT FLOWERS DEPENDS ON THE MODE OF TRANSPORT AND METABOLISM OF SYNTHETIC AUXINS.**Abebie B.^{1*}, Goren R.¹, Huberman M.¹, Meir S.², Philosoph-Hadas S.², Rivov J.¹¹The Hebrew University of Jerusalem, The Robert H. Smith Institute of Plant Sciences and Genetics in agriculture, The Kennedy Leigh Center for Horticultural Research, Rehovot, Israel; ²ARO, The Volcani Center, Bet Dagan, Israel.*Presenter (Bekele@agri.huji.ac.il)

Red Cestrum (*Cestrum elegans* Schlecht.) cut flowers are considered as a new export crop from Israel, although they exhibit both bud and floret abscission during shipment. However, pulsing Cestrum cut flowers for 4 h at 20°C + 16 h at 4°C with 2,4-dichlorophenoxyacetic acid (2,4-D) combined with sliver thiosulfate (STS) significantly reduced abscission, while 1-naphthaleneacetic acid (NAA) failed to do so.

Contrary to its inhibitory effect on floret abscission, 2,4-D induced higher level of ethylene evolution compared to NAA. The data suggest that 2,4-D moved acropetally in a significant amount, sufficient to reduce floret abscission, while NAA did not. These surprising results lead us to study the mode of transport of 2,4-D and NAA in stem sections and intact shoots. In stem sections, transport of NAA was polar with a velocity of 5.92 mm per h. Although the major 2,4-D transport was also polar, it contains a significant non-polar transport component: a fast transport during the first 15 minutes both in the acropetal and basipetal directions, followed by a progressively increased basipetal and decreased acropetal transport. During the transport period of 3 to 11 h, 2,4-D moved at a rate of 1.87 mm per h in the basipetal direction.

Studies with intact flowering shoots also showed a significant acropetal transport and accumulation of 2,4-D in the upper parts of the stem, leaves and florets, while NAA mainly accumulated in the lower parts of the stem. In addition, NAA was metabolized in florets and leaves faster and more than 2,4-D. This suggests that like other abscission systems, the interaction between ethylene and free auxin level, in the tissues, control abscission of buds and florets in Cestrum.

S4-04**FLORAL SENESCENCE: IDENTIFICATION AND CHARACTERIZATION OF DIFFERENT PATTERNS OF PROTEOLYTIC ACTIVITIES IN *Iris oncocyclus* AND LISIANTHUS CUT FLOWERS.**Philosoph-Hadas S.^{1*}, Friedman H.¹, Lers A.¹, Kochanek B.¹, Halevy A.H.², Meir S.¹¹Dept. of Postharvest Science of Fresh Produce, ARO, The Volcani Center, Israel; ²Institute of Plant Sciences and Genetics in Agriculture, Faculty of Agriculture, The Hebrew University of Jerusalem, Israel.*Presenter (vtsoniap@volcani.agri.gov.il)

Proteolysis seems to be a dominant process in flower senescence, involved in programmed cell death (PCD). Several petal development-induced proteases operating during flower opening and senescence were visualized and characterized in *Iris oncocyclus* and *Lisianthus* (*Eustoma grandiflorum*) cut flowers. *Iris* flower senescence was associated with a decline in petal fresh and dry weight and protein content, and an increase in cell sap pH, amino acid content and ion leakage. Cycloheximide (CHI), inhibitor of de novo protein synthesis, delayed significantly flower senescence when applied at a full open stage.

Analysis of petal proteolytic activity during flower opening, maturation and senescence using activity gels revealed in *Iris* three distinct activities (25-50 kDa), detected already at the stages of closed bud, but significantly enhanced at late senescence stages. The optimal pH for these activities was 3.5, suggestive of vacuole localization. All three protease activities were eliminated by either E64 (cysteine protease inhibitor), leupeptin or PMSF (serine and cysteine proteases inhibitors), and were significantly enhanced by dithiothreitol (DTT), strongly suggesting them to be cysteine proteases.

In *Lisianthus* petals two protease activities of 41 and 50 kDa with pH optimum at 3.5 and one activity of 82 kDa with pH optimum at 7.5 were detected. These activities, already evident during flower opening stages, peaked at initial stages of senescence but declined at more advanced stages, and were inhibited by CHI. The pH optima of the protease activities in *Lisianthus* are suggestive of both vacuole and cytoplasm localization. Our findings suggest that floral opening and senescence in *Iris* and *Lisianthus* are active processes involving de novo protein synthesis of proteolytic enzymes. The different patterns of proteolytic activities obtained may explain the relative rates of senescence of *Iris* and *Lisianthus* cut flowers, whose vase life spans 3 or 6 days, respectively.

FUNCTIONAL ANALYSIS OF GENES ASSOCIATED WITH FLOWER SENE- SCENCE.

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In the past decade researchers have reported increasingly comprehensive cDNA libraries of genes associated with floral senescence in ethylene-dependent and ethylene-independent floral crops, including daylily, carnation, iris, daffodil and petunia. Analysis of the function of these genes in flower senescence has depended on the slow process of stable transformation and regeneration of the plants to up- or down- regulate individual target genes. We have adopted an alternative strategy, using virus-induced gene silencing (VIGS) to evaluate the effects on flower senescence of silencing genes whose up-regulation is associated with flower senescence. Using petunia as our test organism, we infect with tandem constructs where the RNA2 of tobacco rattle virus (TRV) is modified by insertion of chalcone synthase and the target gene. Where virus infection occurs, the plant's silencing mechanism also silences chalcone synthase (a key enzyme in anthocyanin biosynthesis), resulting in white sectors on the otherwise purple flowers.

The effect of the test gene on flower senescence can be determined by comparing the pattern of senescence in the purple and white sectors in individual flowers. Since it is likely that the senescence process is coordinated through control elements such as transcription factors, kinases, and DNA binding factors our studies have focused on transcription factors identified in a large EST database housed at the University of Florida. The results of VIGS silencing of selected transcription factors on flower senescence will be reported.

ABSCISSION IN POINSETTIA.

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Poinsettia (*Euphorbia pulcherrima*) is a short day plant that initiates flowering when exposed to a photoperiod reduced beyond a critical value. Further development of the flowers (cyathium, pseudo-flower) is influenced by other environmental conditions. If the conditions during cyathium development are not optimal, their development is either delayed or subject to pre-mature abscission. Pre-mature abscission is undesired in poinsettia because it reduces the quality and the market value of this popular Christmas flower. Although it has been recognized that low light conditions might trigger cyathia abscission, the environmental regulation as well as the biological background of their abscission has not been investigated.

Generally abscission is heavily based on inter organ signalling events, but it is not clear at present how these signals co-ordinate the events within the abscission zone. The breakdown of cell wall matrix is likely to be a complex process involving highly co-ordinated series of changes in cell wall structure, cell physiology and gene expression. We use physiological, cellular and molecular tools as well as transgenic plants to elucidate the events.

Our lab has further developed a transformation method by electroporation to transfer plasmids into meristems of intact plants. We use reporter genes like GUS and GFP and promoters that are constitutive (35S) and AZ specific to visualize successful transformations and expression. We have also developed a method to reduce and synchronize abscission in poinsettia. RNA in situ hybridization with probes against potential AZ specific cell wall degrading enzymes can identify active enzymes at various time points during abscission. Differential display is used to compare mRNA from non-induced and induced AZ of cyathia. We expect to identify novel genes and/or verify genes known from other plants to be involved in abscission.

FUNCTION AND REGULATION OF PLANT SENESENCE-RELATED NUCLEASES.

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Induction of nuclease and ribonuclease activities is characteristic to senescence in higher plants. These activities are likely to be involved in nucleic acids catabolism; however, the regulation and specific function of these enzymes and their encoding genes are unclear. LX ribonuclease transcript and protein were found to be induced during tomato natural leaf senescence, as well as, following ethylene treatment in young leaves. Consequence of inhibited LX expression is investigated in tomato. LX promoter can confer senescence-specific expression to the GUS reporter gene in Arabidopsis. The bifunctional nuclease BFN1 is associated with Arabidopsis leaf senescence and its function is examined in knockout mutants. bin1 promoter can activate GUS senescence-specific expression in Arabidopsis and tomato. The ability LX/bin1 promoters to activate expression in conditions/tissues other than senescence are investigated. In parsley, senescence-related nuclease activities. Pcnuc1 and Pcnuc2 of ~43 and ~40 kDa MW, respectively, were purified and characterized.

The two glycosylated nucleases are identical in the determined amino acid sequence and possibly differ in the sugar moiety. Pcnuc2 nuclease was subjected to biochemical and kinetic analyses demonstrating its ability to degrade both RNA and DNA with higher efficiency manifested toward DNA. The ability of the enzyme to degrade double-stranded plasmid DNA following an initial endonucleolytic digest was demonstrated. Pcnuc1/2 transcript is highly and specifically induced in both naturally and postharvest senescing parsley leaves but can be induced in young leaves by ethylene. The deduced amino acid sequence of Pcnuc1/2 exhibits high homology to other senescence/PCD-related nucleases in plants, including BFN1. Senescence-associated plant nucleases are likely to have a major role in highly organized system for nucleic acid and phosphate recycling in the senescing tissues; however, it is possible they function also in other plant senescence-unrelated developmental stages/tissues.

EFFECTS OF 2,4 D, 2,4 DP, TRICLOPIR AND GA ON PREHARVEST FRUIT DROP AND SENESENCE OF "TAROCCO" BLOOD ORANGES IN SICILY CITRUS ORCHARD.

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"Tarocco" blood orange [*Citrus sinensis* (L.) Osb.] has a tendency for a heavy natural abscission of mature fruits. The present experiment was intended to reduce this problem and consequently expanding the harvest season, improving fruit marketing. During the period 2000/03 effects of the plant growth regulators (PGRs) on senescence and incidence of pre-harvest fruit drop of blood oranges were studied in field experiments.

The best effects of 2,4D, 2,4 DP, triclopir (32 to 10 ppm) and GA (9 ppm) for to delay and reduce unwanted fruit abscission and senescence of "Tarocco" blood orange were achieved when spray has been applied on October through December. At harvest residue was researched but it was not detected, however at this moment in Italy for citrus, the only authorized pre harvest PGRs are GA and triclopir.

S4-10**EFFECT OF 1-MCP ON THE POST-HARVEST PERFORMANCE OF UNROOTED POINSETTIA CUTTINGS.**Faust J.E.¹*, Lewis K.P.¹¹Clemson University, USA.

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Unrooted poinsettia (*Euphorbia pulcherrima* 'Eckespoint Freedom') cuttings were placed into plastic bags at 10, 18, and 26°C for 72 h. 1-MCP was placed into one half of the bags at each temperature, while the other half served as a control. Ethylene concentrations inside the bag were measured at 0, 12, 24, 48, and 72 h. The cuttings were placed on a propagation bench following 72 h of storage and leaf senescence was recorded over the following week. In the control packages (without 1-MCP), the ethylene concentration measured at 48 h increased from 0 to 0.3 ppm as the temperature increased from 10 to 26°C. In the packages containing 1-MCP, the ethylene concentration measured at 48 h increased from 0 to 1.8 ppm as the temperature increased from 10 to 26°C. Therefore, no ethylene was produced by the cuttings at 10°C, and 1-MCP resulted in higher ethylene concentrations in the packages stored at 18 and 26°C. Leaf senescence increased in the control packages as temperature increased from 10 to 26°C, while 1-MCP reduced leaf senescence at all temperatures. For example, at 26°C, the control had 1.3 abscised leaves per cutting, while the 1-MCP treated cuttings had 0.3 abscised leaves per cutting.

A follow-up experiment was conducted in which ten poinsettia cultivars were placed in commercial packages with and without 1-MCP and shipped via standard methods and environmental conditions. 1-MCP significantly reduced leaf senescence in propagation following shipping on all cultivars that were susceptible to leaf senescence. Resistant cultivars displayed little leaf senescence despite being exposed to similar ethylene concentrations as the susceptible cultivars. Therefore, 1-MCP provides a viable means of reducing leaf senescence of unrooted poinsettia cuttings following shipping at non-optimal temperatures.

S4-12**DELAYING SENESCENCE IN BROCCOLI BY GENETIC MODIFICATION.**Eason J.¹, Gapper N.¹, Christey M.², Coupe S.³, McKenzie M.¹, Braun R.², Watson L.¹, Ryan D.¹, Pinkney T.¹, Brummell D.¹*, Heyes J.¹¹NZ Institute for Crop and Food Research, Palmerston North, New Zealand;²NZ Institute for Crop and Food Research, Christchurch, New Zealand;³Dept of Animal and Plant Sciences, University of Sheffield, Sheffield, UK.

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Broccoli is a highly perishable vegetable recognised for its beneficial contribution to our diet. In practical post-harvest terms, fresh broccoli export to distant markets is achievable provided broccoli is stored at close to 0°C, in packaging which retains turgor. Nevertheless the subsequent shelf life becomes increasingly short as the storage duration increases.

Our group has been characterising senescence in broccoli for many years and has described details of the processes which accompany senescence (e.g. water loss, ethylene evolution, yellowing, sugar consumption, protein breakdown) and accompanying changes in gene expression. We have now used anti-sense technology to suppress a number of genes whose expression is normally up-regulated during senescence as a means of testing their significance in the progression of broccoli deterioration. These genes were selected from a range of different pathways including protein breakdown, sugar metabolism and ethylene biosynthesis. Some of these genes play useful roles in growing plants so we restricted the expression of the anti-sense genes to the post-harvest period by using the asparagine synthase promoter. In addition we over-expressed a cytokinin biosynthetic gene (iso-pentenyl transferase) using the SAG12 promoter.

Transgenic broccoli lines with delayed leaf senescence were selected and used in a glasshouse trial. Harvested heads were stored at 20°C and data were collected on colour change and water loss as well as biochemical and molecular data. After four days shelf life some transgenic lines showed delayed senescence but others did not. This multi-target approach tackling genes involved in different pathways has provided fresh insights into the control of post-harvest senescence.

S4-11**FLOWER LONGEVITY AND ETHYLENE PRODUCTION IN DIFFERENT DEVELOPMENT STAGES AND TREATMENTS IN LILIUM.**Burchi G.¹*, Ferrante A.², Nesi B.¹, Grassotti A.¹, Mensuali-Sodi A.³¹Istituto Sperimentale per la Floricoltura, Pescia, Italy; ²Dip. Biologia dellePiante Agrarie, Pisa, Italy; ³Scuola Superiore S. Anna, Pisa, Italy.

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Many studies were carried out on cut flower senescence in Lilium. The published data are often controversial. Some authors and flower auction systems recommend the growers to treat lilies with ethylene antagonists before commercialization. Other experiments indicated that ethylene inhibitors do not improve flower longevity, suggesting that the role of ethylene in cut lilies senescence has limited importance. Other authors demonstrated that cut lilies stored at 4°C before commercialisation have longer vase life when treated with ethylene antagonists.

In this work, flower longevity and ethylene evolution were measured both in intact flowers (from stems left on the plant or placed in water immediately after harvest) and in separated organs (tepals, pistils, stamens and leaves). Asiatic hybrids (cvs. Elite and Prato) were soil-grown in the Research Station of Pescia (Italy). Stems were harvested at a stage where the first bud was fully coloured and within 2 days of opening. At the same stage, some flowers were labelled and left on the plant.

The vase life of cut stems was 9.2 and 9.0 days, in Prato and Elite respectively, and blasting or uncomplete opening of apical buds was observed. A longer life (13-14 days) and a complete development of all flowers was observed in attached stems. The ethylene production was low during the first stages of flower development (0.4-0.7 nl g⁻¹ h⁻¹) and increased during senescence (3.2-3.5 and 1.3-1.5 nl g⁻¹ h⁻¹ at the end of vase life in Elite and Prato respectively), but no climacteric peak was observed. The ethylene production was higher in attached than in detached flowers in Elite. Ethylene production measured in separated organs showed that the pistils produce higher levels at bud stage and that release decreases during development.

S4-13**ETHYLENE PRODUCTION AND POST-POLLINATION DEVELOPMENT OF DENDROBIUM FLOWERS FOLLOWING COMPATIBLE AND INCOMPATIBLE POLLINATION.**Luangsuwalai K.¹*, Ketsa S.¹¹Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

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Pollination is an important phenomena to hasten premature senescence of petals. In this research, open florets of *Dendrobium* 'Kenny' were pollinated by pollinia from five cultivars, and they were held in distilled water at ambient temperature. Ethylene production and post-pollination development following pollination were monitored. Characteristics of ethylene production and post-pollination development following pollination of *Dendrobium* 'Kenny' used pollinia from five cultivars were divided into two groups. The first group was compatible pollination consisted of flowers pollinated by pollinia from *Dendrobium* 'Sakura', *Dendrobium* 'Willie', and *Dendrobium* 'Pompadour'. Pollinated flowers by compatible pollination showed a premature senescence within a day after pollination. The second group was incompatible pollination consisted of flowers pollinated by pollinia from *Dendrobium* 'Karen' and *Dendrobium* 'Kenny'. Pollinated flowers by incompatible pollination did not show a premature senescence. Pollination by pollinia from two cultivars, *Dendrobium* 'Sakura' and *Dendrobium* 'Karen', were selected to represent of compatible pollination and incompatible pollination, respectively. To compare ethylene production, 1-amonocyclopropane-1-carboxylic acid (ACC) content, ACC synthase activity and ACC oxidase activity. The result showed that pollination induced rapidly ethylene production. Compatible pollinated *Dendrobium* flowers produced ethylene higher than incompatible pollination. ACC content and activities of ACC synthase and ACC oxidase in flowers pollinated by compatible pollination were higher than that flowers pollinated by incompatible pollination.

EFFECT OF RELATIVE HUMIDITY AND GAS COMPOSITIONS ON SENESCENT SPOTTING OF BANANA.

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Effects of relative humidity (RH) and gas compositions on senescent spotting of 'Kluai Khai' (Musa AA Group) were studied at room temperature (29 °C). Bananas ripened at colour index 3-4 were wrapped with PVC films without and with silica gel. Senescent spotting of bananas in PVC film packages with and without silica gel was slightly different. RH in PVC film packages without silica gel was about 90%, while RH in PVC film packages with silica gel was about 70%. Carbon dioxide concentrations in PVC film packages with and without silica gel were about 6%. Oxygen and ethylene in PVC film packages with silica gel were about 3.8% and 3-6 ppm, respectively, while oxygen and ethylene concentrations in PVC film packages without silica gel were about 4.2% and 3.9-6.2 ppm, respectively.

Bananas in plastic containers with flow system and silica gel had less senescent spotting than bananas in plastic containers with flow system and had no silica gel. RH in plastic containers with flow system containing bananas and silica gel was about 50-60%, while RH in plastic containers containing bananas without silica gel was about 95-100%. Carbon dioxide, oxygen and ethylene concentrations in plastic containers with flow system and silica gel were about 2.7%, 14-17% and 0.6-2.0 ppm, respectively, while carbon dioxide, oxygen and ethylene concentrations in plastic containers without silica gel were about 4.2%, 15.8-20.0% and 1.1-3.2 ppm, respectively. The development of senescent spotting of bananas was discussed in relation to RH and gas compositions in atmospheres.

GENE EXPRESSION DURING EARLY STAGES OF HYPOXIC RESPONSE IN CUT CARNATION FLOWERS.

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Despite the fact that modified and controlled atmosphere storage (hypoxia) has been used extensively by the food and horticulture industry for decades as a means of extending the storage life of fruits and vegetables, the molecular basis of this phenomenon is unknown. In general the effect of hypoxia on the senescence of horticultural crops includes a decrease in respiration, a delay in the onset of the climacteric rise in ethylene production and a decrease in the rate of ripening. The cut carnation flower provides several advantages as a model system for study of hypoxia since exposure of carnation flowers to hypoxia does not present problems related to gas diffusion as occur in solid plant organs such as potato tubers and apples. Early stage response involves oxygen sensing and signal transduction of hypoxia.

Initially, we identified hypoxia-induced carnation alcohol dehydrogenase (ADH) and pyruvate decarboxylase (PDC) full-length cDNAs from hypoxic carnation petals and characterized their expression. Both cDNAs showed a rapid, strong induction under hypoxia and anoxia. Their increase in expression was followed by a considerable increase of their enzymatic activities, particularly for ADH.

We also investigated the expression of prolyl-4-hydroxylase homologue cDNAs in response to oxygen limitation conditions that were identified from hypoxic carnation petals. In hypoxia-treated Arabidopsis plants, members of the prolyl-4-hydroxylase homologues are up-regulated within the first hours of exposure. In mammals, prolyl-4-hydroxylases are considered members of the oxygen sensing machinery and are involved in the regulation of hypoxic response.

SESSION 5 (S5)

POSTHARVEST QUALITY MANAGEMENT



S5-01**QUALITY MANAGEMENT THROUGH RESPIRATION CONTROL.**Prange R.K.^{1*}, DeLong J.M.¹, Harrison P.A.¹¹Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, Kentville, Canada.

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Postharvest quality deterioration is generally proportional to product respiration rate. The anaerobic compensation point (ACP) is the O₂ concentration at which respiration rate, measured as CO₂ production, is the lowest. If O₂ concentration declines below this value, CO₂ production increases due to increased anaerobic respiration. Therefore, it is desirable to keep the tissue at or just above the ACP to reduce plant tissue to its lowest respiration rate and allow it to survive longer. A goal of postharvest researchers has been the development of an acceptable method to determine the ACP. Previous research has focussed on measuring gases associated with the onset of anaerobic respiration, e.g., increases in ethanol, acetaldehyde or CO₂.

Recently, we discovered that a rapid change in the Fo parameter of chlorophyll fluorescence occurs between ca. 0 to 2.0 kPa O₂, depending on the commodity. A system was designed that provides a very accurate continuous estimate of Fo (F-alpha) and trials around the world have confirmed this system can be used to store product at extremely low O₂ concentrations for extended storage periods. To determine if this system is measuring the ACP, various fruits and vegetables were exposed to decreasing O₂ concentration. As the O₂ concentration declined towards 0%, CO₂ declined to a minimum (ACP), followed by a sudden increase in both ethanol and CO₂ as anoxia occurred. F-alpha increased simultaneously with the occurrence of the ACP and the onset of anoxia. When anoxia ended by re-introduction of O₂, F-alpha returned to its previous low value.

These results confirm that F-alpha is non-destructively determining ACP and allowing chlorophyll-containing produce to be stored at its lowest, optimum respiration rate. Possible physiological explanations for a relationship between respiration-based ACP and photosynthesis-based Fo (F-alpha) will be discussed.

S5-03**FLESH BROWNING OF PINK LADY APPLES: WHY DO SYMPTOMS OCCUR? RESULTS FROM AN INTERNATIONAL COLLABORATIVE STUDY.**Jobling J.^{1*}, Brown G.², Mitcham E.³, Tanner D.⁴, Tustin S.⁵, Wilkinson I.⁶, Zanella A.⁷¹Sydney Postharvest Laboratory, Australia; ²Scientific Horticulture, Australia;³University of California, Davis, USA; ⁴Food Science Australia; ⁵HortResearch, New Zealand; ⁶Primary Industries Research, Australia; ⁷Research Centre for Agriculture and Forestry Laimburg, Italy.

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Pink Lady™ apples are an important new variety with unique market advantages as a result of its quality and market identity. This image is at risk of being damaged as a result of the flesh browning disorder that has been a problem for both domestic and exported fruit over recent years. The disorder is sporadic in nature and occurs in both air and CA storage. This disorder seems to be the result of a combination of factors that have been implicated in other storage disorders of apples.

An international team of researchers from 4 countries from both the Northern and Southern hemispheres contribute to this project. Our preliminary results show that Pink Lady™ apples are sensitive to high CO₂ levels in storage and that late harvested fruit are more susceptible to the disorder. We also have data showing that differences in temperatures during early fruit development among regions are correlated with differences in fruit density and air content of the fruit cortex measured at maturity. We therefore hypothesize that climatic and production practices, such as crop load can influence either the structure of fruit and/or its ripening metabolism and in turn predispose fruit to the disorder. We propose that the structure of the fruit influences fruit sensitivity to CO₂. It is also likely that seasonal conditions influence maturity. Results relating to these hypotheses will be presented and discussed.

S5-02**INCORPORATING BIOLOGICAL VARIATION IN POSTHARVEST MODELING.**Hertog M.L.A.T.M.^{1*}, Lammertyn J.¹, Desmet M.¹, Scheerlinck N.¹, Nicolai B.M.¹¹Flanders Centre/Laboratory of Postharvest Technology, K.U. Leuven, Belgium.

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Using colour change of tomato fruit (*Lycopersicon esculentum* Mill.) as a case study, a stochastic kinetic approach is developed to interpret postharvest batch behaviour combining kinetic models with the concept of biological age governed by stochastic processes. Data from a wide range of cultivars stored at 18 °C will be used to illustrate the concept of biological age and to discriminate between batch and cultivar depending parameters.

Tomatoes from three cultivars (Quest, Style and Tradiro) were stored at 3 storage temperatures (12, 15 and 18 °C). Data from these experiments were used to develop the stochastic kinetic model approach predicting the propagation of biological variation during postharvest describing colour change as a function of time and temperature.

An independent validation experiment on Tradiro tomato stored at 18 °C showed that the developed approach is able to accurately predict propagation of biological variation during postharvest (R²adj=0.96) based on just the initial colour distribution measured at harvest. The developed approach will also be extended to describe batch behaviour under varying temperature conditions enabling the application to more realistic postharvest conditions.

S5-04**DIFFERENT PATHS FOR THE FRESH-MARKET AND THE NUTRACEUTICAL INDUSTRY.**Brovelli E.^{1*}¹Nutrilit Health Institute, Access Business Group, Lakeview, California, USA.

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Recognizing the phytochemical richness of fruits and vegetables and their impact on health and nutrition, the "Produce for Better Health Foundation" launched its "5-a-day" campaign to encourage produce consumption. Despite their efforts, the average American is still not consuming the recommended daily serving suggested by the USDA's food pyramid. Furthermore, convenience being a prime factor in produce selection, consumers often lean toward the most convenient form, as in the case of fried potatoes, the most widely consumed vegetable in the US. In the quest to complement dietary requirements, industry leaders in the nutraceutical sector have taken innovative steps to provide consumers with products that summarize convenience and nutritional value. Experimentation with factors that regulate the level of phytochemicals in plants during production and postharvest handling can result in enhanced nutraceutical value.

Cultivar selection is a critical step in phytochemical enhancement; many current commercial breeding programs emphasize sensory goals and fewer target phytochemical enrichment. Cultural practices can also respond to different goals, whether related to yield or phytochemical yield. Planting density, fertilization, mulching, etc. have all been exploited as techniques to increase phytochemical levels. Furthermore, while prevention of damage by herbivores is critical to yield and sensory quality, the stress of injury elicits the production of plant defence elements, many of which have nutraceutical properties. The development of maturity indices and postharvest technologies typically focus on sensory attributes rather than on the impact on phytochemical production. As the functionality of phytochemicals in the body is better understood, a novel approach consists on assessing the impact of cultural or postharvest technologies on bioactivity. Such approaches are advantageous as they more closely relate to the way in which phytochemicals act in the body and means to affect their performance.

S5-05

DEVELOPING TREE FRUIT QUALITY INDEXES BASED ON CONSUMER ACCEPTANCE AND MARKET LIFE.

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In recent years, we have been developing stone fruit quality indexes based on consumer acceptance and fruit market life with the main goal of increasing fruit consumption. To reach this goal we have taken the following steps: first, we evaluated market life potential based on internal breakdown susceptibility for the most important peach, nectarine and plum cultivars in the California industry. Second, we conducted soluble solids concentration (SSC) and titratable acidity (TA) surveys, which indicated the potential fruit quality range for these cultivars within the industry. Third, we investigated the potential role of pre-harvest factors on these quality attributes. Fourth, we studied the relationship between sensory attributes such as sweetness, sourness, aroma, texture, and overall fruit flavor intensity and the measurements of firmness, SSC, TA and sugar-to-acid ratio (SSC:TA) using a trained taste panel. And finally, we used the above data to design large "in store" consumer tests for the different stone fruit cultivars. After completion of these steps, our industry will have enough solid information to propose a high quality fruit standard if necessary.

S5-07

THE MECHANISM THAT THE PRODUCE KEEP THEIR INITIAL WATER CONTENT DURING LONG-TERM STORAGE.

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Most fruits and vegetables demand low temperature and high humidity, around 0°C and more than 80% RH, when they are being stored. On the other hand, optimum relative humidity for some root vegetables and fruit vegetables is around 60-70% RH. These produce suffer from microbial spoilage when they are stored at higher humidity condition. It often happens that moisture content after long term storage does not show the difference between the initial value and the final value although there is much weight loss of the produce.

In this study, we proposed the model, which illustrate the mass balance of the moisture within the produce to understand the maintenance of the initial moisture content during storage. Model was applied to the garlic storage and its potentiality has been validated through storage test under different temperature and gas composition.

S5-06

PHYSIOLOGICAL CHANGES OF RADISH (*Raphanus sativus* L.) IN POST-HARVEST AS AFFECTED BY PREHARVEST CLIMATE CONDITIONS.

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Radish (*Raphanus sativus* L.) is worldwide a popular root vegetable which are grown throughout the year under varying climate conditions. In Germany radishes are purchased as a bunched product where leaves serve as a quality indicator for the consumer. The quality attributes like glucosinolates and carbohydrates (storage, transport and structural carbohydrates) determine sensory properties and the postharvest behaviour. These quality characteristics are influenced by the products' precondition at the time of harvest which are also determined by the climate conditions during the production process. The present investigations on radishes revealed that the predominate preharvest climate parameters such as irradiation and temperature influenced the formation of the quality compounds studied and their postharvest metabolism. This preharvest dependency ranged from a slight climate influence up to a strong climate impact resulting in different harvest qualities and thus in a different postharvest behaviour.

The knowledge of preharvest conditions affecting postharvest physiology as well as being a decision criteria for suitable postharvest treatments is an essential tool for a comprehensive product physiological oriented quality management.

S5-08

UNDERSTANDING THE BASIS OF CHILLING INJURY IN CITRUS FRUIT.

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Low, non-freezing, temperature is the single most important factor governing maintenance of postharvest quality in stored fruits and vegetables. It may reduce disease, control insect pest, or modify ripening processes but also cause chilling injury (CI). Exposure of chilling-sensitive crops to hardening or non-lethal high temperatures may reduce injury caused by subsequent holding at chilling temperatures. Many varieties of citrus fruit are susceptible to chilling, being 'Fortune' mandarin a good model system to characterise metabolic events underlying CI.

Considerable effort has been directed to understand the physiological and biochemical basis of low temperature tolerance in citrus fruit harvested at different maturity stages, including the role of plant hormones, alteration in lipids, carbohydrate composition, changes in phenylpropanoid metabolism and in oxidative stress-associated processes. However, we still lack solid information on the mechanism controlling chilling. The advent of molecular technologies is providing a powerful means for systematically evaluate the expression of large subsets of genes in response to stress cues. Studies of molecular events by which horticultural crops may tolerate chilling are in their early stages but in citrus fruit it has been shown the complexity of molecular mechanism underlying chilling tolerance.

A functional categorisation of genes expressed in heat-conditioned 'Fortune' fruit exposed to chilling has revealed that long-term heat-induced chilling tolerance is an active process, which requires new transcription factors, activation of secondary metabolism, and stress-related proteins, while induction of HSPs could be ascribed to the early events of chilling acclimation. Future work is necessary to delineate the precise function of the identified chilling-associated responses, but the availability of new molecular strategies will provide an excellent tool to continue the study of the mechanism underlying chilling stress.

S5-09

EFFECTS OF HOT WATER TREATMENT ON REDUCING CHILLING INJURY OF POMEGRANATE (*Punica granatum* L.) FRUITS DURING STORAGE.

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In a preliminary experiment, comparing to chemical treatment, fruits of cultivars 'Malas Yazdi' and 'Malas Saveh' were dipped in warm water at 50 and 75°C, imazalil (1 and 3/1000 v/v) and benzyldadenin (80 and 100 mg L⁻¹) for 2 and 5 min. Distilled water at 25°C was given as control treatment. Treated fruit were stored at 1.5°C and 85 ± 3% relative humidity (RH) for 4.5 months. Although water at 75°C resulted in heat injury of fruits warm water at 50°C comparing to the other treatment significantly reduced chilling injury. In second experiment, fruits of 'Malas Yazdi' were dipped in warm water at 0 (control), 25, 35, 45, 55 and 65°C for 2 and 5 min. Treated fruits were stored under the mentioned conditions of the first experiment for 3 months. The result showed that increasing water temperature to 45 significantly reduced chilling injury, electrolyte and K⁺ leakage but had no significant effect on total soluble solid, total acidity, ascorbic acid and pH of fruits after removal from storage.

S5-10

HEAT PRETREATMENT REDUCES DECAY AND CHILLING INJURY IN SWEET BASIL.

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Exposure of harvested sweet basil (*Ocimum basilicum* L.) to storage temperatures below 12 °C resulted in chilling injury expressed as leaf browning, necrosis, and abscission. Storing the basil at temperatures above 12 °C might result in soft rot, caused by *Botrytis cinerea* and *Erwinia carotovora*, followed by increased leaf abscission. Basil harvested early in the morning and stored at 12 °C was found to be very susceptible to both chilling injury and decay. Delaying the harvest, at least 4 hours after sunrise, but preferably to afternoon or evening, markedly reduced this susceptibility.

Previous experiments revealed that exposure of morning harvested basil bunches to 38 °C for 16 hours, markedly reduced development of soft rot on the leaves and stems but caused slight leaf browning, wilting, and increased leaf abscission. The same heat treatment to afternoon or evening harvested basil, was much more efficient in inducing chilling resistance resulting in less decay and only slight physiological side effects.

Recent experiments revealed, that reducing the length of the heat treatment to only 8 hours for afternoon or evening harvested basil, controlled efficiently both decay and chilling injury. Heat treatment under these conditions enables to store some basil cultivars even at 9 °C which otherwise results in substantial injuries. Basil harvested before noon should be preheated for only 4 hours at 38 °C for achieving the best efficacy. Basil cuttings from multiple-harvested plants were more susceptible to both chilling injury and decay than those from first or second harvest. This susceptibility can be markedly reduced by the heat treatment applied to afternoon or evening harvested basil. Mode of action of the heat treatment will be discussed.

S5-11

TIME-TEMPERATURE-INTEGRATORS (TTI) TO CONTROL THE DISTRIBUTION CHAIN OF HORTICULTURAL PRODUCTS.

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Monitoring quality of horticultural produce throughout the distribution chain has become an important issue during the last few decades. A tool for achieving this goal is a time-temperature integrator (TTI). TTIs are small, inexpensive devices that show a time-temperature dependent, easily measurable and irreversible change, that can be correlated to changes of quality of a food undergoing the same time-temperature exposure. The Belgian Fruit and Vegetable auctions would like to introduce TTIs in their HACCP-system to control temperature abuse.

A first aim of this research was to carry out a feasibility study to evaluate the potential of TTIs to monitor the cooling efficiency of horticultural products after arrival at the auction. The kinetic parameters of the quality loss of mushrooms, lettuce and strawberries were determined during storage at different temperatures. Therefore objective measurements of several quality attributes were carried out at regular time intervals. First order reaction models of the quality loss, based on the Arrhenius equation, were fitted to the data. The acceptability of the quality was determined by experts. Based on these results a selection of commercial available TTIs with the same kinetics as the products was made. To evaluate the TTI performance a similar kinetic study was performed for the selected TTIs as for the products itself. The response of the TTIs was measured during constant and variable temperature profiles with a spectrophotometer.

The results indicated the usefulness of TTIs in the distribution chain of horticultural produce. As the first aim was achieved successfully the second aim of the research was to implement the TTIs in the auctions. TTIs were put on the products after arrival at the auction and they were removed after cooling overnight. The response of the TTIs was evaluated.

S5-12

GENERIC STRESS RESPONSE MECHANISMS IN FRUIT.

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We are increasingly observing common mechanisms and responses of fruit to high and low temperatures and to low oxygen concentrations during postharvest treatments and storage. These generic patterns involving the increased expression of genes and production of protein and enhanced enzyme activity can be modelled to reveal a pattern of dose response and decay.

Induced temperature tolerance, particularly that involving tolerance to low temperature from high temperature exposure, involves similar proteins, such as heat shock proteins and those involved in oxidative metabolism, but also proteins and enzymes specific to high or low temperature. Nevertheless, the overall pattern of response is very similar. A similar generic response can be seen in elements of programmed cell death which may be common to low oxygen responses and temperature in whole fruit or fruit cells. These cross-stress generic responses will be analysed and linked to our genomic approach to stress response in apple and kiwifruit.

S5-13

ETHANOL PRODUCTION AND CHLOROPHYLL FLUORESCENCE IN HEAT STRESSED APPLE FRUIT DURING STORAGE.

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Ethanol concentration and chlorophyll fluorescence were measured as signs of heat stress in apple fruit (*Malus sylvestris* (L.) Mill. var. domestica (Borkh.) Mansf.). 'McIntosh', 'Cortland', 'Jonagold', and 'Northern Spy' apples were held at 46 °C for 0, 4, 8, or 12 h. Following treatments, fruit were stored at 0 °C and evaluated after 0, 1, 2, or 3 months. Ethanol and ethylene production, chlorophyll fluorescence, skin color, soluble solids, titratable acidity, peel and flesh browning, and firmness were measured. Increases in ethanol were apparent following 12 h heat treatments and reflected the degree of heat-induced fruit injury. After 2-3 months of storage, ethanol concentration peaked and were as much as 111-fold greater than that of controls. Heat treatments also reduced ethylene production and chlorophyll fluorescence. After 3 month storage, chlorophyll fluorescence (Fv/Fm) was about 0.2 in fruit held at 46 °C for 12 h compared with 0.5-0.6 for control fruit. Exposure to 46 °C for 12 h also caused severe flesh browning in all cultivars. Severity of flesh browning increased with increasing heat treatment time and storage time. 'Northern Spy' apple fruit were most susceptible to heat stress based on the degree of flesh browning.

The increase in ethanol production and decrease in chlorophyll fluorescence correlated with heat-induced injury, and may be used to predict the severity of injury that develops during storage.

S5-15

SIMULATING CALCIUM DIP EFFECT ON POST HARVEST QUALITY OF PEACHES.

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Peaches during the post harvest operations such as sorting, packaging and transportation are subjected unintentionally to bruises and compressive forces, which affect adversely the shelf life of the peaches.

Peaches of 'Harvester' and 'Juneprince' cultivars were dipped in calcium chloride solution just after harvest and its effect on post harvest quality parameters of firmness and mass was investigated. The control peaches were not dipped. Peaches were stored at 0, 4, 10, and 22°C at RH of 95 ± 1% for three weeks. Mass and firmness of the stored peaches were measured at regular time intervals. Firmness was measured using non-destructive compressive test using Instron® testing machine. A replication was carried out and models were developed from the slopes of firmness and mass values plotted against time for the five temperatures. The models were validated using another harvest. The models were further converted into a user-friendly computer simulation for predicting peach quality during distribution. The simulation predicts the quality parameters at each link of a typical supply chain. The temperature profile, percent firmness and percent mass for a system with or without the calcium dip are simulated and plotted upon data entry.

The simulation enables farmers as well as owners of various links of the supply chain to see graphically the effects of their actions of dipping in calcium and storing at various time-temperature combinations. The producers can quantify the benefit of lowering temperatures during cooling delays and of dipping in calcium. It can act as a decision support system to enable the producers to take decisions regarding calcium dip and storage conditions in conjunction with other economic considerations.

S5-14

THE EFFECT OF PRE AND POSTHARVEST CALCIUM APPLICATIONS ON 'HAYWARD' KIWIFRUIT STORAGE ABILITY.

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The benefits of calcium applications pre and postharvest on fruit storage ability have been mentioned in the bibliography. It was objective of this work to study the effect of calcium preharvest application in two different forms and calcium chloride application postharvest on 'Hayward' kiwifruit storage ability.

Kiwifruit vines were sprayed with 0.03% Calcium one, four and five months before harvest, with CaCl₂ or CaO. The control did not have any treatment. After harvest, half fruits were dipped for 2 min in a solution of 1% CaCl₂, left to dry and stored at 0°C. The other half was stored at the same temperature without any treatment. The commercial yield and firmness was lower in fruits treated with CaO preharvest than in the other treatments. The °Brix was not affected by treatments. During storage, fruits dipped in 1% CaCl₂ softened slower than fruits not treated. Weight loss was higher in fruits treated with CaO preharvest.

This work suggests that immersion of kiwifruit in 1% CaCl₂ postharvest benefits storage life capacity; preharvest spraying with CaCl₂ seems to be better than with CaO. However, we have to try higher calcium concentrations in order to get better results in storage ability but, without causing toxicity on the vines.

S5-16

THE PHENOMENON OF TOMATO BRUISING: WHERE BIOMECHANICS AND BIOCHEMISTRY MEET.

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Tomatoes are a commercially important vegetable worldwide. The fruit quality is substantially reduced by bruise damage. Tomato bruising is not well understood and the main responsible parameters for bruise damage are not yet entirely known. The occurrence of bruising depends on two main factors: the direct mechanical damage of the tomato, and the presence and subsequent action of unregulated cell wall-modifying enzymes. Bruising is considered to be a two-step process, in which mechanical damage occurs first and then enzymatic degradation of the affected tissue, including cell walls takes place. This could result in a rapid enzymatic breakdown of the cell wall polysaccharides, observed as soft spots on the fruit. Bruises would probably not develop if the direct and immediate mechanical damage were the only damage the fruit experienced. This research aims to (i) determine the factors that are responsible for bruising of tomatoes and (ii) elucidate the bruising mechanism. Fruit mechanical and physical parameters were characterized in relation to impact loading. Fruits of 3 ripening stages and at 2 temperatures were subjected to 3 levels of impact energy (0.020J, 0.087J & 0.260J) by means of a pendulum. Fruit biochemical properties were characterized by monitoring the changes in the cell wall composition of the pericarp tissue after bruising. Tomatoes of distinct ripening stages were impacted and incubated for 3 hours, while stored at 12°C or at 22°C. Then, bruised areas and non-bruised control areas of the same fruit were collected. Cell walls were extracted and assayed for pectin and hemicellulose content. This study revealed that, in the case of mechanically damaged fruit, polysaccharide-digesting enzymes are responsible for the rapid breakdown of the cell wall, resulting in soft spots on the fruit. No bruises will form without the enzymatic digestion of the cell wall.

S5-18

1-MCP USE ON *Prunus* spp. TO MAINTAIN FRUIT QUALITY AND TO EXTEND SHELF LIFE DURING STORAGE: A COMPARATIVE STUDY.
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This work shows a summary on the role of 1-MCP applied at different doses (0.25 to 1 $\mu\text{L L}^{-1}$) on two apricot (*Prunus armeniaca* L. cv. Currot and cv. Bulida), two early season plum (*Prunus salicina* Lindl. cv. Santa Rosa and cv. Golden Japan) and two late season cultivars (*Prunus domestica* L. cv. President and cv. Reina Claudia), the latter harvested at two ripening stages. All 1-MCP treatments were performed at 1 °C for 24 h. Fruit were stored for several periods at 1 °C and subsequent days at 20 °C and 90% RH.

1-MCP reduced ethylene production for all cultivars, and prevented the autocatalytic production of ethylene, especially during shelf life at 20 °C. High correlations were found between the 1-MCP dose applied and the reduction of ethylene emission.

1-MCP treatment was effective delaying fruit quality parameter evolution, the highest dose being the most effective during cold storage and shelf life. The correlation between 1-MCP concentration and parameter such as weight loss, colour changes, softening delay and °Brix-titratable acidity ratio permit to suggest that an ethylene dependant and an ethylene independent processes are involved during the ripening. The 1-MCP effect was greater in the more advanced ripening stage, when the sensorial and quality attributes are higher from the point of view of consumers.

In conclusion, 1-MCP could be a good mean to prolong the storability of *Prunus* spp., such as apricot and plum, in which after harvesting no more than 7-10 days of cold storage could be expected with optimal fruit sensory attributes. In terms of extension of shelf life, between 2 and 3 weeks more were achieved in 1-MCP treated fruits compared with controls.

S5-20

COMPARISON OF SILVER THIOSULFATE WITH 1-METHYLCYCLOPROPENE.

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The effects of STS (AVB) and 1-MCP (Ethylbloc) were determined on 14 commonly grown cut flower species, represented by one to three cultivars per species. Cut stems were harvested, untreated, and shipped overnight to Raleigh, North Carolina. Stems were unpacked, sorted, and placed in either deionized water (DI) and subjected to 1-MCP (740 nL L⁻¹) or ambient air for 4 hr or DI plus STS at either 0.1 mM (Alstroemeria) or 0.2 mM (all other species) for 4 h. After treatment stems were removed, placed in polyethylene sleeves and stored either wet in DI water or dry in plastic-lined floral boxes at 5°C in the dark for 4 days. After storage bunches were placed in DI water under 12 h (76 to 100 $\mu\text{mol m}^{-2} \text{s}^{-1}$) light per day. Flowers were monitored daily to determine the end of wholesale vase life which was designated as the first day a change was noticed in the flower or inflorescence that would typically prevent it from being sold by a wholesaler. The consumer vase life was also recorded for each stem and that was designated as the day a typical consumer would dispose of it. The 19 cut flower taxa could be organized into four groups based on effectiveness of STS and 1-MCP: (1) Both STS and 1-MCP increased vase life but STS was more effective: *Dianthus caryophyllus* (all three cultivars), *Bouvardia*, *Lilium* (Asiatic), and *Lathyrus odorata*. (2) Both STS and 1-MCP prevented the negative effects of dry storage: *Freesia* (both cultivars) and *Chamaelirium* (one cultivar). (3) STS increased vase life while 1-MCP did not: *Alstroemeria*, *Delphinium*, *Matthiola*, and *Gypsophila*. (4) STS and 1-MCP either had no effect or a negative effect: *Consolida*, *Eustoma*, *Ranunculus*, *Antirrhinum*, and *Chamaelirium* (one cultivar).

S5-19

INTERACTIONS OF 1-MCP AND LOW OXYGEN CA STORAGE ON APPLE QUALITY.

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The objective of this study was to investigate the interactions of 1-methylcyclopropene (1-MCP) and low oxygen controlled atmosphere (CA) storage on apple quality. 'McIntosh', 'Empire', 'Gala', and 'Delicious' apples harvested at optimum maturity were treated with 1 ppm or no 1-MCP at 0°C for 24 hours. 'McIntosh' and 'Empire' apples were then placed into standard CA (3.0% O₂ + 2.5% (30 days) then 4.5% CO₂, and 2.5% O₂ + 2.5% CO₂ for 'McIntosh' and 'Empire', respectively) at 2.5-3°C, and four low oxygen regimes (1% and 0.7% O₂, each with or without 0.7-1% CO₂) at 2.5-3°C or 0°C. 'Gala' and 'Delicious' apples were also placed into standard CA (2.5% O₂ + 2.5% CO₂) and the low oxygen regimes, but only at 0°C. Within specific CA regimes, apples treated with 1-MCP were 0.5-1 kg firmer than comparable apples after 120 or 240 days of storage. Lowering the oxygen and the presence of CO₂ did not consistently improve firmness, as many apples treated with 1-MCP exhibited the highest firmness regardless of gas concentrations during storage. Firmness of certain cultivars in specific CA regimes was influenced by 1-MCP, gas concentrations, and storage temperature. Ethylene, CO₂, and volatile production were generally lower in apples treated with 1-MCP, held at lower temperatures, and in low oxygen with CO₂, although there were some interactions of these factors. Overall, 1-MCP reduced the incidence of superficial scald, but increased core browning and CO₂ injury, and interacted with the CA regimes to influence internal breakdown. These results suggest that in combination with 1-MCP both standard and low oxygen CA recommendations require revision, as certain cultivars exhibited no further quality benefit from combining low oxygen with 1-MCP.

S5-21

1-METHYLCYCLOPROPENE-INDUCED INCREASE IN ANTIOXIDANT POTENTIAL IN COLD STORED PEARS.

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Differences in oxidative stress and in antioxidant potential between controls and 1-MCP treated fruits were established in Blanquilla pears stored for 5 months in air. These determinations were carried out determining the changes in the levels of hydrogen peroxide and ionic leakage, and analysing the activity of the H₂O₂-generating enzyme superoxide dismutase (SOD, EC 1.15.1.1) and H₂O₂-scavenging enzymes catalase (CAT, EC 1.11.1.6), ascorbate peroxidase (APX, EC 1.11.1.11) and unspecific peroxidase (POX, EC 1.11.1.7) during storage.

MCP treated fruits exhibited lower levels of hydrogen peroxide and less ionic leakage during storage. Concomitantly, 1-MCP treated fruits also exhibited higher enzymatic antioxidant potential throughout storage. Collectively these results showed that the 1-MCP treatment induced a higher resistance to oxidative damage and challenge the hypothesis that the beneficial effects of 1-MCP on ripening were not exclusively due to its action on ethylene but also to an increase in its antioxidant potential in pear.

S5-22

EFFECT OF 1-MCP ON ABBÉ FÉTEL PEARS SORTED AT HARVEST BY TIME-RESOLVED REFLECTANCE SPECTROSCOPY.

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Abbé Fétel pears, with long term storage in normal atmosphere (NA), lose their ripening ability, remaining firm and grainy, while in controlled atmosphere (CA) they are very sensitive to low oxygen, which cause soft senescent scald. 1-Methylcyclopropene (MCP) is an inhibitor of ethylene action, but its effectiveness and dose response in pears seems to be related to fruit maturity. Time-Resolved Reflectance Spectroscopy (TRS) is a new non destructive method, by which the two optical properties of absorption and scattering at selected wavelengths can be measured in diffusive media. TRS has been successfully used to select fruits as regards degree of maturity at harvest. Aim of the research was to assess the effect of different doses of MCP applied on pears of different maturity, as selected by means of TRS, in order to determine the right dose for each maturity stage.

Abbé Fétel pears were picked on 1 September 2003, analysed with TRS, ranked by decreasing absorption at 670 nm (μa_{670}) and divided into two μa_{670} classes (high and low). Fruits in each class were randomized between the MCP (0, 100 and 300 $\mu l/l$) and storage ($-0.5^{\circ}C$, NA or CA 2% O_2 + 0.7% CO_2) treatments. MCP was applied on the day after harvest at $-0.5^{\circ}C$ for 30 h in gastight containers. Analyses of fruit mass, colour, firmness, soluble solids (s.s.) and titratable acidity were carried out at harvest and will be repeated, together with ethylene production rate, after 4 and 6 months' storage and during shelf life. At harvest, fruit in the high μa_{670} (i.e. less mature) class had lower mass and s.s. and higher acidity, starch and firmness. A significant correlation was found between μa_{670} and s.s., acidity and mass. Results after storage will be reported.

S5-24

POSTHARVEST EFFECT OF NITRIC OXIDE ON VEGETABLES AND FLOWERS.

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Nitric oxide (NO) is a highly reactive free radical gas that is an important endogenous regulator in many human physiological systems but it was not until 1996 that plant metabolism of nitric oxide was first demonstrated. A scoping survey has indicated that short term application of nitric oxide gas after harvest can extend the postharvest life of fruit, vegetables and flowers. Data will be presented that optimises the postharvest benefit to the non-climacteric produce, broccoli and mushroom, of fumigation with nitric oxide and the effect on respiration, ethylene production and transpiration. To overcome the logistical difficulty of fumigation, the use of a water soluble, solid nitric oxide donor compound was found to extend the vase life of a range of flowers with different sensitivity to ethylene.

Initial studies on the potential use of such donor compounds with fruit and vegetables will also be reported.

S5-23

EFFECT OF DIFFERENT GAS TREATMENTS (1-MCP AND N_2O) AND MA ON ETHYLENE BIOSYNTHESIS, RIPENING AND QUALITY OF PEACHES.

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Post-harvest storage of peach fruits is limited by the appearance of low temperature induced disorders, mainly internal browning and woolliness. Besides cultivar, growing and climate conditions, other factors are relevant for the appearance of these disorders. Previous studies, using different CA conditions, heat treatments, storage temperatures, were not successful for the Merry O'Henry cultivar. Other treatments with 1-MCP, N_2O and MA have been used with the purpose to see the possible role of ethylene on the appearance of these disorders.

Fruits were selected according to size, colour and flesh firmness and placed at $1^{\circ}C$ for 45 days. Part of the fruits were treated with 1 ppm of 1-MCP for 24 h, other were treated continuously with 50% N_2O and other kept under MA with plastic bags. Controls were stored in air. Samples were taken at 15, 30 and 45 days storage and placed at $20^{\circ}C$ for 4 days. Respiration and ethylene production were monitored as well as ACC content and ACC oxidase activity. Enzymatic peroxidase and polyphenoloxidase activity were also quantified. Quality parameters were determined in pulp (pH, acidity, texture, color, soluble solids and presence of disorders).

Ethylene biosynthesis was significantly influenced by treatments, mainly 1-MCP and N_2O . However, in spite of the reduction of ethylene production, no improvement was observed in fruit quality except in texture. Appearance of disorders, mainly browning, were beginning after 30 days storage in all samples, but the gas treated showed a lower development at 45 days.

S5-25

MODIFIED ATMOSPHERE AS A POTENTIAL TREATMENT TO CONTROL DECAY, MAINTAIN QUALITY AND IMPROVE STORAGE ABILITY OF 'BARHI' DATE FRUITS.

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Full mature date fruits (*Phoenix dactylifera*), c.v. "Barhi" were exposed to modified atmosphere storage conditions with three carbon dioxide concentrations (5, 10, or 20%) during cold storage ($0^{\circ}C$). The control fruits were stored at cold storage ($0^{\circ}C$) under the common air components conditions (0.03% CO_2). Fruits storage ability, decay percentage, and physiochemical changes during the storage period were studied. High CO_2 concentrations extended fruit storage ability, retarded fruits decay, maintained fruit quality, prevented fruit softening, and reduced postharvest losses.

Fruits stored at $0^{\circ}C$ under 20% CO_2 showed significantly longer storage period (lasted for 26 weeks) than all other treatments (i.e. 5 and 10% CO_2 which lasted for 17 weeks) and the control (lasted for 7 weeks). Moreover, fruits stored under MA conditions showed lower decay and weight loss percentage. At the end of the experiment, MA treatment with 20% CO_2 prevented fruit darkening and maintained fruit colour (as control fruit turned brown after only two months of storage), firmness, total sugar content, total tannins, and SSC the overall visual quality (OVQ) of the fruits like to the fresh harvested fruits. This study indicated that "Barhi" date fruits could be stored under modified atmosphere conditions in cold storage to achieve the longest possible storage period (more than 6 months, compared with 2 months for those stored at $0^{\circ}C$ under common air composition) with the best fruit colour and firmness, and most proper eating quality, which ultimately improves market ability.

S5-26

RHEOLOGICAL PROPERTIES OF TENDRAL MELON DURING TRADITIONAL STORAGE.

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Tendral melon is wanted for its desert quality and high handling and transport resistance. One of the most critical shelf-life limiting quality factors for melons is textural integrity. The postharvest quality of Tendral melon was evaluated on fresh fruit at 25, 50, 75, and 100 days of traditional storage. Important correlations were found between weight loss and rheological parameters recorded on compression of the whole fruit, and puncture of the skin and flesh. Within the first 25 days of storage firmness (whole fruit, skin and flesh) decreased significantly but remained nearly constant thereafter. Few changes occurred in flesh colour and physico-chemical parameters (pH, titratable acidity) in the last 50 days; there was a slight decrease of the content of soluble solids between 75 and 100 days of storage. This winter melon is noted for its relatively long storage life.

S5-27

SUGAR AND TANNIN CONTENT CHANGES IN PERSIMMON FRUITS DURING ARTIFICIAL RIPENING WITH DRY ICE.

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A study was carried out to remove astringency from 'Morali' persimmon fruit by dry ice (solid CO₂) application. Fruits were harvested at optimum harvest time. 5 kg of fruits were inserted into 30 L chamber, they were treated for 24 and 48 hour with three different dry ice concentration (90%, 80% and 60% from free volume). Control was applied to persimmon during artificial de-astringency process at room temperature (20°C) was used then chamber was closed. Effect of artificial deastringency process on persimmon soluble sugar content using high performance (HPLC) and fruit firmness (Kgf), soluble solids content (%), soluble tannin content (mg/l) were determined. This study showed that effect of different doses of dry ice on fruit firmness, total soluble solids content, soluble tannin content and was measured. Subsequent application of 90% dry ice for 24 hr was effective when fruit firmness, total soluble solids content, tannin content and soluble sugar content were considered. These treatments caused dramatically reducing soluble tannin to insoluble tannin forms without loss of sweetness which means a 'nonastringent' fruit. Treated fruit with dry ice remains firm and keep its quality after removal of astringency. Sugar and tannin might have interacted during treatment with dry ice (solid CO₂) application form nonastringent from persimmon fruit.

S5-28

EFFECT OF COLD STORAGE OF OLIVE FRUITS ON THE LIPOXYGENASE PATHWAY AND VOLATILE COMPOSITION OF VIRGIN OLIVE OIL.

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The lipoxygenase pathway system has been studied during storage of olive fruits (*Olea europaea* var. Picual) at 25°C and 5°C for four weeks. Key enzymes, lipoxygenase (LOX) and hydroperoxide-lyase (HPL), were assayed along olive fruits storage and content of related volatile compounds analyzed in the obtained virgin olive oils. Clear differences were found in the enzymatic profiles of 25°C stored and cold-stored olive fruits. LOX activity levels remained unaltered in olive fruits stored at ambient temperature but were drastically reduced in fruits stored at 5°C. On the contrary, HPL activity of olive fruits showed a steady decrease during storage at 25°C while no changes in this activity were observed in cold-stored fruits. Changes in the aroma profile of virgin olive oils obtained from olive fruits stored at 25°C and 5°C were related to the different pattern observed in LOX and HPL enzymatic activities. The effect of postharvest conditions of olive fruits on the quality of the resulting virgin olive oil is discussed.

S5-29

RELATIONSHIPS BETWEEN PREHARVEST HORTICULTURAL OIL APPLICATION AND POSTHARVEST BEHAVIOUR OF 'GOLDEN DELICIOUS' APPLE.

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Horticultural oils, commonly applied to apples throughout the growing season, function as insecticide, fungicide, and spray adjuvant. The influence of oil applications on fruit quality and storage behaviour of apples is not well understood. Our study characterized the effects of growing season-applied oil spray on at-harvest and postharvest behaviour of 'Golden Delicious' apples, as well as determined the effects of oil application on the chemical composition of surface lipids and cuticular morphology. Two years of field and storage experiments with apples grown in Pullman and Yakima, Washington USA, tested the following variables: time of application, duration of storage, and influence of storage atmosphere. Fruit measurements included common maturity indices, respiration rate, ethylene evolution, internal ethylene concentration, volatile aroma emission, and surface wax structure. Apples sprayed with 1% soybean oil emulsion showed altered maturation patterns, aroma volatile production and surface wax development, all dependent on field application timing. No phytotoxicity was observed and fruit finish was not affected by soybean oil treatment. In the second year of experimentation, additional observations were made on fruit growth rates, weight loss in storage and during shelf-life period, amount and chemical composition of surface wax, and flavour regeneration capability after CA storage. Based on these data, we conclude that soybean oil application has the potential to alter postharvest behaviour and subsequent storage quality of 'Golden Delicious' apples.

EFFECT OF UV IRRADIATION AFTER THE HARVEST ON THE CONTENT OF FLAVONOID IN VEGETABLES.

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Large quantities of Antocyanin are contained in strawberry fruits. Quercetin is also abundant in onions. As for this flavonoid, the matter that it has physiology function activity is being cleared in the field of foundation medical science. On the other hand, flavonoid contained in the plant tissue, it knows that it acts as a protect material against the ultraviolet rays. So, we tried to raise the amount of flavonoids in those vegetables by irradiating ultraviolet rays after the harvest. As a result, the possibility that ultraviolet rays increased the content of flavonoid in these vegetables was recognized. We propose being one of management technology that UV irradiation after the harvest is effective in the enhancement of vegetable quality.

THE EFFECT OF SEASONALITY, MATURITY AND COLOUR TREATMENTS ON INTERNAL BROWNING IN 'PINK LADY' APPLES.

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Since 2000, internal browning has been observed in controlled atmosphere stored 'Pink Lady' apples originating from Tasmania. This problem was not apparent in fruit immediately after removal from controlled atmosphere, but manifested itself during transport. During the 2000 export season, several containers of fruit originating from Tasmania were condemned upon arrival in Europe due to this disorder, causing severe financial losses to growers and marketers, as well as detrimental affects on the marketing program in the UK. Internal browning is located in the outer cortex of the flesh; the discolouration can range from a slight grey tinge to a dark brown that follows the vascular traces toward the core of the fruit.

Trials over the past four years have shown that this disorder is seasonal and affected by fruit maturity. In the four years studied there has been a yearly variation from 2% to 50% incidence. Fruit maturity appears to be a fundamental factor in the occurrence of internal browning; fruit picked 3 weeks before commercial harvest have a 3 to 5 fold reduction in the incidence of internal browning. Fruit are picked over-mature to improve the red colour of the skin, due to supermarket specifications, so trials were conducted to improve fruit colour. These indicated that cincturing, summer pruning, Regalis® and reflective cloth all improved fruit colour. They also significantly increased the incidence of internal browning; however, cincturing had a much greater incidence of internal browning than the other treatments. Importantly, reflective cloth significantly increased colour over the other treatments without advancing maturity, therefore, reflective cloth may be used to improve fruit colour and allow the commercial harvest to be conducted 2-3 weeks earlier to minimise internal browning in Tasmanian 'Pink Lady' apples.

TOMATO QUALITY EVALUATION USING ELECTRONIC NOSE SYSTEMS TO COMPLEMENT SENSORY ANALYSIS.

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In Belgium a large number of new tomato cultivars are yearly submitted to several quality evaluations and growth characteristics before getting commercialized, in order to select the most valuable varieties. Flavor (aroma and taste) is one of the main quality attributes evaluated in tomatoes. Among the different methods to evaluate aroma, sensory analysis have been widely used, however recently, electronic noses are promising fast instrumental means for aroma evaluation in food. The aim of this study was to compare, discuss and illustrate the performances of electronic nose systems and sensory analysis during tomato aroma evaluation.

Twenty-four tomato cultivars were considered for the experiment. They were harvested at the red-ripe stage of maturity. Sensory evaluations were performed by 6 experts at the Center for Applied Vegetable Research East-Flanders. The panel was previously trained to recognise tomato/green, flower, fruity/almond, green/grass and overall aroma attributes in tomatoes. Two electronic nose systems: a Libra nose (E-nose) and a mass spectrometry based electronic nose (MSE-nose) were considered for instrumental analysis. The detection principle of the Libra Nose was based on eight quartz microbalances sensors (QMB) coated by modified metallo-porphyrins. The MSE-nose analysis consisted of a solid phase micro-extraction coupled to gas chromatography-mass spectrometry. The volatile samples were introduced into the GC/MS without prior separation and a mass spectrometry pattern, characteristic of the unresolved mixture of volatiles, was then recorded. The data were analysed with multivariate statistics. In first place, the electronic nose systems were compared with each other and with those from the sensory panel. The results suggest that the E-nose and the MSE-nose can complement traditional chemical and sensory approaches to the selection of new tomato cultivars. Details of the results will be discussed in the final paper.

QUALITY ATTRIBUTES OF TOMATOES SUBMITTED TO DIFFERENT POSTHARVEST TREATMENTS.

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Shipping tomatoes to distant markets is always a great challenge for tomato growers in tropical countries. Delaying ripening can be a useful technique to maintain quality throughout the transportation. This work was carried out to investigate the ability of different postharvest treatments to extend the shelf life of tomatoes.

Tomato (*Lycopersicon esculentum* Mill.) fruit, cultivar Carmem, an extended shelf life variety (ESL), were harvested at the pink stage at commercial fields in Goiás, Brazil. After harvest, fruit with no external blemishes were graded for weight (250±5g) and diameter (6±0.5cm), and treated with coconut grease (applied to the stem end), wrapped in plastic films (coextruded polyolephin, 18 micrometers), 1-methylcyclopropene (1000 nL L⁻¹), and control. Fruit were stored for 10 days under refrigerated conditions (10±0.5°C / RH 90-95%) and every 2 days were analyzed for total soluble solids, firmness, weight loss and colour (L*a*b*).

It was verified that weight loss increased during the storage period. Control fruits and fruits treated with 1-MCP lost around 4% of their initial weight, whereas fruit treated with coconut grease in the stem end lost around 2%. Fruits stored under modified atmosphere showed less weight loss compared to other treatments. Treatment with 1-MCP delayed fruit softening. At the end of the storage period fruit treated with the ethylene antagonist had a firmness that was 50% higher than control fruit. 1-MCP significantly delayed chlorophyll degradation and concomitant synthesis and revelation of carotenoids pigments. At the tenth day, 1-MCP treated fruit had a predominant green colour when compared to other treatments. Soluble solids content was not significantly affected by the different postharvest treatments.

EFFECT OF POST HARVEST TREATMENTS, PACKAGING MATERIALS ON EXTENSION OF SHELF LIFE OF CUSTARD APPLE (*Annona squamosa* L.) FRUITS.

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The present investigation was undertaken to study the effect of post harvest treatments, packaging materials on extension of shelf life of custard apple (*Annona squamosa* L.) fruits. For this purpose, the custard apple fruits were harvested at proper stage of maturity and given post harvest treatments viz., waxing (6%), NAA (30 ppm), KMnO₄ packing either alone or in combination. The custard apple fruits were then packed in polyethylene bags (2% vents and 100 gauge thickness) and some fruits were wrapped individually by special polyfilm (75 gauge thickness). These fruits were stored at room temperature (6.12 to 35.18 °C and 25.50 to 89.00% RH) and in zero energy cool chamber (7.10 to 17.00 °C and 80.00 to 93.45% RH).

It was found that the shelf life of custard apple fruits could be extended up to 7 days when treated with waxol or waxol + KMnO₄ or waxol + NAA (30 ppm) and packed in individual wrapping polyfilm at room temperature as against 4 days of control ones. The shelf life of custard apple fruits was extended up to 11 days under the same treatments when stored in cool chamber. The fruits treated with waxol + NAA (30 ppm) and packed in individual wrapping polyfilm treatment registered the best with the highest organoleptic score. Moreover, cool chamber has the added advantage of easy construction, maintenance and low cost.

INFLUENCE OF PREHARVEST CALCIUM TREATMENTS ON POSTHARVEST QUALITY OF SOME ESTONIAN APPLES.

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Current research was conducted with apple (*Malus domestica*) cultivars Kuldrenett, Krameri tuviõun, Talvenauiding and Tellissaare in Estonian Agricultural University during 2002-2003. The aim of the research was to find out the influence of preharvest Calcium sprays from different sources, CaCl₂ and Ca(NO₃)₂, on postharvest quality and storability of apples. Samples of 300 fruits per plot were picked at optimum harvest stage and stored in commercial coldstore in +2...+5°C and 80...85% RH in normal atmosphere. Storage period for 'Kuldrenett' and 'Krameri tuviõun' was 4 months, for 'Talvenauiding' 6 months and for 'Tellissaare' 7 months. Following variables were measured at harvest and monthly during storage: loss of salable yield, loss of fresh weight, content of dry matter, soluble solids and organic acids. Main physiological disorders such as bitter bit, bitter rot and superficial scald were scored visually every month. On the average of all cultivars, Calcium treatment had no effect on the amount of spoiled fruits at the end of the storage, but in most cases effect of cultivar was remarkable. Content of soluble solids, organic acids and dry matter of fruits after harvest was significantly reduced by calcium treatment and had values of 12.8 and 11.7% for soluble solids, 0.79 and 0.67% for organic acids and 13.1 and 12.3% for DM for control and calcium-treated variants, respectively. By the end of the storage season negative influence on content of soluble solids and dry matter remained significant, influence on content of organic acids had vanished. Bitter bit incidence was significantly reduced by calcium treatment, but incidence of bitter rot in calcium-treated 'Krameri tuviõun' was increased. Effect of calcium treatment on changes of mentioned quality characteristics during storage and their possible reasons will be discussed.

MIDDLE EAST REGIONAL AGRICULTURAL PROGRAM - SURVEY ON POSTHARVEST LOSSES OF TOMATO FRUITS (*Lycopersicon esculentum* L.) AND TABLE GRAPES (*Vitis vinifera* L.).

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Studying the postharvest activities, particularly loss prevention activities, within a marketing context, will provide needed information and guiding principles for loss-reducing activities, as well as the potential increased benefits arising from reduced losses, higher quality and thus higher prices, which would exceed the cost of the proposed corrective measures proposed. Losses from producer to the consumer may be as high as 50%. Postharvest losses, which are reducing farmers returns from fruit and vegetables do occur mainly because of: 1. Lack of infrastructure, 2. Poor handling and marketing know-how.

The objectives of this regional survey were to study the main reasons for postharvest losses based on postharvest practices in each country, farmer's experience in farming and his education in order to disseminate the know-how of finest postharvest practices.

Sorting and grading tomatoes or grapes immediately after harvest significantly improved the overall quality of these fresh produce. The existence of packinghouse in the farm maintains better fruit quality. Farmers with more experience in pre- and postharvest practices and higher education have better quality. Training and providing the know-how is the most essential step in reducing postharvest losses and improving the fresh products quality.

EFFECTS OF STORAGE CONDITIONS AND 1-METHYLCYCLOPROPENE ON SOME QUALITATIVE CHARACTERISTICS OF TOMATO FRUITS.

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The experiment was conducted to study the effects of 1-Methylcyclopropene (1-MCP) on Rapsodie tomato fruits. Four maturity stages (MS), 5 storage periods (SP) and 3 storage temperatures (ST) on some ripening related parameters including firmness, hue angle (H^a) and chroma were investigated. The experimental design was factorial using RCB with 3 replications. Analysis of variance revealed a significant difference between 15 nL L⁻¹ 1-MCP and control for H^a (P<0.01). The storage temperatures had also significantly different effects on firmness and H^a (P<0.01). The effect of maturity stages and storage periods were also significantly different for all traits. Interactions of MS _ ST for H^a, MS _ SP for all traits, 1-MCP _ SP for H^a and ST _ SP for firmness were also significant (P<0.05). The results showed that a single pretreatment with 1-MCP slightly delayed tomato ripening according to H^a (control = 48.8 and 15 nL L⁻¹ 1-MCP = 49.9), firmness and chroma. At early breaker (EB) stage, the fruits were firmer and had higher H^a and chroma than other maturity stages. The fruits had also greater H^a at all three temperatures compared to other treatments. At all maturity stages the H^a and firmness decreased by increasing the SP. The tissue firmness decreased by increasing the ST, whereas H^a and chroma was not changed. However, firmness and H^a decreased by an increase in SP.

EFFECT OF 1-MCP ON AVOCADO QUALITY IN RELATION TO MEMBRANE INTEGRITY, POLYPHENOL OXIDASE AND PEROXIDASE ACTIVITY.

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Ripening of Fuerte, Pinkerton and Hass avocado cultivars was significantly inhibited by 1-methylcyclopropene (1-MCP). Application of 1-MCP at low concentrations (150-300 ppb; for 18 h at 20 °C) prior to the climacteric peak, was effective in reducing both CO₂ and ethylene production, as well as decreasing fruit softening and electrical conductivity (EC) measurements. The EC measurement carried out using a special probe that penetrated the intact fruit was found as a good indicator for predicting and expressing membrane integrity.

Avocado treated with 1-MCP before storing for 4 weeks at 5 °C, resulted in reduced chilling injury symptoms expressed as mesocarp discoloration, and a decreased polyphenol oxidase (PPO) and peroxidase (POD) activity. Both PPO and POD activity that initially were quite low in the freshly harvested fruit, increased significantly during the cold storage and thereafter its removal to ambient temperature simulating commercial shelf life conditions. Ethylene action inhibited by 1-MCP, probably prevented the disruption of the cell membranes, which reduced the contact of the PPO enzyme with the phenolic substrates, resulting in a lesser amount of pulp browning. Chilling injury symptoms in the avocado fruit expressed as mesocarp discoloration was found to be correlative with higher EC values. The highest EC values were found in the brown tissue of the midsection part close to the seed, while the lowest EC values were found in the green tissue close to the peel. The data highlight that 1-MCP could be utilized to keep quality of avocado during cold storage and shelf life by reducing ethylene levels, decreasing the oxidative activity, maintaining membrane integrity and inhibition of chilling injury symptoms.

TOMATO FRUIT QUALITY RETENTION BY 1-MCP TREATMENTS AS AFFECTED BY CULTIVAR AND RIPENING STAGE AT HARVEST DURING STORAGE.

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Four tomato cultivars ('Daniela', 'Patrona', 'Cherry' and 'Raí') at two ripening stages (pink and red, for the 3 first cultivars, and breaker and light pink for 'Raí') were treated with two 1-MCP doses (0.3 and 0.5 µL L⁻¹). Fruit were stored at 10 °C and 90% RH for 4 weeks. Samples were weekly taken, half to study fruit quality parameters during cold storage and half left at 20 °C for 1 week (shelf life). Weight loss, colour, ethylene production, °Brix-titratable acidity ratio, firmness and decay were analysed.

For all cultivars and ripening stages, the treatments were effective in reducing weight loss and rate of softening, and retarding colour changes and °Brix-titratable acidity ratio evolutions, either during cold storage or shelf life. A positive relationship could be established between 1-MCP dose and the different analysed parameters, the 0.5 µL L⁻¹ dose being the most effective during cold storage and further shelf life.

For most cultivars and ripening stages, no reduction on ethylene production was detected, as a consequence of 1-MCP treatments. This might be due that in tomato fruit, the ethylene climacteric peak occurred at the breaker stage, and thus at harvest all cultivars were climacteric, and only decreases in ethylene production were observed during cold storage and shelf life. However, the blockage of the ethylene receptors by 1-MCP treatment reduced the evolution of fruit quality parameters, which are considered to be controlled by this plant hormone. Also, a reduced occurrence of decay was observed for those tomato fruit treated with 1-MCP, especially for 0.5 µL L⁻¹ 1-MCP dose and harvested at late ripening stage, in which almost no decay incidence during cold storage and between 2-4 fold lower during shelf life was observed.

EFFECT OF HEAT TREATMENT ON ANTIOXIDANTS AND QUALITY CHANGES IN PAPAYA FRUIT STORED AT LOW TEMPERATURES.

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The use of pre-storage heat treatments has shown beneficial reduces chilling injury during low temperature storage. The objectives of this study were to study the physio-chemical changes of papaya stored at low temperatures. Mature papaya cv. Sunrise were harvested and stored at 20, 5 °C or heated at 42 °C for 6 h before stored at 5 °C.

The fruit stored at 5 °C without heat treatment were found to be the most of chilling injury symptoms, including hard areas in pulp, skin pitting and abnormal ripening. On the other hand, the papaya stored at 20 °C showed no symptoms of chilling injury. The pre-storage heat treatment reduced chilling injury symptoms, delayed the decline of superoxide dismutase and catalase activity and suppressed the increase of peroxidase activity. These results indicated that chilling injury in papaya might involve with the activity of superoxide dismutase, catalase and peroxidase.

EFFECT OF SHORT-TERM EXPOSURE TO CO₂-ENRICHED ATMOSPHERES ON 'VALENCIA' ORANGES QUALITY.

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Quarantine treatments must be currently applied to Spanish citrus export shipments to markets such as the US because of the endemic presence in the Mediterranean area of the Mediterranean fruit fly *Ceratitis capitata* (Diptera: Tephritidae). The current accepted quarantine treatment is fruit exposure to temperatures ranging from 1.1 to 2.2°C. Alternatives are needed because fruit quality of some cold sensitive cultivars can be adversely affected by this treatment.

Since CO₂ has shown proved insecticidal activity, short-term exposure to this gas appears as an interesting alternative. In the present work, 'Valencia' oranges quality was assessed on fruit exposed to 98% CO₂ at 22°C for 8, 16, and 24 h, stored at 5°C for 7, 14, and 21 days, and then kept at 20°C for 7 days to simulate shelf life. The following quality and sensory attributes were analyzed on treated and control fruit: rind colour and firmness, maturity index, juice yield, the fermentative volatile compounds ethanol and acetaldehyde, taste, and chewiness.

No general negative effects were observed in CO₂-exposed fruit. Ethanol content was significantly higher on fruit exposed to the gas for 24 h and stored at 5°C for 21 days than on control fruit. However, ethanol content on treated fruit did not reach 200 mg per 100 ml of juice. As a conclusion, exposure to CO₂-enriched atmospheres shows promise for the control of *C. capitata* on citrus cold-sensitive cultivars.

SENSORY AND INSTRUMENTAL QUALITY CHARACTERISTICS OF 'FUJI' APPLES STORED IN DIFFERENT ATMOSPHERES.

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Standard quality parameters, sensory characteristics, and total aroma production of 'Fuji' apples (*Malus x domestica* Borkh.) were studied in relation to storage conditions, storage duration and shelf-life period. 'Fuji' apples harvested at 185 days after full bloom were analysed after 3, 5, and 7 months of cold storage in normal atmosphere (21% O₂ - 0.03% CO₂) or under three different controlled atmosphere (CA) treatments, in which oxygen and carbon dioxide were held at 1% + 1%, 2% + 2% or 1% + 3%, respectively. During post-storage ripening, apples were kept at 20°C for 1, 5 and 10 days before analytical measurements were made.

Standard quality parameters in 'Fuji' apples were maintained well throughout storage, especially in CA- than in normal atmosphere-stored apples. Conservation under 1% O₂ + 1% CO₂ was most effective in maintaining flesh firmness, soluble solids content and titratable acidity during storage. Differences in skin colour (exposed side and shaded side) were not always significant. On the other hand, the highest aroma production was reached in fruits stored in normal atmosphere during 5 and 7 months, after 1 day at 20°C. CA-stored fruit (1% O₂ + 1% CO₂ and 2% O₂ + 2% CO₂) showed lower aroma production. Sensory acceptability (by semi-trained panel) was not significantly different after 3- or 5- month storage; however, after 7 months plus 5 or 10 days of ripening at 20°C, apples stored in CA atmospheres scored better than those stored in normal atmosphere. Also, after 7 months plus 10 days at 20°C, fruit stored under 1% O₂ + 1% CO₂ scored best in relation to sensory firmness, sensory flavour, sensory acidity and appearance.

MODE OF ACTION OF HEAT TREATMENT APPLIED TO SWEET BASIL (*Ocimum basilicum*) FOR REDUCTION OF CHILLING INJURY.

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Sweet basil (*Ocimum basilicum*) is a tropical crop sensitive to low temperatures. When basil is stored below 12°C chilling injuries (CI) are developed leading to serious limitation for postharvest storage. The CI is manifested in the leaves as black dots or necrotic spots, browning of upper young leaves and wilting. Damage severity depends on storage temperature and length of exposure. Postharvest heat treatment was found to improve basil tolerance to low temperatures.

Our research is aimed at identifying biochemical and molecular mechanisms involved in mediating the heat pretreatment for reducing basil chilling sensitivity. Possible involvement of the antioxidative system is suggested by the increase in observed general reductive potential in the leaves, as well as induction of super oxide dismutase (SOD) activity following heat treatment and cold storage. To identify candidate genes involved in the induced chilling resistance we have performed a PCR-select analysis. Several cDNAs were identified which represent genes induced in heat treated leaves compared to control. Two of these cDNAs, Ribulose 1-5 biphosphate carboxylase oxygenase and Calceinuril B-like calcium sensor proteins (CBL) kinase, were previously suggested to be involved in plant response to abiotic stresses.

The Rubisco activase was suggested to be involved in plants tolerance to heat acting as a chaperone, while CBL kinase belongs to a protein family that function as signal sensors which has an important role in plant response to different stresses. Expression analysis of these genes in basil supports their involvement in induction of chilling resistance by the heat treatment.

EFFECT OF HYDROXYPROPYL METHYLCELLULOSE-BEESWAX EDIBLE COMPOSITE COATINGS ON PLUM (CV. ANGELENO) QUALITY DURING STORAGE.

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Plums are climacteric fruits, which are suitable for cold storage for a short period depending on the susceptibility to internal breakdown and loss in texture. Edible coatings can offer a possibility to extend the self life of fresh products by providing a semipermeable barrier to gases and water vapor. The objective of this work was to study the effect of beeswax (BW) content on the performance of hydroxypropyl methylcellulose (HPMC)-BW composite coatings on postharvest quality of plums cv. Angeleno. Beeswax was selected as the hydrophobic phase at 0%, 20%, 40% and 60% (d.b.). Stearic acid, glycerol and BW were added to the HPMC suspension, and the mixture was homogenized to get uniformly-dispersed emulsion. Plums were dip-coated following by drying in tunnel. One group remained uncoated as control. Plums were stored 2, 4 and 6 weeks at 1°C and transferred to 20°C from 1 to 3 weeks. Weight loss, deterioration index and texture of plums were measured during storage.

No differences on weight loss were observed between uncoated and 0% BW-coated plums. Weight loss decreased as lipid content increased from 20% to 40%, but above 40% BW content, weight loss was not further reduced. Coatings improve texture compared to uncoated plums after prolong storage at 1°C and at 20°C. No differences were observed in the deterioration index between treatments as storage time at 20°C increased for samples initially stored 2 weeks at 1°C. However, the deterioration index of coated samples stored 4 or 6 weeks at 1°C decreased compared to uncoated plums as storage time at 20 °C increased. Results indicate that HPMC-BW coatings have the potential to extend self life of Angeleno plums for prolong storage at 20°C.

IMPROVEMENT THE POST-HARVEST QUALITY OF CUT PATUMMA (*Curcuma alismatifolia* VAR. CHIANG MAI PINK) FLOWERS.

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Patumma or 'Siam tulip' var. Chiang Mai Pink is newly export cut flowers to the international market from Thailand. The exported quantity has been reported very low due to the lack of suitable post-harvest management. In the present study, the effects of various treatments on their vase life and post-harvest quality were investigated. The vase life of patumma is approximately 12 to 14 days, depended on the flowering season. The vase life of these flowers is considered terminated when comma bract colour faded or withered. Inflorescence stems deflated and their color turned yellow while holding in distilled water also terminate the flower longevity. Water balance in the inflorescence is the major problem determining the post-harvest quality of cut patumma flowers. The rapid decreasing of water uptake within four days after harvested triggered the deflation of inflorescence stem. A pulsing treatment with the mixture of the plant growth regulators (gibberellic acid and benzyladenine) delayed inflorescence stem collapsed, therefore, the vase life can be extended. Ethylene has little effect on comma bract but can cause early wilting of the true flowers. Pulsing treatment with 1mM silver thiosulfate (STS) for two hours improved the number of true flowers opening and the period of flowers opened, but had no effects on the inflorescence longevity. Various chemicals being dissolved in the vase solutions showed no effect on prolonging their vase life and caused inflorescence stem to collapse earlier. Effects of each chemical treatment on the longevity and post-harvest quality of cut patumma flowers will be discussed.

S5-47

RELATIONSHIP BETWEEN LOW-OXYGEN INJURY AND ETHANOL METABOLISM IN VARIOUS FRUITS AND VEGETABLES.

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The relationship between low oxygen injury and ethanol metabolism in twenty kinds of fruits and vegetables were investigated. The fruits and vegetables were stored under a continuous flow of 0%, 1%, 3%, 5% and 10% O₂ (balance N₂) or air at 20°C for 7 days. At 0% O₂, low-oxygen injury was induced and developed during storage in all the commodities. A visible low-oxygen injury, skin pitting, appeared in okra, eggplant and cucumber fruit, while discoloration occurred in Chinese chive leaves, cauliflower, spinach leaves, eggplant and pear fruit. In addition, water-soaked tissue appeared in Chinese chive leaves, cauliflower, spinach leaves, strawberry, banana and pear fruit. Significantly, off-flavor or off-odor was detected in all commodities after storing in various durations during experiments. Hence, the occurrence of off-flavor or off-odor is the most common and important detrimental symptom that limit tolerance of fruits and vegetables to low oxygen. Since the levels of ethanol were higher than those of acetaldehyde in all commodities at day 7, the development of off-flavor or off-odor was related to increases in ethanol concentration but not to acetaldehyde during storage. The rate of increase in alcohol dehydrogenase (ADH) activity was lower than that in ethanol levels of fruits and vegetables, and changes in ADH activity did not necessarily correlate with the changes in the levels of ethanol or with the development of off-flavor or off-odor. However, the intensity of off-flavor or off-odor was associated with the levels of soluble solids content (SSC) of fruits and vegetables. Hence, SSC is important in determining the ethanol level that causes off-flavor or off-odor and has significant implications regarding the development of off-flavor or off-odor in fruits and vegetables.

S5-49

CHILLING-INJURY SENSITIVENESS OF CV. ROJO BRILLANTE PERSIMMON.

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The effect of cold storage on quality parameters of 'Rojo Brillante' persimmon was studied in two consecutive years. Persimmon fruits were stored at 1 or 15°C for 15, 30 or 50 days, after cold storage periods fruit were submitted to deastringency treatment (95% CO₂, 20°C, 24 h) and then held to 20°C for 7 days simulating shelf-life. Ethylene and CO₂ production, firmness, external color, weight loss, soluble solids and juice volatiles concentration were evaluated.

This cultivar presented evident chilling injury symptoms when stored at 1°C during 15 days. The most important disorder was the drastic flesh softening that occurred when fruit were transferred from cold storage to shelf-life conditions. Acetaldehyde production and calyx abscission also appeared as possible responses to chilling stress. Values of C₂H₄ and CO₂ production were very low and no significant changes were observed along storage. Storage temperature did not affect soluble solids content. Although at 15°C, persimmons maintained high quality during 15 days plus shelf-life, after 30 days the values of firmness were very low, therefore extended storage it is not possible at this temperature.

S5-48

EFFECTS OF BLUE-LIGHT PPFD PERCENTAGE DURING RED AND BLUE LED LOW LIGHT IRRADIATION STORAGE ON PHOTOSYNTHETIC PROTEIN CONTENTS OF GRAFTED TOMATO PLUG SEEDLINGS.

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We have recently reported that mixed light irradiation of red and blue rather than red light alone would suppress the decrease in photosynthetic protein contents of grafted tomato seedlings during red and blue LED low light irradiation storage. In the present study, we investigated the effect of blue-light PPFD percentage during storage on the photosynthetic protein contents of seedlings. Grafted tomato (*Lycopersicon esculentum* Mill.) plug seedlings were stored at 10°C for 21 d under 2 µmol m⁻² s⁻¹ PPFD using mixed light from red and blue LEDs, with different percentages of blue-light PPFD (0, 2, 5, 10 and 50%). On the last day of storage, ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) and chlorophyll contents in the 1st to 3rd leaves were determined.

Rubisco content in leaves at all leaf positions and chlorophyll content in the 1st leaves increased with increasing the percentage up to 5%, and these contents were unchanged when the percentage exceeded 5%. Chlorophyll content in the 2nd leaves was greater in the 2 to 50% blue-light PPFD treatments than in the 0% blue-light PPFD treatments. Chlorophyll content in the 3rd leaves was constant under all percentage treatments. It can be concluded that the 5 to 50% was the best percentage for the tested percentages. However, in our previous report, no applicable tendency was shown in dry weight of tomato plants cultivated for 14 d following 21 d of storage by increasing the percentage.

These results indicate that the difference in Rubisco and chlorophyll contents caused by different percentages did not affect the growth during cultivation following storage. However, red and blue LED mixed light irradiation with 5 to 50% blue-light PPFD contributed to visual quality improvements because the decrease of chlorophyll content was suppressed during storage of the grafted tomato seedlings.

S5-50

WATER PERMEABILITY CHANGES OF THE CELL MEMBRANE AS A FUNCTION OF TIME.

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Water loss and microscopic water movement inside tissues or cells are major causes of vegetable deterioration and wilting during the postharvest period. Water loss and water movement caused by respiration and evaporation are influenced by the condition of the cell membrane or other biomembranes. Therefore, for the studying of postharvest technology it is essential to understand the changes in the properties of biomembranes of the agricultural products during the storage.

Changes in water permeability coefficient (Lp) of barley cotyledon cell membrane with time course were measured. The barleys were cultivated in our laboratory for 12 days. Its cotyledons were cut from the plants and stored within test tubes at 20°C in dark. The storage periods were 0, 24, 48 and 72 h. After the storage, protoplasts were separated from the cotyledons and the Lp of the cell membranes were measured by Two Laminar Flow (TLF) Method. In the TLF Method, the Lp was determined from volume change ratios of the protoplast under the osmotic stress. Initially, the sample protoplasts were osmotically in equilibrium with 0.4 M mannitol solution. The osmotic stress was applied by replacing the surrounding solution of the protoplasts with 0.6 M mannitol solution rapidly.

Before the storage, the average value of Lp was 0.072 pm/s/Pa and it decreased to 0.033 pm/s/Pa after 24 h of storage. However, afterward it increased and was 0.044 and 0.053 pm/s/Pa after 48 h and 72 hours of storage respectively. It was supposed that decline in functional activities or decrease in amount of the water channels in the cell membrane induced the initial decrease of the Lp and deterioration of phospholipids bilayer composing the cell membrane caused the latter increase of the Lp.

S5-51

IMPACT DETECTION IN POTATO HANDLING LINES WITH SENSORS BASED ON TRI-AXIAL ACCELEROMETERS.

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Mechanical damage in potato postharvest processes has become a major concern for potato producers. The amount of potatoes rejected by the Spanish potato industry because of severe bruising increases annually. Mechanization and automation of the postharvest processes raise the production capacity but the potatoes run an increased risk of getting damaged by mechanical impacts. In this work the use of "electronic potatoes"; is evaluated as a way to detect the mechanical impacts on potatoes, caused by commonly used types of storehouse handling lines. Two different impact-detecting sensors also known as "electronic potatoes" were used in the tests: the PTR 200 (SM Engineering, Denmark) and the IRD 400 (Techmark Inc., USA). The experiments were carried out in four grading and packing centres in the main potato production area of the Northwest of Spain. The four storehouses were equipped with different machines. The tests were focussed on the determination of (1) the number and type of drops, (2) the drop heights, (3) the transportation velocity, (4) the velocity changes and (5) the changes in direction of transportation. The impact data obtained from the two electronic potatoes were compared to examine any possible differences in performance of the two electronic devices.

S5-53

EFFECTS OF STORAGE ON KUTDIKEN LEMONS 'TUZCU' SOUR ORANGE CLONE ROOTSTOCKS SELECTED FROM EAST MEDITERRANEAN REGION.

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In this work Kutdiken Lemons (*Citrus Limon*) which is standard variety in Turkey were grafted on four different clonal rootstocks that selected from east Mediterranean region and they compared from the stand point of storage in common and conventional cold stores. Kutdiken Lemons, those are grafted on different clonal rootstocks were wrapped into papers and stored eight months for the first year and nine months for the second year at 10 °C and 90-95% relative humidity (RH) in conventional stores, 7.5-11.2 °C and 85-97.5 % relative humidity for common stores without using any chemicals or fungicides. Quality measurements were done by destructive methods in each month and results were evaluated to understand effect of rootstocks on lemon storability.

This research showed that the fruits of Kutdiken lemons, which were grafted on T14, T16, and T20 clonal rootstocks were stored their quality better than the others.

S5-52

POSTHARVEST CA AND HEAT TREATMENTS OF SWEET CHERRIES.

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Losses during marketing of sweet cherries in Norway are estimated to be above 20%. The major causes of these losses are water loss, fruit rots and decay (overripe). To avoid losses due to fruit rots, the fruits in commercial orchards are sprayed with fungicides close to harvest. Alternative treatments are sought as the consumers are growing more aware of pesticide residues, and the losses are affected by other factors than fruit rots.

Sweet cherries (*Prunus avium* L., cvs Van and Lapins) were dipped for 2 minutes in: 1) Distilled water at 20°C; 2) 1% Ca(OH)₂-solution at 20°C; 3) Distilled water at 50°C and 4) 1% Ca(OH)₂-solution at 50°C. The fruit quality was registered as soluble solids content, titratable acidity, colour and firmness. Over all quality and off flavours were analysed by a panel of trained judges. Fruits were stored at 2°C and 20°C up to 2 weeks. Every 4 days samples were analysed as described above. The number of fruits with fruit rots was registered, and the fruits discarded. Weight losses were registered. Ca treated fruits tended to have higher contents of soluble solids and titratable acidity. No changes in colour were observed. After storage heated fruits were less firm than unheated fruits. The decrease in firmness, however, was less in Ca treated fruits. The Ca and heat treatments did not effect the sensory evaluations. Ca and heat treated fruit were less susceptible to fungal attacks. The weight losses during storage were higher in heated fruits. Results from related experiments with alternative treatments in sweet cherries and plums will be referred.

S5-54

APPLICATION OF POSTHARVEST TREATMENTS TO CUT FLOWERS.

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Flowers cut stems often have a short vase life, showing in few days decolouration of petals, a rapid browning of tissues, loss of single components of the flower and total senescence. Such problem determines a shorter vase life, so flowers don't result more available, after few days from harvest. To prevent such delay, a system of packaging (Modified Atmosphere, MA) that consist to introduce in the package different gaseous mixtures, to reduce decolouration of petals and to increase vase life of flower, can be used.

Some tests on three cultivar of Gerbera, two cv. of Lilium and two of Rose were carried out to find the suitable atmosphere, packaging flowers with three different gaseous mixtures: one represented by the normal air (A = 78% N₂ - 21% O₂ - 1% CO₂) and two without O₂ (B = 100% N₂; C = 90% N₂ - 10% CO₂). Wraps were subsequently preserved at 4±1 °C. Package opening was effected after 3, 6, 9 and 12 days of storage in MA. The method used to effectuate this first screening is founded on the aspect assumed by flowers during the shelf life, and on the instrumental analyses results, comparing such data with the analyses on the product not packaged (control). Flowers vase life was evaluated after the opening of wraps, at 20 °C, as well as the daily water consumption.

The gaseous mixture containing air conferred a greater vase life for Gerbera and Lilium, in comparison to the control, while for Roses the mixture B results to be the best.

S5-56

EVOLUTION OF AMYLASE ACTIVITY IN TUBEROUS ROOTED CHERVIL TUBERS DURING STORAGE AT VARIOUS TEMPERATURES.

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Tubers of tuberous-rooted chervil (*Chaerophyllum bulbosum* L.) are of great interest for their nutritional and gustative properties. The storage of tubers after harvest is necessary for the gustative qualities to be developed, via starch hydrolysis. This process can take several months before tubers can be commercialized. It has been shown that storage at low temperature accelerate the degradation process of starch, and therefore could shorten the storage time. In order to explain this phenomenon and optimize the storage conditions, we have studied the enzymatic activities of amylase in tubers stored at 4, 10 and 16°C. The results have shown a higher activity of beta-amylase at 4°C than 10 or 16°C, and conversely a higher activity of alpha-amylase at 16°C. The activity of beta-amylase increased immediately at the beginning of storage, while alpha-amylase activity was present later. The activity of beta-amylase was overall higher than alpha-amylase activity.

The results suggest that beta-amylase activity in tuberous-rooted chervil tubers would be induced by low temperature and would be responsible for the early starch hydrolysis observed. These findings are important for the commercial development of this new crop.

S5-58

LIGHT CONDITIONS DURING PLANT GROWTH INFLUENCE POSTHARVEST SHELF LIFE OF *Coriaria myrtifolia*, A NEW PLANT FOR CUT FOLIAGE.

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Coriaria myrtifolia is a native plant of the South-eastern Spain suitable for cut foliage. The objective of this work was to study the influence of the light intensity during cultivation and of different preservatives on postharvest shelf-life.

Plants of *C. myrtifolia* were cultivated in three shelters. The first shelter had 85% of natural light reduction, the second shelter had 65% of natural light reduction and the third shelter had 45% of natural light reduction. Plant density was 1 m⁻². Plants were harvested three times (in spring, in summer and in autumn). After harvesting, all collected stems were classified in two groups, suckers and lateral stems, and placed in water to avoid dehydration. Then all stems were put in vases at room temperature with the following treatments: control (water), 2.5 g L⁻¹ sucrose, 2.5 g L⁻¹ sucrose + 1 ml L⁻¹ sodium hypochlorite, 2.5 g L⁻¹ sucrose + 2 ml L⁻¹ sodium hypochlorite and 2.5 g L⁻¹ sucrose + 3 ml L⁻¹ sodium hypochlorite.

Best production results were obtained with the least reduced light intensity in terms of number of suckers and stems, implying that *Coriaria myrtifolia* prefers higher light conditions. 2.5 g L⁻¹ sucrose + 2 ml L⁻¹ sodium hypochlorite induced longer shelf life, regardless of the shelters used. In addition, the suckers had longer shelf life than the lateral stems. Larger diameter of both suckers and lateral stems enhanced postharvest shelf life.

S5-57

INVESTIGATION ON EARLY SOFTENING OF KIWIFRUIT.

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Early softening is the main problem for the exports of Chilean kiwi fruit. It has been related to orchard condition and to harvest and postharvest handling. In this investigation, experiments were carried out to test the influence of growing conditions and some fruit characteristics on the softening rate of kiwi fruit, from different orchard in the central zone of Chile. Fruits from all orchards were harvested at 6.2-6.5 soluble solid content, and kept under the same storage condition (0°C, air). Samples were taken every fifteen days to determine softening index (S.I.), which was calculated by the initial firmness minus final firmness, divided by the days till the fruit reached 2 kg of firmness.

There was a large variation in I.S. between orchards and also in the same orchard. In the best orchard the fruits were stored for 135 days having S.I. 0.116; in the worst for 60 days and S.I. 0.257. The tested fruit characteristics were size, position, and illumination of fruit in the plant. For this purpose fruit from the same plants were harvested and tested in the same way as described before. The influence of size on early softening was found in 3 of the 4 orchards tested, having the larger fruit (>115 g) the lowest S.I. The position of the fruit on the plant (distances from the base of the cane) had no influence on S.I. The fruit better illuminated on the plant had higher initial firmness, but also higher softening index during storage. Nevertheless the final firmness was higher in the better illuminated fruit.

S5-59

PHENYLALANINE-AMMONIA-LYASE AND ACCUMULATION OF PHENOLIC COMPOUNDS IN THE ETHYLENE-INDUCED TOLERANCE TO RIND-STAINING IN 'NAVELATE' FRUIT.

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The orange fruit cultivar 'Navelate' is prone to develop postharvest rindstaining (RS) during storage at non-chilling temperatures. This disorder is manifested as extensive collapsed and dried areas of the flavedo and part of the albedo. Ethylene has been shown to protect citrus fruit against RS but the mechanisms associated with the ethylene-induced tolerance to this disorder are unknown.

In this study we have examined the effect of applying ethylene, before or during holding of 'Navelate' fruit under postharvest conditions (22°C, 90-95% RH) inducing RS, on changes in the activity of the enzyme phenylalanine-ammonia-lyase (PAL), the initial rate-controlling enzyme in the phenylpropanoid pathway, and on phenolic content. PAL activity increased concomitantly with albedo and flavedo damage development in control fruit maintained in air. Exogenous ethylene treatments, which efficiently reduced RS incidence, induced a sharp and great increase in PAL activity and phenolic content in both peel tissues from the beginning of the storage period, which preceded the appearance of RS in air-treated fruit. In addition, PAL and phenolic levels were, in general, higher in the ethylene-treated fruit than in those fruit kept in air during the storage period examined.

These results indicate that the induction of the enzyme PAL and of subsequent phenylpropanoid compounds may play a role in reducing the development of RS symptoms and are part of the mechanisms involved in the beneficial effect of ethylene protecting citrus fruit against this physiological disorder. Furthermore, in the present study we have evaluated weight loss, decay and internal quality and have shown that ethylene conditions that reduced RS were not deleterious for 'Navelate' fruit.

FORCED HOT AIR TREATMENT OF STONE FRUIT TO INHIBIT THE DEVELOPMENT OF MEALINESS.

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Conditioning stone fruit by allowing a 48-hour period of ripening at 20 °C prior to cold storage is being increasingly practiced in California as a means to enhance fruit quality following storage by reducing the incidence of mealiness and flesh browning. Conditioning, while very effective, takes a relatively long time to implement and results in fruit that are more susceptible to handling damage and decay. Treatment with forced hot air was tested as a potential alternative to this practice. Conditioned fruit (CF) or nonconditioned fruit (NF) of 'Elegant Lady', a peach cultivar that is susceptible to becoming mealy, were treated with forced hot air using a heating rate of 12°C h⁻¹ and a final chamber temperature of 46°C prior to cold storage for 2 to 4 weeks at 1°C. Following storage fruit were ripened and evaluated for mealiness by determining the percentage of free water (FW) present in the fruit. Fruit stored for 2 weeks were juicy regardless of treatment, although CF maintained an average FW of 57.3% versus 47.2% for NF. After 3 weeks of storage NF that had not been heated had a FW value of 26.9% as compared to 49.6% for nonheated CF and had become mealy. Heating slowed the loss of FW and maintained juiciness, although 3 hours of heating or more was required to have an effect and the FW value for the NF fruit heated for 4 hours was still 7% less than that from nonheated CF. Both CF and NF had become mealy by the end of 4 weeks of storage and had low FW values. Forced hot air can effectively reduce the incidence of mealiness but further research is needed to determine if the technique could be useful commercially.

ROOTSTOCK AND STORAGE REGIME INFLUENCE SUMMIT CHERRY QUALITY.

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Summit sweet cherries from five-year old trees grown on 4 rootstocks were collected and preserved under normal cold storage (NCS) and under different kinds of controlled atmosphere (CA: 1– 2.5% O₂+10% CO₂; 2– 2.5% O₂+15% CO₂; 3–2.5% O₂+20% CO₂).

Fruit samples were analysed and their quality evaluated at harvest and 42 days later. At the end of the storage periods, tasting panels evaluated fruit attractiveness and flavour. Rootstock and storage regime significantly influenced all the studied quality parameters: fruit weight, shape, firmness, juice pH, titratable acidity (malic acid), soluble solids content, and fruit/peduncle colour (CIE L*a*b*; L*C*H°). Fruit size and titratable acidity were higher on invigorating rootstocks, because of their lower productivities. Fruit ripeness occurred later on Gisela 5, with L*C*H° values being superior to those corresponding to the other rootstocks.

As expected, soluble solids content was higher after NCS than after CA, owing to greater mass loss. Fruits stored under CA 3 maintained a better quality, with greenish peduncles, a light red to pink colour (higher H°), a better attractiveness and more brightness. Fruits from Cab 11E ripened earlier and offered better attractiveness after storage. Tasting panels did not distinguish between fruits from CA 3 and CA 2.

NITRIC OXIDE TREATMENT TO EXTEND SHELF LIFE IN 'HAYWARD' KIWI-FRUIT.

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Kiwifruits (cv. Hayward) were harvested at the mature stage and stored at 0°C. After cold storage, fruits were treated with nitric oxide (NO) at concentrations of 100, 200, and 500 ppm for 12 and 24 h under oxygen free atmosphere, respectively. Treated fruits were transferred to 15°C to investigate physiology and quality characteristics during shop holding periods.

As results of sugar/acid ratios and firmness, ripening of fruits treated NO was delayed. They also showed the reduced respiration rate and ethylene production compared to the untreated fruits. The use of NO is an effective method to extend postharvest life as an inhibitor of ethylene production in kiwifruits.

THE EFFECT OF METHYL BROMIDE FUMIGATION ON THE SKIN FINISH OF TASMANIAN 'FUJI' APPLES.

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Stain is a natural phenomenon on 'Fuji' apples appearing as brown patches on the skin of the fruit. It is often associated with areas of the fruit that have been exposed to ultra-violet radiation. Stain may occur in the weeks leading up to harvest, or during storage and transport. This discolouration is exacerbated by MeBr fumigation, as occurs for the 'Fuji' apples exported to Japan from Tasmania. Growers have recently become concerned that this disorder may also impact on domestic sales.

In the USA this disorder is considered commercially significant. This component of the project examined the post-harvest factors that impact on stain. During the 2002 and 2003 seasons stain increased significantly with maturity, indicating that fruit should be picked at least 2-3 weeks earlier. It is important to note that stain varied greatly with grower-line, this could be due to micro-climate effects, production practices or handling procedures. The effectiveness of post-harvest dips was examined; it was found that 2% ascorbic acid was very effective in minimising the development of stain, however this is an expensive product, so methods of application, or the use of other anti-oxidants is being explored. Grading also has a major impact on the development of stain. Two grading lines were examined; one had high rates of stain in the picking bins that diminished after this point, the other line had lower levels of stain in the picking bins but these levels increased to a maximum after the waxing process.

Fruit were placed in simulated transport at 0 °C, 2°C, 4°C, 6°C and 12°C, it was found that the greater the simulated transport temperature the lower the incidence of stain, at the destination market due to the disappearance of the disorder.

S5-64

MECHANICAL HARVESTING AND QUALITY OF MARRONI.

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Chestnut growing represents a typical cultivation of niche that allows to maintain agriculture alive also in marginal areas, destined otherwise to be abandoned. Marroni cultivar shows better organoleptic qualities than other chestnut's varieties: the fruit has bigger size, oval and elliptic shape, brown and light brown pericarp with prominent striations. This higher value cultivar is however considered the most delicate for its greater susceptibility to bruises and abrasions during the harvesting that can prejudice the quality of product storage.

The research has the aim to analyze the effects of the mechanical harvesting on the quality of marroni chestnuts: several laboratory tests were performed to quantify damages (splits, bruises, abrasions), than to estimate the storage of the fruits after the "curatura" treatment. The results show how for fruit marroni chestnut harvest is possible to introduce new models of mechanization capable to effectively reduce the cost without having any consequences on the quality and on the marketability of the picked marroni chestnuts.

The damages consisted mainly of light pericarp abrasions which do not determine the exterior appearance and the quality of the product itself. The average values of percentage of damaged hand picked marroni chestnuts were from 3,6% to 17%, for mechanically harvested marroni chestnuts were from 18,5% to 26% (vacuum machine) and from 20,2% to 45% (mechanical harvester). Marroni chestnuts without petiole ranged from 20% to 22,4% in case of hand picking, from 44% to 49,7% in case of harvesting with vacuum machine, and from 45% to 63% in case of use of mechanical harvester. The colorimetric analysis on healthy marroni chestnuts taken from the different thesis shows a remarkable similitude, both for the hue angle and the saturation index.

S5-66

EFFECT OF 1-MCP ON THE RESPIRATION AND ETHYLENE PRODUCTION AS WELL AS ON THE FORMATION OF AROMA VOLATILES IN 'JONAGOLD' APPLE DURING THE STORAGE.

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Ethylene inhibitors at the level of blocking the ethylene receptors can inhibit the ripening and senescence processes in several fruits and vegetables. There have already been many results about the effectiveness of 1-MCP on the maintenance of the most important quality parameters, such as firmness, colours, sugar and acid content. On the other hand, only a little is known, about the MCP affect on the formation of fruit own aroma volatiles. In this work, the effect of 1-MCP on the gas metabolism of apple fruit, specially on the respiration, on the ethylene production and on the formation of aroma volatiles were investigated.

'Jonagold' apples were cooled to 5°C immediately after harvest and treated with 1-MCP (625 ppb) during 24 h. Subsequently, apples were stored under refrigerated storage conditions in air and in CA for 7 months and sampled 4 times at fixed intervals.

During an 8 days shelf life period at 20°C immediately after the treatment, the effect of 1-MCP was apparent through a distinctive decrease in respiration and a complete inhibition of the formation of ethylene and aroma volatiles. In contrast, the untreated control fruits showed a typically climacteric increase of respiration and ethylene formation. The differences in respiration and ethylene formation between the treated and untreated 'Jonagold' apples remained very different during the entire 7-months storage period. At the same time, the aroma volatiles production of 1-MCP treated fruits from CA storage was very low. However, after 5 months the MCP fruits stored in air showed an increase of aroma volatiles similar to untreated control fruits.

S5-65

STORAGE LIFE AND WATER LOSS OF PLAIN AND CURLED LEAF PARSLEY Almeida D.P.F.^{1*}, Valente C.S.²¹Faculdade de Ciências, Universidade do Porto, Portugal; ²Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.

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Parsley (*Petroselinum crispum*) wilts very rapidly after harvest. Rapid cooling to near 0°C and packaging in plastic films are the best techniques to reduce water loss. The placement of the petioles in water is an effective means of preventing water loss, often used in local markets, but has limitations for transport and storage.

We examined the storage life and water loss of two horticultural types of parsley - plain and curled leaf - at 22, 10, and 1°C, with and without a folded polyethylene bag. Without plastic wrapping the leaves lasted for 2-4, 4, and 12 days at 22, 10, and 1 °C, respectively. Water loss from plain leaf parsley occurred at an average rate of 12.1, 4.3, and 1.0% day⁻¹ at 22, 10, and 1°C, respectively. Packaging in plastic film reduced the rate of water loss 5-8 fold in relation to the unpacked leaves.

When the leaves were dry-stored in the dark at 20°C for 0, 6, 12, and 24 h before placing the petioles in water, the rate of water loss was 11.8% day⁻¹ for plain leaf and 18.8% day⁻¹ for curled leaf parsley. The dehydration periods depressed the subsequent rate of water uptake. However, in both cultivars, the leaves were able to recover full hydration when the petioles were placed in water after losing 11 to 18% of the initial fresh weight.

S5-67

INDUCTION OF IONIZATION WITH ACCELERATED ELECTRONS IN APRICOT PRESERVATION (*Prunus armeniaca* L., var. BÚLIDA).Egea I.¹, Martínez-Madrid M.C.^{2*}, Sánchez-Bel P.³, Ballesteros P.², Murcia M.A.¹, Romojaro F.³¹Universidad de Murcia, Spain; ²Universidad Miguel Hernández, Orihuela, Spain; ³CEBAS (CSIC), Murcia, Spain.

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The apricot, like other climacteric fruits, even shows a shorter period of preservation when it is stored at temperatures next to 0°C. For this reason, there is a great interest in the study of new techniques which can extend their shelf life without affecting the safety and the sensorial and nutritious quality. In this way, the combination of refrigeration with ionizing radiations presents a very interesting alternative postharvest treatment.

We have study the possibility of extending the postharvest shelf life of apricots (*Prunus armeniaca* var. Búlida) by applying ionizing radiations by electron beams, using doses of 0.5 and 1 kGy. Changes on physical-chemical, physiological and nutritional parameters of the ionized apricot during storage at 2°C have been evaluated.

The ionization treatment significantly affected the ethylene production in the apricots and caused an earlier appearance of the climacteric peak and a decrease in the ethylene concentration in that peak; this effect was more pronounced at the greatest dose (1 kGy). The texture of the apricot showed a slight tendency to softening when fruits were irradiated at 1 kGy. The other physical-chemicals and nutritional parameters studied (colour, titrable acidity, soluble solids, carotenoid and vitamin C) showed no significant changes regarding the control apricots without radiating. As far as enzymes of the antioxidant system defence is concerned, only peroxidase registered a significant increase in its activity, that was greater at the greatest radiation dose (1 kGy).

S5-68

SUSCEPTIBILITY OF SPANISH MELON FRUITS TO CHILLING INJURY DURING COLD STORAGE.

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The objective of this work was to analyze the chilling injury development in spanish melon fruits type Piel de Sapo under different cold storage conditions and treatments: 1-methylcyclopropene, Gustec, and ethylene. The 1-MCP is a new alternative for extending the storage period by blocking the ethylene receptors; it is effective when the treated fruit is stored at 0-3 °C. Gustec is a wax that protects the fruit from the loss of water and chilling injury and handling.

Ethylene is a hormone that in some cases protects against chilling injury. Melon fruits were treated with 1-MCP at different doses: 0 and 750 ppb. Regarding Gustec, the treatment was carried out by deeping at a dose of 3.2%; and ethylene was applied at a dose of 100 ppm. Melon fruits were stored at 2 and 8 °C for 34 days. Sampling schedule was weekly for cold storage and then transferred to 20 °C. Evolution of chilling injury symptoms, electrolyte leakage, ethylene production, CO₂ production, ethanol and acetaldehyde, firmness and sensorial analysis were determined. Exposition at 2 °C resulted in a severe injury of fruits independently of the treatment applied and then, after 20 – 25 days, the fruits cannot be commercialized.

On the other side, exposition at 8 °C did not cause any damage and the fruits kept their organoleptic quality during the whole period of cold storage. At 8 °C, the fruits with the best evaluations were those treated with 1-methylcyclopropene (1-MCP).

S5-70

EFFECTS OF 1-MCP TREATMENTS ON FRUIT QUALITY AND STORABILITY OF DIFFERENT PEAR VARIETIES.

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The effects of 1-MCP treatments on Williams, Bosc and Packhams Triumph pears stored in controlled atmosphere (CA) were studied. Every variety was harvested at three different stages of maturity (Optimal harvest date (OHD) – 1 week, OHD, OHD + 1 week). After harvesting, the fruits of each stage of maturity (ca. 40 kg) were divided in two samples. One sample was treated with MCP 625 ppb the other one was untreated. After treatment the samples were stored for approximately 300 days under CA conditions (temperature –0,5°C, O₂ 2,5%, CO₂ 2,0%).

Whereas untreated fruits showed excessive firmness losses and reduction of titratable acidity during shelf-life 1-MCP delayed softening and stabilised titratable acidity of all tested varieties. These effects depended only on stage of maturity and were not variety-dependent. Fruits in stage of over maturity lost more in firmness and acidity than fruits harvested at their optimal stage of maturity. TTS were not affected by 1-MCP. Fungal decay caused by *Penicillium expansum* (blue mould decay) and *Botrytis cinerea* (grey mould decay) was the main problem after long term storage. CA and also 1-MCP were not effective in preventing abundant storage losses caused by excessive fruit rotting. The ability of 1-MCP to reduce fungal decay varied considerably among the cultivars and the stage of maturity. When to late harvested pears were treated with 1-MCP only very little or no response occurred.

S5-69

EXPANDING OF THE MARKETING PERIOD OF APPLES UNDER COMBINED NORMAL ATMOSPHERE - ULO STORAGE CONDITIONS.

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The trial was conducted for 24 apple cultivars and hybrids, promising for commercial apple market in Latvia and Baltic Region. The 1st step of combined storage: fruits were stored in normal atmosphere conditions (90-95% relative air humidity, +2 ±1°C) until they reached the stage of consumption maturity, decreased undesirable acidity, developed full aroma, and becomes ready for marketing. The 2nd stage: fruits were replaced in two different ULO - type atmospheres to evaluate the possibility to expand the marketing period for cultivars usually realized till February in normal atmosphere storage conditions. There was not applied any chemical treatment. During trial period water soluble solids, flesh firmness, physiological and microbiological weight losses, fruit appearance (especially, presence of the scald development), preservation of natural aroma and taste quality were registered.

The aim of the trial was to find storage conditions for significant decelerating of further ripening till June, and to determine the tolerance level to O₂ and CO₂ for each tested cultivar in such advanced maturity stage. The first results of the trial shows that it is possible to decelerate fruit ripening processes during storage for some cultivars, so that fruits in advanced maturity stage keeps good market quality for prolonged time. The best results were obtained for cultivars 'Ilga', 'Bogatir', 'Merigold', 'Sinap Orlovskij', 'Auksis', 'Orlik', 'Belorusskoje Malinovoje', 'Spartan', 'Lobo', 'Pervinka', 'Kovalenkovskoje', 'Lawlam', 'Tellisaare', and two apple elite hybrids of Latvian origin - AMD-19-14-23 and AMD-31-2-14.

S5-71

INFLUENCE OF THE STORAGE TEMPERATURE, THE DIMENSIONS OF THE TUBER AND THE NITROGENOUS NUTRITION ON THE CONTENT OF VITAMIN C IN THE POTATO.

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L-ascorbic acid (AsA) is an important and ubiquitous compound for the higher plants. It is found in high concentration in leaves and some fruits and storage organs (Mapson et al, 1958, 1970).

The AsA is important for many important physiological process, like the redox processes during photosynthesis, protection against environment-induced oxidative stress (ozone, UV, high light, SO₂ etc), during wound and pathogen induced oxidative processes. The antioxidant property of AsA is one of the main function in humans, who are unable to synthesize this acid. One of the main, and cheap source of AsA in the world is the potato, which supply for a good percentage of the world human requirements. The AsA content in the tissues change depending on the techniques of cultivation adopted, storage conditions and the physiological age of the tuber. For this reason, an activity has been conducted to check the evolution of AsA content, chemically determined by HPLC, to quantify the AsA in the tissues, by silver nitrate staining to identify the location in the tissues.

The experiment has been conducted using tubers coming from plants submitted at different fertilization regimes and from tubers stored under different conditions:

- about 20°C, dark
- 5°C, dark

The results show the presence of modification in AsA content depending on the physiological age of the tubers, the N fertilization and dimension of tuber

SS-72 THE IMPACT OF Ca TREATMENT ON THE YIELD AND STORAGE QUALITY OF CARROTS.

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Carrots are one of the broadest grown vegetables for winter consumption in Latvia therefore the storage problems are actual. Optimal content of Ca²⁺ in the soil is one of the most important factors influenced the yield and quality. Also storage facilities deteriorate in the case of calcium lack. Investigation on the impact of Ca top-dressing fertilisers on the carrot yield, quality and storage properties in Latvia conditions were carried out in the Pure Horticultural Research Station from 1999 to 2002. Two varieties ('Narbone' F1 and 'Newburg' F1) were investigated. Dressing was done in four variants: all dose of calcium nitrate (Ca(NO₃)₂) applied once or divided in two and three times per vegetation period, as well as control variant (dressing by ammonium nitrate (NH₄NO₃)) was included. Carrots were stored from October till April in the storage room at +1...2°C, relative humidity 95-97%. The highest yield was obtained in the variant with three-times divided top-dressing. Nevertheless highest quality roots were harvested in the variant of twice divided top-dressing. The highest 1st grade yield was obtained in all variants with Ca top-dressing in comparison to control. Root mass changes were influenced by the time of top-dressing, Ca treatment and length of the storage period. In total the less mass losses for the period from October till April were observed for the variant with twice-divided Ca treatment. The studies of dry matter content showed significant influence of Ca treatment, but dressing time had no influence. The highest sugar content in the carrots at the moment of harvest was measured in the control variant and variant with once-divided Ca top-dressing. Nevertheless influence of one concrete factor on the sugar content changes in carrots during the storage period was not stated.

SS-74

FACTORS AFFECTING EFFICACY OF 1-MCP TO MAINTAIN QUALITY OF APPLES FRUIT AFTER STORAGE.

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Many potential benefits of 1-MCP to manage fruit quality during and/or after storage have been identified. The degree to which ripening processes are inhibited and quality maintenance enhanced by 1-MCP is dependent of several factors. Responses induced by 1-MCP increase with concentration from 10 ppb to 1 ppm and saturation responses occur in 12 h exposure when 1 ppm of 1-MCP is applied. In general, fruit temperature during treatment was not critical.

Experiments conducted with 'Delicious' and 'Gala' apples harvested over a 4-week period indicated that fruit harvested after optimum maturity for long-term CA is benefited from use of 1-MCP. However, the potential for long-term storage of late harvested fruit remains low compared to fruit harvested earlier. The duration of responses induced by MCP can also be influenced by an interaction between fruit maturity and treatment concentration. Riper fruit may require higher MCP concentration (1 ppm) for maximum duration of MCP-induced responses. The length of the delay between harvest/cooling and treatment is another critical factor determinant of 1-MCP efficacy.

Experiments conducted with 'Granny Smith' and 'Gala' apples indicated that maximum control of fruit softening, superficial scald and senescent breakdown is achieved by treatment as soon after harvest as possible. Effects of 1-MCP on retention of fruit firmness and acidity of 'Gala' apples throughout 28 weeks storage were more evident in RA- than in CA-storage. However, the combination of 1-MCP treatment then storage in CA can provide benefits in excess of either treatment alone.

SS-73

POST-HARVEST 1-MCP TREATMENT AFFECTS SHELF LIFE DEPENDING UPON STORAGE TEMPERATURE IN NECTARINES: RELATIONSHIP WITH POLYAMINE TITRES.

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1-methylcyclopropene (1-MCP) inhibits ethylene action and fruit quality achievement by binding to ethylene receptors. Developmental stage, timing and concentration and storage temperature may modulate MCP effects. In preclimacteric nectarines a single MCP treatment induced a decrease in ethylene production and biosynthesis, while repeated treatments retarded the induction of ethylene emission and ACS1 and ACO1 transcript accumulation (Mathooko et al. 2001 PBT 21: 265-281). Plants may overcome MCP action through synthesis of new receptors (Rasori et al. 2002 JEB 53: 2333-2339). Ethylene and the growth regulators polyamines (PAs) share the precursor S-adenosylmethionine. An inverse relationship has been suggested in several physiological processes. At ripening in peach, as well as in other climacteric fruit, PA levels are at their minimum. Exogenous PA treatment in pre-harvest inhibited ethylene production and fruit softening in peaches and nectarines with effects on ACS and ACO transcript levels (Bregoli et al. 2002 Physiol Plant 114: 472-481, Torrigiani et al. 2004 PBT, in press). A role for PAs in post-harvest is also emerging probably correlated with their antisenesescence and antistress properties.

To clarify the role of ethylene and its relationship with PAs, MCP effects on post-harvest have been studied at 25 and 4°C in Stark Red Gold nectarines. At 25°C, MCP strongly inhibited ethylene production, and ACS and ACO expression, and caused an increase in PA levels. At 4°C ethylene production was not altered, although ACS and ACO mRNAs were affected, while PA concentration was further enhanced. A transient PA increase is associated with MCP treatment at both temperatures, independent of ethylene production, suggesting a correlation with MCP- and/or cold stress. MCP is more active at 25°C, but effects on quality are also observed at 4°C. PAs could help in maintaining fruit quality.

SS-75

INFLUENCE OF POSTHARVEST CURING ON MARSH GRAPEFRUIT QUALITY DURING LONG-TERM STORAGE.

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Citrus fruit can incur rind damage due to chilling injury (CI) if stored for extended periods below recommended temperatures. High-temperature pre-storage conditioning or curing treatments have been successful in preventing or reducing CI in many horticultural crops. Marsh grapefruit fruit (*Citrus paradisi* Macf.) was cured (24 or 48 h at 37 °C, 90% R.H.) previous storing to determine its effect on chilling injury symptoms on the peel, weight loss and internal quality. Cured and not cured grapefruit harvested in Concordia (Argentina) were stored during two months at 2 °C or 9 °C.

Fruit quality was evaluated every 15 days and after shelf life (7 days, 20 °C). CI was influenced by treatments, temperature and storage duration. Pitting was observed in grapefruit kept at 2°C after 30-45 days. The severity of this damage increased according to the storage period. Fruits stored at 9 °C did not show CI. Postharvest heat treatment (24 or 48 h) reduced significantly the severity of CI. Slight CI was observed in fruits cured after 60 days at 2 °C. Curing increased weight loss and ripening index. Ethanol and acetaldehyde content in juice increased with storage. Volatile levels were higher in fruits not cured and stored at 2 °C.

EVALUATION OF VASE LIFE OF ANANAS LUCIDUS AFTER EXPORT PROCESS.

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The export of tropical flowers is increasing in Brazil. This fact has been occurring because these flowers have a great number of exotic species, diversity of forms and colours, in addition to their great post harvesting durability. Amongst the species, which present the best prospects for international exports, there is mini red ananas (*Ananas lucidus*). The goal of this work was to simulate the usual procedure to export *Ananas lucidus* and evaluate its vase life after the transport by air.

Stalks of mini red ananas were harvest and package in standard box, after this the boxes were maintained at 20°C for 36 h before being transported by airplane. After the transport the boxes arrived in the laboratory of postharvest of Agronomic Institute, where the stalks were analyzed, put in solution of benziladenine (0.50, 100 and 200 mg L⁻¹) by 24 h and after this they were maintained in water until to the end of the experiment. The experiments were arranged in random block design comprising 10 stalks per treatment.

The results revealed that the procedure used is adequate for this specie and the use of 50 mg L⁻¹ of benziladenine could prolong in two days the vase life of *Ananas lucidus*.

FRUIT INFILTRATION WITH Mg²⁺ IS A FEASIBLE WAY TO PREDICT BITTER PIT SUSCEPTIBILITY IN 'GALA' APPLES GROWN IN SOUTHERN BRAZIL.Amarante C.V.T. do¹*, Ernani P.R.¹, Chaves D.V.¹¹Universidade do Estado de Santa Catarina, Brazil.

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Apples cv. Gala were harvested 20 days before anticipated commercial harvest from orchards in Southern Brazil having a historic of high incidence of bitter pit. Fruit were vacuum infiltrated (100 mm Hg/2 min) in 0.1 M MgCl₂ (with 0.3 M sorbitol/0.1% Silwet L-77) and held for 14 days at 20°C/60-70% RH when the number of induced pits (NIP) was recorded on individual fruits. Fruits from the same orchards were harvested at the commercial maturity and cold stored (0-2°C/90-95% RH) for four months.

These fruits were then left for seven days at 20°C/60-70% RH to allow the full manifestation of bitter pit symptom and them assessed for number of pits (NP) per fruit. Twenty-five individual fruits with none to very high levels of pits per fruit from both, infiltrated or cold stored apples, were selected and then analyzed for flesh and skin content of N, K, Ca, and Mg. Tissue mineral status versus fruit susceptibility to bitter pit (NIP for infiltrated fruit) and fruit severity of bitter pit (NP for cold stored fruit) were plotted to predict bitter pit risk based on mineral analysis as well as to assess the viability of fruit infiltration with Mg²⁺ to predict postharvest risk of bitter pit. The risk of bitter pit was Ca related. The skin tissue provided better fitting than the flesh tissue for any model relating Ca content vs NIP and NP. For both, infiltrated and cold stored fruits, apples with a Ca content in the skin and in the flesh lower than 150 mg kg⁻¹ f.w. and 25 mg kg⁻¹ f.w., respectively, showed increased severity of pits. Therefore, fruit infiltration with Mg²⁺ represents a valuable tool to assess the risk of bitter pit in 'Gala'.

QUALITY AND AROMA OF GOLDEN DELICIOUS APPLES AT HARVEST AND AFTER STORAGE AS INFLUENCED BY PRUNING TECHNIQUES.

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Apple fruit quality depends on a number of factors including the type of breeding and consequently the pruning techniques adopted and storage conditions. Controlled atmosphere (CA) can delay fruit ripeness and can reduce volatile emission. The influence of pruning techniques and storage conditions on apple fruit quality and on volatile emission were investigated.

The trial was carried out in 2001 and 2002 in an Aosta Valley orchard (North-West Italy) at 1000 m a.s.l.. Two types of pruning techniques were taken into account: fuseau Fougères and vertical axis to the solaxe. Fruits of Golden Delicious clone B were harvested when the ethylene concentration reached about 0.6 ppm. Fresh and dry weights, soluble solid content, titratable acidity, firmness and volatile compound emission were measured. Fruits were stored in CA (1.8% O₂, 2.8% CO₂ at 1°C) and tested in January, March, May and June. Volatiles were extracted in methylene chloride and they were separated and identified with a GC/MS.

Fruits from vertical axis to the solaxe showed better qualitative characteristics. Free volatile compounds of Golden Delicious fruits were classified as norisoprenoids, terpenes, benzene derivatives, esters and aldehydes, aliphatic alcohols and acids. 1- Butanol, 1-hexanol, 2-exenal, hexanoic acid, eugenol and 1-butanol-2-methylacetate were largely represented both at harvest and after storage. Total volatile emission was largely influenced by storage period and by the return to normal atmospheric conditions, particularly for fruits from fuseau Fougères.

POSTHARVEST QUALITY AND SHELF-LIFE OF MANGO CULTIVARS GROWN AT SINALOA, MÉXICO.

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New mango orchards along the west coast of Mexico has been growing in the last years, due mainly to the economic perspectives presented with the increasing demand on the international markets. One of the main characteristics considered for the growers on the new orchards are the selection of new cultivars with high quality fruit and extended shelf-life.

Sinaloa state has been one of the most important mango producers for exportation in Mexico with the traditional varieties such as Haden, Kent, Tommy Atkins and Keitt. Growers continuously evaluate the adaptation, yield, disease resistance, quality and shelf-life of new varieties to their areas. On this work, we evaluate quality and shelf-life of three relatively promising new cultivars to the area and compared them with two of the traditional ones.

The experiment was set using mango fruits from five different cultivars (Kent, Tommy Atkins, Ataulfo, Gouveia and Osteen) harvested at physiological maturity. Fruit were evaluated at arrival and stored under simulated marketing conditions (20 ± 2°C and 80% RH) to follow the changes on firmness, colour, titratable acidity, total soluble solids content and pH, every three days. Weight loss, respiration rate and ethylene production were determined daily. Morphological characteristics such as seed weight, were determined once on 50 fruits by cultivar. Total soluble solids content increased in all cultivars reaching after 15 days values that ranged from 15.0 °Brix on Osteen, up to 20.4 °Brix on Gouveia. Tommy Atkins presented the firmer fruits at the end of the study with 35.5 N, while Osteen was the softer with 5.7 N. Based on appearance, the new varieties evaluated did not presented extended shelf-life as compared with Tommy Atkins and Kent. Shelf-life of Gouveia and Osteen stored under the simulated marketing conditions was two weeks.

S5-81

EFFECT OF CALCIUM AND EDIBLE COATING TO MAINTAIN THE QUALITY OF 'KENT' MANGOES DURING COLD STORAGE.

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The 'Kent' mangoes are characterized, being one of the main varieties for commercialization, nevertheless his perishable character reduces his shelf life. The main objective of this work is to maintain its postharvest quality through combined applications of calcium and an edible coating. The fruits were treated hydrothermally, selecting them according to size, colour and weight. They were submerged in different solutions: a) Wax; b) 0.5% CaCl₂; c) 0.5% CaCl₂+Cera; d) 1% CaCl₂ and e) 1% CaCl₂+Cera. Then, storage at 10°C by 30 days and transferred to 20°C to make quality evaluations. Rate of respiration, general appearance and loss of weight were made daily, while firmness, colour of the pulp, total solids, pH, titrable acidity, amount of total calcium in the rind and the pulp were made every three days. The immersions with CaCl₂ increased the calcium content in the rind of the fruits, with proportional values to the concentrations applied compared with the witness. The amounts of calcium in the pulp were no significant. Damages in the surface of the fruits by the application of solutions of CaCl₂ were not observed at 0.5 and 1%. The fruits dealt with CaCl₂+Cera showed significant difference with the rest of the treatments, being observed an excellent and good appearance, free of spots and without decay during the first 9 days of the evaluation. Similarly, a low in the respiratory rate and the loss of weight in the fruits was observed. Retention of the firmness was not obtained.

S5-83

OXIDATIVE STRESS AND CHILLING INJURY OF MUNGBEAN SEEDLINGS.

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Mungbean (*Vigna radiata* (L.) Wilczek cv. AC Harosprout) seedlings were used to test the hypothesis that moderate stress offers protection against chilling injury. Two methods of moderate stress were imposed prior to chilling at 2.5°C. Chilling injury was measured by decreased elongation of radicle length at 25°C following 1 to 4 days of chilling at 2.5°C. First, a continuous flush of pure oxygen for 24 hours onto mungbean seedlings with radicle length of 10 - 12 mm showed a partial reversal of chilling injury, when seedlings were subsequently subjected to chilling at 2.5°C for 1 or 2 days. When seedlings were chilled at 2.5°C for 3 or 4 days, the promotive effect of oxygen pre-treatment disappeared. Secondly, a pre-treatment of soaking mungbean seedlings at 5 mm radicle length with 0.1% hydrogen peroxide for 45 minutes prior to chilling at 2.5°C decreased the radicle length of chilled and non-chilled seedlings. In a follow up experiment, H₂O₂ soaking had no effect on radicle length of chilled and non-chilled seedlings when H₂O₂ soaking was applied at 5 mm radicle length and chilling was delayed until radicle length was about 10 mm. These preliminary results indicated a possible role of moderate stress in a partial tolerance to chilling under some conditions.

S5-82

VARIATION OF ANTIOXIDANT ENZYME GENE EXPRESSION DURING COLD STORAGE OF AUBERGINE.

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Reactive oxygen species (ROS) are dangerous molecules because they can cause damage to proteins, lipids and nucleic acids. ROS production in plants increases at low temperatures; particularly sub-tropical species are sensitive to ROS when they are exposed to temperatures below 10°C. To prevent damage from ROS and to scavenge them, plants developed an enzymatic and a non-enzymatic antioxidant system.

The enzymatic antioxidant system was studied in this work during the post-harvest cold storage of aubergine using the real time PCR technique in order to monitor changes in the transcript level of genes encoding for ROS scavenging enzymes. Changes in Mn Superoxide-dismutase, Catalase, Glutathione reductase, Ascorbate peroxidase gene expression were analyzed during storage at 0°C and at 10°C up to 10 days. Catalase gene expression is stimulated during storage at 10°C and inhibited at 0°C. Equally, Glutathione reductase gene expression is upregulated in this milder refrigeration condition. On the contrary Mn-superoxide dismutase and Ascorbate peroxidase transcript levels decrease with respect to the initial amount for both temperatures.

This suggests that oxidative stress can cause damage during cold storage of aubergine. The expression of ROS scavenging enzymes is positively regulated during the 10°C cold storage contrary to the 0°C cold storage, indicating the presence of oxidative stress and a tissue reaction.

S5-84

INFLUENCE OF REFRIGERATED STORAGE IN THE QUALITY AND SHELF LIFE OF HABANERO CHILE PEPPERS (*Capsicum chinense*, JACQ).González M.¹, Latournerie L.², Centurión A.¹, Sauri E.¹*¹ Instituto Tecnológico de Mérida, Yucatán, México; ² Instituto Tecnológico Agropecuario 2, Conkal, Yucatán, México.

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Consumption of hot chile peppers is due, mainly to their pungent flavour. In the Yucatan Peninsula of Mexico, habanero chile peppers (*Capsicum chinense*, Jacq), are one of the hottest peppers cultivated in special conditions of climate and soil that give them a distinctive and very hot flavour. Due to their commercial and industrial importance, it is advantageous to prolong their shelf life.

The objective of this study was to evaluate the influence of the grade of maturity at harvest, the shelf life and the effect of refrigerated storage on the quality of the product. Chiles with three grades of maturity were gathered: green, green mature and green beginning to change to orange colour; they were stored at 22°C and periodically principal changes during storage were evaluated. Additionally with chile peppers gathered with the grade of green mature the effect of refrigerated storage time on change of quality were evaluated. The chiles were stored at 7°C, samples of them were obtained during a one month period and they were allowed to ripen at 22°C and changes of quality were evaluated in terms of general appearance, loss of weight, acidity, vitamin C content, skin color, firmness and content of total capsaicinoids. It was concluded that optimum maturity grade for harvesting was green mature, since they developed enhanced characteristics in terms of quality and longer shelf life of 10 days at 22°C. At 7°C habanero chiles achieve peak quality during 20 days and at 5 additional days in post refrigeration at 22°C. In conclusion, conservation at 7°C ensures optimal results in terms of quality and shelf life.

S5-85

Raphanus sativus PRODUCTION IN SOILLESS OR TRADITIONAL CULTURE SYSTEMS AND POSTHARVEST PACKAGING.Nicola S.^{1*}, Fontana E.¹, Hoeberechts J.¹, Saglietti D.¹, Piovano G.¹¹Dipartimento di Agronomia, Selvicoltura e Gestione del Territorio, Università degli Studi di Torino, Italy.*Presenter (silvana.nicola@unito.it)

Radish is commercialized fresh in bunches or loose but can be conditioned in packages, to give an added value to the fresh product. Different cultural systems were investigated to optimize radish root production and quality, and postharvest shelf-life. 'Jolly' and 'Tabasso' radishes were grown in two cultural systems: soilless culture system (SCS) and traditional culture system (TCS). At harvest, root fresh and dry weight, length, diameter, and nitrate content were measured.

Macroperforated and vacuum-sealed films were used to package roots from the SCS system for postharvest shelf-life in cool chamber. No significant interaction cultivar by culture system was found for any parameter, while culture system was always significant; cultivar influenced dry matter, root length and diameter, and nitrate content. Fresh weight of roots grown in the SCS was greater than that in the TCS (12 vs 8 g per root, respectively); dry matter was lower in roots grown in SCS than that in TCS (4.7 vs 5.6%). Nitrate content was lower in roots grown in the SCS than that in the TCS (211 vs 445 mg kg⁻¹ fw) and lower in roots of 'Jolly' than that of 'Tabasso' (266 vs 390 mg kg⁻¹ fw). During postharvest fresh weight of radishes packaged with macroperforated films decreased rapidly, losing ca 8% of value every four days, reaching a final decrease of 33%; fresh weight of radishes vacuum-sealed was slightly reduced over time, reaching a final decrease of 3%.

At the end of shelf-life fresh weight loss was significantly different between the two types of packaging. Absence of free air into the vacuum-sealed package could have reduced respiration loss. SCS can be a suitable system to grow high quality radish; vacuum-sealed films might be used to preserve root turgor during shelf-life

S5-86

EFFECT OF 1-METHYLCYCLOPROPENE ON VASE LIFE OF NEW CUT FOLIAGE SPECIES. FIRST EXPERIMENTAL RESULTS.Devecchi M.^{1*}¹Dipartimento di Agronomia, Selvicoltura e Gestione del Territorio, Università di Torino, Italy.*Presenter (marco.devecchi@unito.it)

Cut foliage is more and more required by the market, since it is an element of capital importance in flower compositions, as a consequence of its considerable aesthetic value. Considering the knowledge acquired up to day in the experimentation on traditional cut foliage on post-harvest senescence physiology, specific investigations on new foliage species are still necessary, because their cultivation is increasing. Therefore the following experimentation was carried out: *Aster novae-angliae*, *Bergenia crassifolia*, *Callicarpa bodinieri* cv Profusion, *Cornus alba* cv Elegantissima, *Cotinus coggygria* cv Royal purple, *Hosta fortunei*, *Hosta halcyon*, *Photinia x fraserii* cv Red Robin, *Physocarpus opulifolius* cv Diabolo, *Phytolacca americana*, *Symphoricarpos* cv White Pearl.

The parameters considered were vase life and fresh weight trend during the conservation period. The preserving solution was made of 25 mg L⁻¹ AgNO₃ + 50 mg L⁻¹ Al₂(SO₄)₃ + 25 g L⁻¹ sucrose and was compared with deionized water. Also the action of 1-methylcyclopropene was evaluated (during 12 hours treatment).

So the treatments the foliage species received were:

25 mg L⁻¹ AgNO₃ + 50 mg L⁻¹ Al₂(SO₄)₃ + 25 g L⁻¹ sucrose;

25 mg L⁻¹ AgNO₃ + 50 mg L⁻¹ Al₂(SO₄)₃ + 25 g L⁻¹ sucrose + MCP;

Deionized water;

Deionized water + MCP.

An amount of 35 mg of EthylBloc® was used and the container in which the foliage was put had a volume of 50 L.

The results obtained highlighted the worth of using 1-MCP with the following species:

Bergenia crassifolia as fresh weight trend and vase life;

Cornus alba cv Elegantissima as weight trend and vase life;

Cotinus coggygria cv Royal purple as weight trend;

Hosta fortunei as vase life;

Hosta halcyon as vase life;

Photinia x fraserii as fresh weight trend;

Physocarpus opulifolius cv Diabolo as fresh weight trend;

Phytolacca americana as vase life and fresh weight trend.

S5-87

EFFECT OF 1-MCP ON POSTHARVEST STORAGE OF GUAVA AND ANTIOXIDANT ENZYME ACTIVITIES.Kochhar V.K.¹, Kochhar S.^{1*}¹Division of Biotechnology and Plant Physiology, National Botanical Research Institute, Rana Pratap Marg, Lucknow, India.*Presenter (sunitany2002@yahoo.com)

Guava is an important fruit crop of North Indian Plains. The fruits are rich in vitamin C, pectins and nicotinic acid, phosphorus and soluble fibres. Guavas are considered as poor man's apple in India. But guavas are highly perishable having a very short shelf life. Therefore, this work was conducted with an aim to increase the shelf life and to study the underlying biochemical changes. Fruits of L-49 (Lucknow 49-a locally grown cultivar) were selected for their uniform size and maturity. One set of 50 fruits was kept as control while two other sets of equal number were treated with 0.5 and 1.0 mg L⁻¹ of 1-MCP for 24 h. The fruits were then stored at room temperature. The activities and isoenzyme pattern of antioxidant enzymes such as Superoxide dismutase (SOD), Peroxidase (POD), Catalase (CAT) and Ascorbate peroxidase (APX) were determined at periodic intervals. The degradation of flavonoids, anthocyanins and ascorbate was also determined.

The results have shown that 1-ppm MCP treated fruits showed increased shelf life of 10 days as compared to 2-3 days in control. The treated fruits retained their colour and firmness for a longer time. The activities of SOD and CAT were higher while POD and APX activity were lower in treated fruits. There were some marked differences in the isoenzyme patterns of these antioxidant enzymes. The degradation of anthocyanin and ascorbic acid was also slower in the treated fruits. This is the first report of antioxidant enzymes and isoenzyme pattern as affected by 1-MCP in guavas.

S5-88

HOT WATER TREATMENT FOR DISEASE CONTROL AND EXTENSION OF SHELF LIFE OF KESAR MANGO (*Mangifera indica* L.) FRUITS.Waskar D.P.^{1*}¹Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Dist. Ahmednagar, Maharashtra, India.*Presenter (dpwaskar@yahoo.com)

The present investigation was undertaken to study the effect of post harvest hot water treatment for disease control and extension of shelf life of Kesar mango fruits grown under arid zone. For this purpose, the mango fruits were harvested at proper stage of maturity and given hot water treatments at 52 °C for 10 minutes either alone or in combination with fungicidal dips viz., Bavistin (0.1%) and Captan (0.2%). The mango fruits were then packed in corrugated fibre board box and then stored in two storage environments viz., at room temperature (28.12 to 36.18 degree centigrade temperature and 46.18 to 71.25% RH) and in zero energy cool chamber (21.47 to 27.10 °C temperature and 91 to 95% RH). It was observed that hot water treatment combined with Bavistin (0.1%) was found to be the best in controlling the incidence of anthracnose and stem-end rot. It was also found that shelf life of mango fruits could be extended for more than 28 days when given hot water treatment coupled with fungicides and stored in cool chamber. On the contrary, the shelf life of fruits was found to be 21 days when given same set of treatments and hardly 17 days when untreated and stored at room temperature. It was also observed that hot water treatment coupled with fungicide to mango fruits recorded lower physiological loss in weight and high organoleptic score when stored in cool chamber as compared to room temperature storage. The untreated (control) fruits were found to have infected with *Colletotrichum gloeosporioides* and *Diplodia natalensis*.

DIFFERENTIAL EXPOSURE TO FIELD SOLAR RADIATION AND POSTHARVEST CHILLING INJURY OF CANTALOUPE MELONS.

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Sensitivity to chilling injury (CI) of *Cucumis melo* var. cantalupensis varies from slight to severe, depending on cultivar, and limits temperatures to be used during storage depending on conservation period. Previous studies in other fruits, including *C. melo* var. inodorus cv. Honey Dew, have shown a close relationship between exposure to solar radiation in the field and postharvest CI of fruits. In these studies carried out at an intermediate latitude (32°25'S), the highly sensitive cantalupensis cv. Colima was sown sequentially, from early to late spring, and fruits tagged at anthesis were left uncovered, shaded with a 50% shading mesh or partially covered with sunlight excluding bags. Fruits harvested at different dates during the summer were stored for 14 days at $\pm 1^{\circ}\text{C}$, plus 3 additional days at 20°C , and rated for CI symptoms. Results demonstrated highly significant effects of incident solar radiation on CI expression. Although ratings varied according to total accumulated solar radiation, fruits exposed to direct sunlight showed higher CI and, on a given fruit, sun exposed areas were most affected.

SESSION 6 (S6)

**GENETICS AND MOLECULAR
GENETICS FOR QUALITY AND STORABILITY**



S6-01

MOLECULAR AND GENETIC REGULATION OF SENSORY QUALITY OF CLIMACTERIC FRUIT.

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The sensory quality of fruit has become a major criterion in making the purchasing decision by consumers. Breeding programmes have mainly been directed, from the postharvest stand point, towards improving shelf-life, but this has generally been accompanied by a loss of flavor. Because the plant hormone ethylene plays a central role in both storability and ripening of climacteric fruit, the generation by biotechnology of ethylene-inhibited fruit has offered a powerful tool to better understand, at the molecular genetic level, the inter-relations between storability and sensory quality.

In the melon, inhibition of ethylene synthesis results in a strong inhibition of the synthesis of aroma volatiles while the accumulation of sugars is not affected or is even improved. The softening of the flesh is strongly affected but not abolished. Mid or long shelf-life melons generated by classical breeding present the same behaviour. The generation of near isogenic lines by crossing a typical climacteric melon (Cantaloup Charentais of the *cantalupensis* group) with a non climacteric melon (PI161375 of the *agrestis chinensis* group) allowed to demonstrate that the climacteric character is conferred by 2 duplicated loci only, which are of great importance in for the regulation of storability and sensory quality.

Due to the importance of aroma volatiles in sensory quality and to the strong negative correlation between aroma production and ethylene synthesis, we have developed a research program aimed at isolating genes involved in the synthesis of aroma volatiles. We will report on the recent advances in the field with special emphasis on the characterization of genes responsible for the synthesis of esters, a family of compounds crucial for the flavour of many fruit.

S6-02

POSTHARVEST QUALITY OF ACS DOWN REGULATED APPLES.

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Apples are an important agricultural commodity globally. Most apples are produced for the fresh market, and have to be stored under controlled atmospheric conditions to avoid softening. The softening of fruits is the result of structural changes in the cell walls. These structural changes are caused by the hydrolytic enzymes that are under the control of the ripening hormone ethylene. Ethylene is synthesized in plants from S-adenosyl methionine by two enzymes: 1-aminocyclopropane-1-carboxylic acid synthase (ACS) and 1-amino-cyclopropane-1-carboxylic acid oxidase (ACO). To interfere with ethylene synthesis in plants we have cloned two ACS genes from ripening apples (McIntosh). The gene showing the closest similarity to ripening-related ACS gene in other fruits was used to make antisense constructs using the CaMV-promoter and kanamycin resistance as selectable marker.

Royal Gala and McIntosh plants were transformed with these antisense constructs using an Agrobacterium mediated transformation system. Transgenic plants were propagated on antibiotic-containing agar, transferred to the green house for conditioning and later to the field. Transgenic McIntosh and Royal Gala fruits were evaluated for morphological characteristics, ethylene production, firmness and other ripening parameters. Data indicate a direct relationship between ethylene production and fruit firmness.

S6-03

FUNCTIONAL MARKERS AS GENETIC APPROACH TO STUDY ETHYLENE PRODUCTION AND FRUIT SOFTENING IN APPLE (*Malus x domestica* Borkh.).

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To date different types of molecular markers have been used in genetic studies on agronomic traits. These markers are usually interspersed over the entire genome and their trait association is determined by linkage analysis. In contrast, functional markers are located within a target gene. Their allelic variation is directly associated with sequence differences of this gene. If these sequence differences affect phenotype, then these markers represent different functional alleles of the gene that controls the expression of a (complex) trait. In order to investigate particular aspects of fruit quality, three functional markers relative to ACO and ACS family gene members, which are involved in the ethylene pathway, and to an expansin gene member, which plays a key role in fruit softening, have been positioned on molecular marker linkage maps (Fuji x Mondial Gala and Prima x Fiesta) and evaluated for their involvement on Fuji x Braeburn progeny phenotype.

Md-ACO1 mapped on linkage group 10 of cvs. Fiesta and Mondial Gala. On Fiesta map, this marker was placed on the border of the 5% confidence region of a known QTL for firmness (King et al. 2000).

Md-ACS1 was mapped on LG15 of Prima and Fiesta, but was not associated with any known QTL for apple firmness. Each Fuji x Braeburn offspring that was homozygous for allele Md-ACS1-2 showed low levels of ethylene synthesis and extremely good retention of fruit firmness and shelflife.

Md-EXPDCA1 on L01 of Prima, was mapped at approximately 9 cM of the Vf gene and was strongly correlated with a known QTL for crispness and juiciness (King et al. 2000). Comparative mapping among apple and pear maps showed an interspecific synteny for Md-EXPDCA1 marker which includes a microsatellite motif, tested on 44 apple and two pear genotypes.

S6-04

CLONING AND FUNCTIONAL EXPRESSION OF AN (E,E)-A-FARNESENE SYNTHASE CDNA FROM APPLE FRUIT.

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Increased production of terpenes and many other volatiles occurs with ripening in apple fruit. Ethylene plays a key role in induction of volatile synthesis, but the mechanism is not understood. Using a degenerate primer based on a short conserved sequence shared by several sesquiterpene synthases, RT-PCR with RNA isolated from peel tissue of 'Law Rome' apples yielded an ~800-bp gene fragment. This was used to screen a cDNA library generated from peel tissue mRNA. A full-length terpene synthase (TS) cDNA 1931 nucleotides long was isolated. The 1728-bp open reading frame encodes a protein 576 amino acids long with a molecular mass of 66 kDa.

Sequence analysis of the apple TS showed it to be most similar to several monoterpene synthases (MTSs). The TS includes an RR(X8)W motif near the N-terminus that is common among MTSs but it lacks the plastid transit peptide sequence associated with MTS genes. Expression of the TS gene in bacteria gave epitope-tagged and untagged proteins estimated at ~68 and ~66 kDa, respectively. In sesquiterpene synthase assays with farnesyl diphosphate as substrate, the untagged bacterially-expressed TS gene product synthesized (E,E)-a-farnesene almost exclusively. In monoterpene synthase assays including geranyl diphosphate, the untagged TS produced only (E)-b-ocimene, albeit at much reduced levels. This is the first report of an (E,E)-a-farnesene synthase gene (AFS1; GenBank accession number AY182241) from a flowering plant. RNA gel blots showed that AFS1 transcript increased fourfold in peel tissue of apple fruit during the first 4 weeks of storage at 0.5 °C. In contrast, when fruit were treated at harvest with 1-methylcyclopropene, a blocker of ethylene action, AFS1 mRNA declined sharply over the initial 4 weeks of cold storage, and was nearly undetectable by 8 weeks.

S6-05

THE USE OF MOLECULAR GENETICS TO IMPROVE PEACH AND NECTARINE POST-STORAGE QUALITY.

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Internal breakdown (IB), also known as chilling injury, is the collective term for various disorders that occur during prolonged cold storage and/or after subsequent ripening of stone fruit. Symptoms include meeliness, flesh browning, loss of flavour, and red pigmentation (bleeding). The symptoms are usually not noticed until fruit reaches consumers, and therefore affects consumer consumption. Certain pectin-degrading enzymes appear to play a role in the development of meeliness.

To date, our program had evaluated approximately 133 peach and nectarine varieties for their susceptibility to IB. Some cultivars tend to be more susceptible than others, indicating that the trait has a genetic component. However, the genetic mechanisms by which low susceptibility genotypes avoid IB symptoms are not clear. Using two related and genetically variable populations of peach, we have undertaken a classical and molecular genetics approach to gain a better understanding of the genetic control of IB and lay the foundation for marker-assisted selection (MAS) for these traits. A partial genetic linkage map was constructed, based on random SSR and RAPD markers, candidate gene markers, and gene-targeted SRAP markers. Segregating morphological markers were also mapped, including the Freestone (F), Melting flesh (M), and Flesh colour (Y) loci. QTL analysis was performed on the linkage groups, using phenotypic data collected for three seasons. QTLs for flesh meeliness, browning, and bleeding were located.

Candidate gene analysis identified that a gene encoding the cell wall degrading enzyme, endopolygalacturonase, pleiotropically controls the F and M loci. A large genetic effect on meeliness was detected for this locus, reflecting the observation that meeliness occurred only in some freestone melting flesh progeny and was entirely absent in clingstone non-melting flesh progeny. The use of MAS in breeding for low susceptibility to internal breakdown symptoms appears to be an achievable goal for peach.

S6-06

EFFECTS OF REDUCING COMPOUNDS ON AGROBACTERIUM-MEDIATED TRANSFORMATION OF SWEET POTATO.

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Genetic transformation is prerequisite to molecular breeding for quality improvement of crop plants. Some of primary crop plants such as sweet potato, soybean and maize are recalcitrant to Agrobacterium-mediated transformation because they exhibit strong defense response to pathogens. A part of the defense machinery is an enzymatic browning of the tissues that makes a dead cell barrier to protect them from pathogen infection and insect attack. Reducing compounds are used to inhibit the enzymatic and non-enzymatic browning of fruits and their processed food products to keep their quality. Application of these compounds has so far contributed to the establishment and betterment of Agrobacterium-mediated transformation of these plants, probably due to the suppression of the enzymatic browning of host plants. However, little attention has been paid how much the reducing compounds affect an individual parameter of Agrobacterium system. Therefore, we examined the effects of L-ascorbic acid and four thiol-compounds (dithiothreitol, L-cysteine, 2-mercaptoethanol, and reduced glutathione) on the browning, callus formation, transient- and stable- transformation events of sweet potato leaves as well as vir gene expression in Agrobacterium. All compounds used here reduced the levels of the soluble brown pigments produced by sweet potato leaves. But some of them prohibited callus proliferation and further induced the necrosis or chlorosis of the leaves.

The compounds except 2-mercaptoethanol also repressed the vir gene expression that is essential to deliver T-DNA molecules from the bacteria to plant cells. Taken together, the results indicate that reducing compounds have both the positive and negative sides of the effects on these parameters. Based on our results, we shall discuss the optimal usage of these compounds on the Agrobacterium system.

S6-07

THE EUROPEAN PROJECT HIDRAS: INNOVATIVE MULTIDISCIPLINARY APPROACHES TO BREED HIGH-QUALITY DISEASE RESISTANT APPLES.

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The European project HiDRAS (High-quality Disease Resistant Apples for a Sustainable Agriculture) is a collaborative effort between 11 European groups from 8 different Countries aimed at the identification of the genetic factors controlling apple fruit quality. In the frame of the project, an innovative strategy based on the phenotypic and molecular characterisation of a large number of related genotypes will be adopted.

New software programs will be developed to fully exploit genotypic, phenotypic and, most interestingly, pedigree data, with the aim of identifying fruit quality QTLs and to follow the transmission of their alleles along the pedigree trees. A large number of highly informative markers, including markers from fruit-quality-related genes, will be generated and an apple genetic map with evenly distributed markers will be constructed to guarantee complete genome coverage and a efficient QTL analysis. Part of the project is devoted to investigate Consumer's needs to identify the quality parameters that determine the success of a new apple variety in different European countries. In those occasions our scientific research will be presented increasing the trust of European citizens towards disease resistant apples, therefore favouring their diffusion. Last but not least an apple data repository is going to be established to collect and share data among HiDRAS participants. Initially the database access will be limited but later it will be opened to the scientific community and it will constitute a reference point for all apple breeders and molecular biologist. The original and well concerted multidisciplinary approach, including apple breeding, genetics, molecular biology, statistics and bioinformatics, will ensure the achievement of the project objectives.

S6-08

RIPENING AND SHELF-LIFE OF A FIRM TOMATO MUTANT, WILD TYPE AND HYBRIDS.

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Several postharvest morphological characteristics have been modified by a firm (firme) mutation found in tomato fruits of cultivar Santa Clara, which were evaluated by univariate and multivariate techniques. The results from the analysis of variance showed that the firm mutation caused changes in characters such as soluble solids level in ripe fruits, lycopene, b-carotene and total carotenoids of green-pink fruits, shelf-life and firmness of mature-green fruits. From the eighteen characters initially evaluated in this experiment, eleven of them were considered important for the study of genetic divergence among the studied genotypes. The Tocher method grouped cultivar Santa Clara and the reciprocal hybrids in a cluster group and the firm mutant into another. The dispersion of the first two canonical variables showed that the hybrids had the shortest distance from the cultivar Santa Clara, confirming the cluster method results.

Regarding the contribution of each character to the total divergence, it was established that shelf-life and total carotenoids content were responsible for at least 35.66% of the total divergence. Therefore, the firm mutation in a homozygous state increases shelf-life, firmness of mature-green fruits, lycopene, b-carotene and total carotenoids, however reduces soluble solid levels of ripe fruits and had similar rate of weight loss throughout storage at room temperature. The mutation in heterozygous state presents intermediary shelf-life between the firm mutant and original cultivar Santa Clara. As for the other characters, the results followed a pattern similar to the latter parent.

EFFECT OF HIGH CO₂ LEVELS ON PHENOL METABOLISM IN TABLE GRAPE FRUIT STORED AT LOW TEMPERATURE.Sanchez-Ballesta M.T.¹, Maldonado R.¹, Escribano M.I.¹, Merodio C.^{1*}¹Departamento de Ciencia y Tecnología de Productos Vegetales. Instituto del Frío-CSIC. José Antonio Novais, Madrid, Spain.

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Short-term exposure to high CO₂ before storage at low temperature is an effective postharvest technology to control some physiopathological disorders, thereby extending the storage period of fruit and vegetables. Different studies have demonstrated that the exposure of fruits to moderate stress conditions can induce resistance to severe stresses. However, the molecular mechanisms implicated in the effectiveness of the treatments with high CO₂ levels are still unknown. In grape, one of the best characterised defence reactions upon infection by *Botrytis cinerea* is related to the accumulation of phytoalexins. We have analysed the potential of 20% CO₂ plus 20% O₂ for 3 days pre-treatment in table grape (*Vitis vinifera* L. cv Cardinal) to maintain the quality and to prolong postharvest storage period. The physiological results indicate that high CO₂ maintained table grape fruit quality during low temperature storage and avoided browning and rigidity of the stalks. Differences in the relative amount of polyphenol fractions as a response to post-harvest applied CO₂ at low temperature have been also observed. Some of these phenolic compounds determine table grape quality characteristics of colour and taste such as bitterness and astringency and contribute to their potential health benefits.

In order to understand the molecular mechanisms activated by high CO₂ pre-treatment in table grape we have focused our study on a number of cDNAs of the phenylpropanoid pathway. Using degenerate primers we have isolated three cDNAs encoding a L-phenylalanine ammonia-lyase (PAL), the entry-point enzyme of the phenylpropanoid pathway, chalcone synthase (CHS), the key enzyme of the flavonoid pathway and stilbene synthase (STS), which catalyse the synthesis of resveratrol the major phytoalexin in grape. The potential role of this gene as markers of the effectiveness of high CO₂ levels to delay the loss of fruit quality will be discussed.

SESSION 7 (S7)
PRECOOLING
AND STORAGE TECHNOLOGY



S7-01

STORAGE TECHNOLOGIES AND THEIR EFFECTS ON QUALITY OF HORTICULTURAL PRODUCTS.

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Traditional postharvest technologies, especially control of storage temperature and relative humidity, are the mainstay strategies of horticultural industries in maintaining product quality to meet consumer needs. Modified atmosphere and controlled atmosphere storage are also utilized extensively to maintain quality of some products. Requirements for product disinfection, and the phasing out of methyl bromide as fumigant has led to investigation, and sometimes commercial implementation, of innovative replacements to meet quarantine requirements of importing states or countries. These include non-chemical methods, often involving imposition of stress (heat, low oxygen, elevated carbon dioxide) to harvested products.

An emerging technology is the use of an inhibitor of ethylene binding, 1-methylcyclopropene (1-MCP), which provides an exciting new chemical to control ethylene action and potentially affect storability of many horticultural products. Postharvest technologies, therefore, are integral components of horticultural industries from the producer to the consumer, adding value to products in the marketplace by maintaining quality, extending marketing periods, allowing transport to distant markets, and overcoming quarantine barriers. Most technologies exert beneficial influences on quality attributes by delaying senescence and ripening, and recommended temperatures, relative humidity and atmospheres are available for most horticultural products. However, commercially, compromises are often made because of difficulties of handling mixed products and limited facilities. Considerable abuse occurs during movement of the products to the markets, wholesalers and retailers, and few studies simulate these conditions.

In this overview, the effects of major technologies on quality attributes such as color, texture, nutrition, aroma and flavor of horticultural products will be presented, with emphasis on underlying metabolic processes.

S7-03

POSTHARVEST CALCIUM CHLORIDE DIPS FOR INCREASING PEACH FIRMNESS.

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Postharvest bruising of peaches might be reduced by increasing fruit firmness. This study evaluated changes in firmness resulting from dipping peaches in a calcium solution soon after harvest. Cartons of 'Harvester' and 'Juneprince' peaches were obtained from a commercial packinghouse from three harvests each. Half were dipped for 30 minutes at room temperature in a 1% calcium chloride solution and held at 0, 4, and 10°C and 95% relative humidity. Nondestructive tests (firmness, mass, and colour) were made five or more times during 21 days of storage on 180 fruits from the two varieties (30 fruits x 3 temperature x 2 calcium levels). Firmness was from parallel plate deformations at 10 N. Mass was measured to a resolution of 0.001 g. Colour was measured with a Minolta colour comparator in L, a, b units. Destructive tests were made on 15 fruits from each treatment: total soluble solids (% Brix), acidity (pH), firmness (Magness-Taylor), and taste. Firmness (nondestructive and destructive) during storage was higher for fruit treated with calcium than for untreated fruit. However, temperature affected firmness more than the calcium treatment. Calcium treatments increased mass loss only on 'Harvester' fruit stored at 10 degrees and lowered hue angle only in a few cases near the end of storage.

The main differences in TSS were due to days of storage with little influence caused by the calcium treatments. An undesirable taste was noted in the fruit that was treated. A study is needed to determine if a lower concentration of calcium chloride could provide beneficial increases in firmness without changing the taste of the fruit. The effect of temperature on calcium absorption should also be studied.

S7-02

FRUIT FLUORESCENCE RESPONSE TO LOW OXYGEN STRESS: MODERN STORAGE TECHNOLOGIES COMPARED TO 1-MCP TREATMENT OF APPLE.

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A non-destructive monitoring system (HarvestWatchTM; Satlantic Inc., Halifax, N.S., Canada) that assesses the low-oxygen stress of chlorophyll containing fruit, was applied during storage. It allows to adapt the atmospheric composition in the CA-room to the actual physiological state of the fruit, in contrast to the usual static conditions of CA-storage. Decreasing the oxygen concentration to the lowest tolerated levels by the fruit should enable to obtain the maximum benefits of ULO storage without the risk of losses caused by anaerobic conditions. The monitoring system is based on the measurement of the chlorophyll fluorescence by the means of FIRM™ (Fluorescence Interactive Response Monitor, Satlantic Inc.) sensor on samples of 6 apples each. A central computer is collecting on-line the fluorescence data. Below a fruit-specific oxygen-threshold the theoretical estimate of F0 increases. The oxygen concentration of the controlled atmosphere was set close above the tolerance level of the fruit, determined by the rise of F0.

The effects on quality preservation on apple fruit of three different maturity stages were compared with optimal CA-conditions and with 1-MCP postharvest treatment. The delay of quality loss was determined in terms of internal quality, by firmness, total soluble solids content and titratable acidity; of de-greening; and of physiological disorders, like superficial scald, core flush, anaerobic breakdown. In the case of 'Granny Smith', according to the fruit's fluorescence response to low oxygen stress, O₂ was set at 0.4 kPa. After 6 months of storage and 7 days shelf-life at 20°C, no signs of low oxygen disorder were observed. The occurrence of scald was significantly reduced and better firmness was maintained, compared to conventional CA storage.

S7-04

APPLICATION OF PI CONTROL OF PPFD DURING LED-LOW LIGHT IRRADIATION STORAGE FOR QUALITY PRESERVATION OF GREEN PLANTS.

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A low light irradiation (LLI) storage system that provides stored green plants (transplants, postharvest green vegetables or herbs) with photosynthetic photon flux density (PPFD) at which CO₂ exchange rate of the plants becomes zero can be considered to suppress the dry weight change of the plants during storage and to contribute to long-term quality preservation of the plants. We have built a light emitting diode (LED)-LLI storage system that automatically controls PPFD using a proportional-integral (PI) controller so that CO₂ exchange rate of stored plants becomes zero. The supplied voltage to red LEDs was controlled based on the difference between the CO₂ concentration of inflow (C_{in}: 400 μmol mol⁻¹) and outflow (C_{out}) air of the storage case. Grafted tomato plug seedlings were stored at 10°C for 35 d under two different LLI conditions: red light PPFD-PI control with either blue light 0 μmol m⁻² s⁻¹ PPFD (B0) or blue light 0.2 μmol m⁻² s⁻¹ PPFD (B0.2). C_{out} in both B0 and B0.2 was satisfactorily maintained at around 400 μmol mol⁻¹ during storage except for the first 12 h. Total PPFD was almost stabilized in the latter 25 d and the mean values were roughly 2.3 and 3.6 μmol m⁻² s⁻¹ in B0 and B0.2, respectively. Dry weight of the seedlings on day 35 was not significantly different from that before storage in B0 and B0.2.

These results indicate that the PI control of PPFD during LED-LLI storage contributed to suppress the dry weight change and that the addition of a low percentage blue light reduced the PPFD required to suppress the dry weight change.

S7-05

INFLUENCE OF PEAR-FACTORS ON WEIGHT LOSS OF CONFERENCE PEARS.

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The storage disorder "slack necks" is an important factor that limits CA-storage of Conference pears in the Netherlands. The disorder is due to loss of turgor near the pedicel (stem end of the fruit). It is correlated with dehydration. We investigated the biological variation in the rate of transpiration, between and within batches. Pears from 12 orchards, from 3 production areas, were harvested in 2002 and 2003. Harvesting occurred on the date for optimal CA-storage, as well as 10 days before and after this date. Directly after harvest and after 4 months in CA-storage, weight loss was determined for a 48 h. period at uniform physical conditions (20°C, 60% RH, airspeed 0.4 m s⁻¹; herein referred to as forced dehydration). Measurements were done on individual pears.

Results indicate that harvest date is not a key factor in moisture loss of Conference pears, but fruit weight is. Other observations are: pears from different orchards show a large variation in weight loss under the applied forced dehydration; results after harvest are consistent with those after 4 months of CA-storage; results of the applied forced dehydration are mostly consistent with weight loss during actual storage and shelf-life. The possibility to generate a descriptive model, suitable for prediction of the potential of batches of pears for long term CA-storage will be discussed.

S7-07

EFFECTS OF HIGH O₂ PRETREATMENT AND HIGH O₂ MAP ON QUALITY OF CUCUMBER FRUIT.

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The response of cucumber fruit to high O₂ (100%) MAP (HO-MAP) and high O₂ pre-treatment with 100% O₂ for 48 hours were investigated at 5 °C. The fruit stored in HO-MAP showed no weight loss during the storage. The weight loss of air-stored fruit was two times higher than the pre-treated fruit with 100% O₂. The drying of cucumber fruit was concomitant with the reduction of fruit weight. The shrivel appearance was detected in control fruit and pre-treated fruit with 100% O₂ on day 4 and day 8, respectively. The onset on chilling injury was inhibited by HO-MAP. Pre-treated fruit with 100% O₂ showed less severity of chilling injury compared to air-stored fruit. The severity of chilling injury was related to the percentage of weight loss. The concentrations of CO₂ in HO-MAP increased up to 20% while O₂ levels decreased to 50% at the end of the storage. Fruit in the HO-MAP did not detect any abnormal visual quality throughout storage. On day 8, however, off-flavour was detected in fruit stored in HO-MAP, furthermore, the percentage of ion leakage from flesh tissues also increased over those of other treatments. The ion leakage of control and 100% O₂ pre-treated fruit showed similar level during the first week of storage. The sharply increase of ion leakage from control fruit to the higher level than those of 100% O₂ pre-treated fruit was observed after day 8 till the end of storage. Fungal decay was showed in control fruit and fruit pre-treated with 100% O₂ on day 13 and 15, respectively. Pre-treatment with 100% O₂ lowered the respiratory rate in cucumber fruit compared to control.

S7-06

COOLING LOAD CALCULATION DURING FAST COOLING OF FRESH PRODUCE.

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Refrigeration load capacities for fast-cooling vary significantly for the different commodities based on a number of factors. These factors include product cooling range; specific heat of the product; carton/box design; additional packaging materials used; stacking patterns during cooling and other production variables. The refrigeration capacity requirements for fast-cooling are much greater than just holding products in a typical cold storage room. Typical fast-cooling capacities may be as much as 5 or 6 times greater than the requirements for a standard cold room design. The objective of this study was to develop a cooling load calculation model during forced air cooling as affected by the product initial and final temperatures and the cooling cycle for different types of fresh produce. The model is also to account for the fan heat load and values of specific heat for the different commodities.

Based on the developed model, the cooling capacity is achieved within the time required for quality maintenance without the need for an excessively large plant. The developed model uses the seven eighth cooling times and cooling heat flow factor which is an empirical measure and takes into account that as high as seven eighth of the cooling only occurs at the corresponding seven eighth cooling time. The developed model was validated using the cooling rates values for strawberries and green beans obtained from two pre-cooling stations, which were designed and built using the current design specifications. The obtained cooling curves agreed well with those predicted by the model.

S7-08

A COMPARISON OF ANATOMICAL CHANGES BETWEEN NORMAL AND CHILLING INJURY LONGAN FRUIT PERICARP.

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The anatomy of pericarp from longan fruit (*Dimocarpus longan* Lour.) cv. Daw has been compared between normal and chilling injury fruit. The normal pericarp thickness was 630-700 micron and consisted of three layers. The exocarp had discontinuous cuticle with many natural openings and some epidermal hairs. The subepidermal sclerenchyma layer was thick. The mesocarp had some parenchyma cells with large intercellular spaces as the main body of the pericarp. The endocarp was made up of a single thin layer of epidermal cells. However, during chilling injury, the pericarp showed the cuticle flakes, damaged epidermal hairs and fibrous tissue on the exocarp, and damaged parenchyma cell walls appeared in the mesocarp.

S7-09

MODIFICATIONS IN BIOSYNTHESIS OF AROMA VOLATILE COMPOUNDS IN 'FUJI' APPLES AFTER CONTROLLED-ATMOSPHERE STORAGE.

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Although controlled-atmosphere (CA) storage is a common practice allowing longer commercial availability of a number of fruits, such storage conditions have been reported to decrease volatile production in some apple (*Malus domestica* Borkh.) cultivars, and thus to be detrimental to fruit aroma. Because "Fuji" is a cultivar showing excellent organoleptic quality and long-term storage potential, it is desirable to optimise conditions for maintaining fruit quality throughout storage. "Fuji" apples were harvested at commercial maturity in an orchard near Lleida (Spain). Immediately after harvest, fruit were selected for uniformity, and cold-stored under air (21 kPa O₂ + 0.03 kPa CO₂) or under three different CA conditions (3 kPa O₂ + 2 kPa CO₂; 1 kPa O₂ + 1 kPa CO₂; or 1 kPa O₂ + 2 kPa CO₂) during a period of 3, 5, or 7 months, after which apples were placed at 20°C. Emission of aroma volatile compounds, acetaldehyde and ethanol contents, and some enzyme activities related to volatile biosynthesis were assessed 4 days thereafter, and used for Principal Component Analysis (PCA) of results. Storage caused modifications in the aroma profile as compared to the moment of fruit harvest: ethyl hexanoate, one of the main compounds contributing to aroma of freshly-harvested fruit, was undetectable after storage, regardless of conditions. PCA revealed differences according to storage atmosphere and storage period, the main volatile compounds contributing to "Fuji" aroma profile being associated to cold storage in air and correlated to higher pyruvate decarboxylase activity and acetaldehyde content. Storage under ultra-low oxygen concentrations was associated to increased alcohol dehydrogenase activity and ethanol contents. The highest emission of total volatile compounds after storage was found for fruit stored during 5 months, and alcohol O-acyltransferase activity was found to be closely related to differences arising from storage period.

S7-10

THE EFFECT OF 1-MCP ON STORAGE POTENTIAL OF PLUM (*Prunus domestica*) & GREENGAGE.Tully M.S.¹*, Hanney S.J.², Bishop C.F.H.B.²¹Landseer Ltd (UK); ²Writtle College, UK.

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Victoria plums were harvested on one date, from two different agri-climatic areas, with Margorie and Greengage harvested from one location at a later date. Samples of the fruit were treated with 1-MCP (Smartfresh™) within 12 h of harvest, prior to storage in air. The 1-MCP was applied at 650 nL L⁻¹ for 24 h at 1°C.

All fruit was stored in air at 1°C for 28 days. Fruit was removed from the cold store at 7 day intervals, with each sample having a untested subsample transferred to 20°C for 7 days. The fruit quality was tested by colorimeter (Minolta a* reading), the presence of decay, pressures and soluble sugars. For both cultivars the most notable effect of 1-MCP was the improved firmness of fruit both from cold storage and after 7 day at 20°C. The agri-climate region had an effect on the fruit pressure in Victoria, with a 7 day benefit over the untreated sample for the firmness to drop below 4 kg cm⁻². There was a similar benefit for greengage.

The firmness for Margorie was around 3.5 kg cm⁻² at harvest, but the 1-MCP treatment sample did not decrease to below 3.5 until 35 days, with the control falling below this figure after 21 days.

S7-11

EFFECTS OF DECREASING OXYGEN LEVELS IN THE STORAGE ATMOSPHERE ON THE RESPIRATION AND PRODUCTION OF VOLATILES OF 'IDARED' APPLES.

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Based on the concept of dynamic CA-storage, the effect of stepwise decreasing oxygen levels in storage atmosphere has been assessed for 'Idared' apples. Considered was the storage duration under LO-conditions (4°C, 1.5% CO₂, 1.0% O₂) of the fruit prior to measurements (0, 5 and 8 months). 'Idared' apples are known to be susceptible to chilling injury below 3°C and sensitive to CO₂ above 3%. During oxygen reduction temperature was held at 4°C and 1°C, respectively, and CO₂ concentration was held at a constant level of 1.5% and 4.0%, respectively. Respiration rate and the production of ethanol and total volatiles were monitored daily for individual fruit. Regardless of temperature and CO₂ concentration during oxygen reduction, all fruit showed an identical anaerobic compensation point (ACP), below which CO₂ production increased significantly. Oxygen concentration at the ACP was 0.37% just after harvest as well as 5 months after harvest, and decreased then to 0.17% after 8 months storage duration. Fruit held at a temperature of 1°C showed the same or a slightly higher level of oxygen consumption compared to fruit held at 4°C, a respiratory pattern which may be expected as a response of fruit to stress.

The evolution of total volatiles of apples exposed to decreasing oxygen levels paralleled that of ethanol as determined using solid phase microextraction (SPME) technique. The rate of volatile or ethanol production was constant or decreased slightly with decreasing oxygen level, and increased twice to fourfold for the volatiles and up to ten fold for ethanol at or below the ACP.

S7-12

ADVANCEMENTS IN THE IMPLEMENTATION OF CA TECHNOLOGY FOR STORAGE OF PERISHABLE COMMODITIES.

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Noncryogenic air separation technology has become the predominate method for establishing and maintaining Controlled Atmosphere (CA) conditions for the storage of perishable commodities. The two types of commercially available noncryogenic air separation CA systems are based on membrane and adsorption technology.

An analysis of existing commercially available CA systems is presented, along with an examination of the distinct advantages and disadvantages of each. The review of operator experience and implementation trends of the past few years indicate that membrane based CA systems remain the technical solution of choice for the majority of CA system markets.

EFFECT OF THE SURFACE AREA OF EVAPORATOR COIL ON ENERGY CONSUMPTION, REFRIGERATED STORAGE ENVIRONMENT AND WEIGHT LOSS OF FRUIT.

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Refrigerated storage is one of the major techniques for retention of quality. For long term storage, the most significant economic parameters are product weight loss and cold room climate, which affects quality as well as the quantity of saleable produce and the energy consumption in running the plant. For the most of the refrigerated store, direct expansion evaporator is used for cooling room. In this case, frost accumulation on the surface of coil is the cause of moisture decrease in cooling room and fruit moisture loss. In addition, because of frost accumulation on the coil surface tends to insulate the coil and reduce the refrigeration capacity, the frost must be removed periodically by raising the surface temperature of coil above the freezing point of water. This is the cause of an increase of electricity consumption and room temperature variation. However, most of the information available is on the effect of relative humidity on fruit moisture or weight and quality changes during storage. Little information is available on surface area of evaporator coil effects on energy consumption, storage environment and weight loss of fruit. In this study, the amount of frost accumulated on the surface of evaporator coil, variation of temperature and relative humidity in cold room, temperature difference between room air and discharge air from the evaporator coil, electricity consumption, and weight loss of fruit were monitored according to the surface area of evaporator coil.

From the experimental results, it was possible to design an evaporator that little frost was accumulated on the surface of coil and high humidity level is maintained in cold room. When we used newly designed evaporator to commercial cold room, it was possible to reduce 6.1% weight loss of pears and 54% electricity consumption after 4-month storage.

CONSIDERATIONS TO CONTINUE THE RESEARCH IN THE PRECOOLING'S AREA OF NUMERICAL SIMULATION OF AGRICULTURE PRODUCTS IN FEAGRI / UNICAMP.

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This work intends to discuss the arguments that lead to the implementation choice of two types of finite difference methods: explicit and implicit, in research with numerical simulation of physical process. Therefore, it was taken the example of the strawberry pre-cooling numerical simulation, because it was the first research in FEAGRI / UNICAMP, where was used this methodology to develop studies in the area of agricultural engineering process. In this case, it was considered the unidimensional mathematical model, based on Fourier's law, in spherical coordinates, and the initial and border conditions was based on specific experiment realized previously. Observing the theoretical advantage and disadvantage - as it consists in the apply of mathematical bibliographic reference - it is evidenced that the explicit method is slower than implicit, because the first method needs to be executed satisfying the stability criterion. However, in view of that in this type of process, both the methods produces results with the same accuracy in seconds, and considering that the implicit method implementation is avoided for the most part of the beginners researchers, to judge it very complex, it can be suggested, for the continuity of to research using explicit method, mainly if allied with a bidimensional model, what already have been developed.

EFFECTS OF GASEOUS OZONE EXPOSURE ON COLD STORED ORANGE FRUITS.

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The influence of Ozone treatment in relation with storage temperature and venting system on orange fruits decay was examined in an intermittent ozone exposure. In order to allow the rooms to be free of gas during the working time the experimental trials were carried out generating ozone in day-night cycles and the ozone were on-line controlled using an infrared analyser. The effects of gaseous ozone exposure on development of post-harvest green and blue moulds (*Penicillium digitatum* and *Penicillium italicum*) in artificially inoculated citrus fruit (104cfu ml⁻¹) were evaluated. The orange were pre-treated according with the following protocol: control (no wash), washing with ozonized water (0.6 ppm), washing with chlorinated water (50 ppm). After the washing-pre-treatments the fruits has been stored for 8 weeks at 5°C and 90-95% relative humidity in an intermittent ozone exposure (treatment) and in normal cold storage room (control). Gaseous ozone at 0.3 ppm did not reduce *Penicillium* mould incidence in no-wash fruit: apparently, fungal structure in wounds remain protected from oxidant effect of ozone.

The data collected shown a synergistic effect between ozone and chlorine wash and exposure at 0.3 ppm in inhibiting mycelial growth and preventing sporulation on citrus inoculated with *Penicillium*. Ozone would also decrease the load of pathogenic spores in the storage room and inhibit the surface growth of mould on packages, walls and floors, with a subsequent reduction in the amount of inoculum available for re-infections of stored product. Ozone exposure reduced ageing and weight loss than oranges stored in a non-ozonated environment.

STORAGE AND SHELF LIFE OF VENUS NECTARINE CULTIVAR.

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The objective of this study was to determine storage and shelf life of Venus nectarine cultivar grown in Mersin (Tarsus/Yenice). Fruits were kept at 0°C and 85-90% relative humidity for 2 months to determine cold storage conditions. In addition, three replicates of fruits taken from storage room at a week interval were kept at 20°C and 65-70% relative humidity for 6 days to determine shelf life.

Percent weight loss, skin colour (L, a, b), flesh colour (L, a, b), fruit flesh firmness (kg force), total soluble solids (%), pH, titratable acidity (g malic acid 100 ml⁻¹), physiological and fungal disorders were determined in the fruit samples taken during cold storage at a week interval and those kept at 20°C at a two-day interval. Weight loss increased during storage and reached about 5% at the end of storage. Fruit flesh firmness decreased, but still remained above 4 kg-force at the end of 2-month storage. Total soluble solid (%) and pH increased while titratable acidity (%) decreased. As the storage period was extended the shelf life was observed to be shortened.

S7-17**THE RESPIRATION RATE MEASUREMENT OF FRESH PRODUCE USING AUTOMATED FLOW-THROUGH SYSTEM.**Lee H.D.^{1*}, Yoon H.S.¹, Lee W.O.¹, Jeong H.¹, Choi J.U.²¹National agricultural Mechanization Research Institute, Korea; ²Kyungpook National University, Korea.*Presenter (lwo2000@rda.go.kr)

This study was conducted to measure the respiration rate of fresh produce using an automated measuring system based on the flow-through measurement method under the various gas compositions. The developed system was consisting of mainly two parts; one is a gas mixture generator, and another is a gas analyzer. The gas mixture generator consists of precision pressure regulators, manipulators, and metering valves. The volume flow rate of O₂, CO₂ and N₂ (balanced with N₂), which were supplied from cylinders, was controlled by the precision pressure regulator and metering valve to obtain the desired gas mixture. The measuring part consists of multi-position valve, sample loop and gas chromatography. The gas flow line is connected to multi-position valve, which separates inlet and outlet from gas mixture of chamber. Therefore it is possible to analyze gas sample by gas chromatography according to the flow through method. The gas mixture generators make a gas mixture as $\pm 0.2\%$ accuracy via desired gas concentration from the 0.0 to 20.6%. In the empty chamber test, gas concentration difference of inlet and outlet from chamber is $\pm 0.02\%$. When the gas sample was analyzed three times at each gas flow line (inlet and outlet), the measuring repeatability was $\pm 0.03\%$.

The result of respiration rate measurement about tomatoes and apples at 12°C were: O₂ consumption rate of tomatoes, 2.0~8.2 mg kg⁻¹ h⁻¹; CO₂ evolution rate of those, 3.5~6.9 mg kg⁻¹ h⁻¹; O₂ consumption rate of apples, 0.8~2.8 mg kg⁻¹ h⁻¹ and CO₂ evolution rate of those, 0.7~4.8 mg kg⁻¹ h⁻¹ according to gas compositions. The measurement values of automated system were similar to values from the literature.

S7-19**STUDY ON CHARACTERISTICS OF VACUUM COOLING FOR AGRICULTURE PRODUCTS.**Lee W.O.^{1*}, Yun H.S.¹, Lee K.H.¹, Jeong H.¹, Lee H.D.¹, Cho K.H.¹, Kim M.S.²¹National Agricultural Mechanization Research Institute; ²Chungnam National University, Korea.*Presenter (lwo2000@rda.go.kr)

Perfect temperature manipulation is represented in general by Cold Chain System, and in this system, fruit and vegetables are immediately precooled after harvests and distributed under cold package throughout entire system. In these procedures, the effect of precooling absolutely overwhelms initial quality of fruit and vegetables, and particularly, with vacuum precooling, the temperature of green groceries can be reduced in a rather short period of time. Thus vacuum precooling is used in the early stage of Cold Chain System as an efficient cooling method.

In order to design an efficient vacuum cooling system, a test has been carried out to examine cooling characteristics that changed according to vacuum pressure of the vacuum cooling system in a pilot size and manipulation of the system, and the test results have revealed that the evaporation index of moisture affects mainly cooling speed during the period of time immediately until the pressure in the chamber is controlled evenly at fresh point, and also it has revealed that if the pressure in the chamber is consistent, quality of green groceries and its weights are maintained almost uniformly. In addition, if the specific surface area of the object is large, the test reveals that cooling speed increases faster. However, during the period of time when the final pressure and the temperature of green groceries become stable, it displays a tendency of decreasing weight.

The ratio in connection with the temperature lowering and the amount of weight loss during this period of time brings a decrease of cooling time. It is believed that evaporation of moisture due to radiation heat around the surface of object during the time causes a decrease of weight. Thus, the final level of pressure to reach in chamber has been confirmed as an important parameter to decide the final temperature of object.

S7-18**ENERGY USAGE IN ONION STORAGE.**Hanney S.J.^{1*}, Bishop C.F.H.B.¹¹Writtle College, UK.*Presenter (simonhanney@hotmail.com)

The current practices and performance of curing and cold storage of Rijnsberger onions (*Allium Cepa* L.) within the UK was investigated between September 2002 and April 2003. The study aims included investigation into the energy usages, economic, managerial and logistical aspects of three types of common onion storage methods; bulk, tonne container and large container (18 tonnes).

To fulfil the study aims, approximately 15.85% of the UK stored crop was investigated, and the store raw data collated and subject to analysis to produce a "storage index". The complete costs of each store was also investigated and compared by store type. It was found that the energy inputs do not necessary relate directly to the overall costs of storage, indicating many factors involved in the storage types investigated during this study. It was found that there was a relationship between the bulk density and the storage index, with the bulk storage methods having a lower storage index than for onions stored in containers. Comparing the container storage; large containers were cheaper to run than smaller containers, but had a higher initial capital investment, leading to a higher overall cost per tonne stored.

The energy costs per tonne were not in the same order as energy usage showing the importance of tariff selection. The choice of onion curing and cold storage is a complex issue that includes many enterprise specific factors, such as client base or cooperative ventures. However this study shows that energy factors correlate with store type in all cases.

S7-20**EFFECT OF THE RATE AND DURATION OF FORCED AIR COOLING ON THE QUALITY OF IMPERIAL APRICOTS AND PIONEER AND SONGOLD PLUMS.**Jooste M.M.^{1*}, Khumalo P.²¹Department of Horticultural Science, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa; ²Capespan Technology Development, P.O. Box 1231, Stellenbosch, 7599, South Africa*Presenter (mjooste@sun.ac.za)

Gel breakdown (GB) and overripeness (OR) remain the biggest internal problems with Imperial apricots which makes the biggest contribution to the total volume of apricots exported from South Africa per annum. Pioneer, an early season South African plum cultivar, ripens quickly on and off the tree which results in rejections for soft fruit at packing and on arrival overseas. Songold, a yellow, midseason plum cultivar tends to develop GB and OR during cold-storage in some seasons, which renders the fruit inedible and results in high rejection rates.

Prompt cooling and good temperature management are essential to lower the rate of physiological deterioration of stone fruit. In some instances, FAC can take as long as 48 to 72 h, depending on the type of packaging, in some of the commercial depots where FAC is applied on stone fruit in South Africa. The trial fruit was subjected to the following FAC rates at a delivery air temperature of -1.0°C to a pulp temperature of -0.5°C: 6 h, 12 h, 24 h stepwise cooling and 48 h stepwise cooling for the apricot, and 12 h, 24 h, 48 h stepwise cooling, and 72 h stepwise cooling for the two plum cultivars. The fruit was evaluated after a cold-storage and a simulated shelf-life period. The trial was conducted in two consecutive seasons.

Imperial apricots had the best internal quality after 8 h of FAC, Pioneer plums were not sensitive to FAC rate or duration, and Songold plums had the best internal quality when FAC was applied for 12 h and longer. This result on the plums demonstrates that cultivar differences must be considered when drawing up handling protocols for stone fruit, as a blanket recommendation may lead to the induction of quality defects.

EFFECT OF PRESTORAGE MANIPULATION ON THE REDUCTION OF CHILLING INJURY IN TOMATOES.Ilic Z.^{1*}¹Faculty of Agricultural - Pristina, Lesak, Kosovo.

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Chilling injury is a physiological disorder that develops in subtropical fruits such as tomatoes when they are exposed to non freezing temperatures below 10°C. When a heat treatment was administered to tomato fruit their sensitivity to low temperature was reduced and they could be stored for up to a month at 2°C without developing chilling injury (CI).

Heat stress with hot water dips (50°C for up to 1 min) and HWRB – Hot Water Rinsing and Brushing (a short-term treatment of pink tomato at 52°C for 15 s) has potential for maintaining fruit quality and fruit resistance to chilling injury. Under stress, plants synthesize specific proteins, and their accumulation has a role in protecting the tissue from possible damage. The protective effects of heat treatment against CI in tomatoes has been correlated with the accumulation of heat shock proteins (HSPs) in fruit tissue (pericarp). The elevated temperatures initiates synthesis of these proteins HSP.

Inhibition of normal protein synthesis and production of HSP were found at high temperature. Maximal production (HSP) was found after 24 h after treatment in both heat treatment. Synthesis HSP protein after 48 h is smaller than after 24 h or immediately after heat treatment. The protein continued to accumulate throughout the heating period and remained present during storage for 3 weeks at 2°C. Unheated fruit (control) after storage did not developed full red colour, but did develop high levels of CI and decay.

SESSION 8 (S8)

HORMONAL REGULATION INCLUDING ETHYLENE BIOSYNTHESIS AND ACTION



S8-01

CONTROL OF ETHYLENE RESPONSES DURING FRUIT RIPENING.

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Ethylene controls many aspects of plant development as well as response to the environment. In tomato, ethylene is essential for flower senescence, organ abscission, adventitious root initiation and fruit ripening. Ethylene responses are also critical for aspects of biotic and abiotic stress responses. Much of the control of these events occurs at the level of hormone synthesis.

We will present recent work on controlling ripening via reduced synthesis. However, it is now apparent that levels of the ethylene receptors are also highly regulated. The tomato ethylene receptors are encoded by a family of six genes and levels of expression of these genes are spatially and temporally controlled throughout development. Further, a subset of the receptor genes respond to external stimuli. Genetic and biochemical evidence supports a model in which the ethylene receptors act as negative regulators of downstream responses; in the absence of ethylene, receptors actively suppress expression of ethylene responsive genes. Consistent with this model, reduction in the overall level of receptor increases ethylene responsiveness of a tissue while higher expression of receptor decreases ethylene sensitivity. Evidence to support this model will be presented.

S8-03

PRE AND POSTHARVEST HORMONAL CHANGES OF CARROTS.

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Auxins, gibberellins, cytokinin, ethylene and abscisic acid content were evaluated during growth, development and cold storage at 0° and 5°C to determine the effect of hormonal profile on sprouting and rooting which are the most important postharvest quality criteria for carrots. Other quality parameters such as sensory quality, respiration rate, weight loss, total soluble solids and morphological differentiation on the roots were also investigated during the experiments.

While auxine increased through harvest and decreased at harvest time, ABA and GA3 were low at the beginning of growth and development period and increased through harvest. The level of all those hormones were found higher in leaf tissues than root samples. Ethylene production decreased in leaf tissues and increased in roots during growth and development period. Cytokinins were accumulated in root tissues during this period then decreased at harvest maturity.

Auxine level increased while ABA and GA3 decreased during cold storage at 0 and 5 °C and rooting and sprouting occurred during this period. Ethylene level increased at the beginning of storage period and then decreased. Rooting was noticeable during low ethylene production period. Ethylene level increased again due to senescence at the end of storage. Cytokinin level showed a general decrease after reaching to a pick value during cold storage. Hormonal changes showed that there is a short dormancy period after harvest due to pre-harvest hormonal accumulation. Dormancy period ended with the decrease of ABA, ethylene and GA3 and with the decrease of cytokinin and auxine during storage period. All other criteria investigated in this research also proved the existence of dormancy period.

S8-02

ETHYLENE IN THE PROTECTION OF CITRUS FRUITS TO CHILLING-INDUCED DAMAGE.

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Development of chilling injury symptoms in the peel of chilling-sensitive citrus fruits during storage at low temperature is concomitant with the stimulation of ethylene production. This response is part of the defence mechanisms developed by citrus fruit to cope with this stress condition.

To understand the mode of action of ethylene in the response of Fortune mandarin to the chilling-induced damage, the effect of a pre-treatment with 1-MCP and of a continuous application of ethylene during fruit storage at 1°C on chilling injury was studied. Inhibition of ethylene action accelerated the development of chilling injury whereas in an ethylene-atmosphere the cold-induced damage was delayed. The effect of these treatments on the expression of: 1) cold-induced genes, 2) genes that may be involved in the tolerance to cold induced by a heat conditioning treatment (3 days at 37°C), and 3) genes of the ethylene biosynthetic pathway, all of them previously isolated in our laboratory, were further examined. Some of the cold-induced genes showed an ethylene-dependent expression but an ethylene-independent expression was also inferred.

Interestingly, some genes whose expression was enhanced by the heat treatment or by the combination of heat and cold were not clearly associated to the ethylene-induced cold tolerance. Genes involved in ethylene biosynthesis, ACC synthase (ACS) and ACC oxidase (ACO) were differentially regulated by ethylene during cold stress. The potential involvement of the isolated cold- and heat-regulated genes in the ethylene-induced protection to chilling injury will be discussed.

S8-04

THE REGULATION OF ETHYLENE PRODUCTION DURING FRUIT RIPENING IN JAPANESE PEAR.

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Ethylene production by cultivated Japanese pear (*Pyrus pyrifolia* Nakai) fruits varied from 0.1 nL/g f.w./hr to 300 nL/g f.w./hr during ripening. This data indicate that there are both climacteric and non-climacteric cultivars of Japanese pear. Climacteric-type fruits exhibit a rapid increase in ethylene production and have a low storage potential, while non-climacteric fruits show no detectable ethylene production and fruit quality is maintained for over a month in storage. Thus, fruit storage potential is closely related to the amount of ethylene produced.

To elucidate the reason for the large differences in ethylene production among cultivars, we have cloned three 1-aminocyclopropane-1-carboxylate (ACC) synthase genes (PPACS1, PPACS2 and PPACS3) and studied their expression during fruit ripening in Japanese pear. PPACS1 is specifically expressed in cultivars with high ethylene production, while PPACS2 is specifically expressed in cultivars exhibiting moderate ethylene production. Moreover, we have identified two RFLP markers tightly linked to the locus conferring the ethylene production of ripening fruit, using RFLP analysis with two ACC synthase genes (PPACS1 and PPACS2). RFLPs were designated as marker A for PPACS1, linked to high levels of ethylene and marker B for PPACS2, linked to moderate levels of ethylene. The absence of these two markers enabled the identification of low ethylene producers.

Using these markers, we have identified ethylene genotypes for 40 Japanese pear cultivars that are commercially important and used in breeding programs. This information is very useful for the marker assisted selection (MAS) of Japanese pear seedlings with good storage potential.

EASY PCR METHOD TO ISOLATE UNKNOWN ACC SYNTHASE GENES IN ORNAMENTAL PLANT SPECIES.

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Ornamental plants present a high number of species from different plant families. To investigate the ethylene syntheses in each species a fast and easy method for isolating the involved genes is necessary.

The enzyme that limits the ethylene synthesis is the 1-aminocyclopropane-1-carboxylic acid (ACC) synthase, which catalyzes the formation of ACC, the immediate precursor of ethylene. Cloning of the first ACC synthase genes from different plant species revealed a multi-gene family.

By using degenerate oligonucleotides that correspond to conserved amino acid residues of known ACC synthases, we amplified different genomic fragments that encodes ACC synthase homologue DNA fragments. As a result of the intron size variation of ACC synthase genes, the amplification several ACC synthase genes with only one PCR reaction was possible.

By means of this method we was able to isolate several unknown ACC synthase genes in a rage of ornamental plant species such as *Rosa hybrida* L., *Euphorbia pulcherima* L., *Schlumbergera truncata* and *Campanula carpatica*.

RIPENING-ASSOCIATED REGULATION OF GENE TRANSCRIPTION IN THE TOMATO.

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Like other plant developmental processes fruit ontogeny and ripening are under multi-hormonal control. While the role of ethylene in triggering and regulating the ripening of climacteric fruit have been clearly demonstrated, little is known on the role of other hormones. Phytohormones exert their effect on plant development via a chain of transduction pathway that ultimately activates specific transcription factors, which in turn regulate the expression of a set of target genes. In order to uncover the role of hormones that act in concert with ethylene to regulate tomato fruit development, we screened for transcription factors showing differential expression from fruit set through ripening. Differential clones encoding either ethylene response factors (ERF) or auxin response factors (ARF and Aux/IAA) were isolated and characterised. Among the isolated Aux/IAA homologs, some showed fruit-specific ethylene regulation that correlated with their pattern of ethylene responsiveness clearly suggesting a cross-talk between ethylene and auxin throughout fruit development. Molecular and physiological characterisation of transgenic tomato plants under- and over-expressing these transcription factors confirmed their role during the fruit development and ripening processes. The promoter regions of a selected number of these genes were isolated and fused to reported genes to analyse their activity in planta. The developmental regulation of these genes along with their responsiveness to auxin and ethylene suggest that both hormones play an interactive role during tomato fruit development and ripening.

FARNESYLATION OF COMPONENTS OF THE ETHYLENE SIGNALING PATHWAY MAY BE NECESSARY TO THE DEVELOPMENT OF SUPERFICIAL SCALD IN APPLES.

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Superficial scald is an apple storage disorder characterized by patches of browned or blackened peel that seriously impact fruit marketability. Current thought relates peel cell death associated with scald to products of farnesene oxidation, most notably oxygen radicals, yet action of the plant hormone ethylene is also strongly implicated in the development of scald. Some components of the ethylene signaling pathway have been identified, two of which are known to physically interact: ETR1, an ethylene receptor, and CTR1, a mitogen activated protein kinase kinase kinase (MAPKKK), and a putative component of a MAPK signaling cascade. Farnesyl protein transferase (FPT), is the enzyme responsible for farnesylating proteins in both plant and animal models. The hydrophobic farnesyl moiety targets the protein to a membrane or hydrophobic domain of another protein. Recently, FPT has received attention in biomedical studies due to implications regarding its role in cellular signal transduction and the development of several forms of human cancer. Apparently, studies in other systems suggest farnesylated proteins such as Ras are necessary to assist in targeting proteins like MAPKs to cell membranes, and FPT activity is necessary for the activation of all major classes of MAPKs. In an attempt to dissect the molecular events leading to the development of superficial scald, we studied 'Granny Smith' scald development by assessing benchmarks for volatile production, and collection of organic radical species by using a chromotropic spin-trapping compound in peel from apples stored in regular and controlled atmospheres, in 1-methylcyclopropene-treated apples, and in apples treated with an FPT inhibitor. We have verified the presence of FPT protein and are studying the potential interaction with CTR1 with regard to attenuation/enhancement of scald symptoms in apple peel tissue.

DIFFERENT RESPONSE OF APPLE AND PEACH FRUITS TO 1-MCP. A CASE OF DIFFERENT SENSITIVITY TO ETHYLENE?

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1-MCP is known as an antagonist of ethylene action. However, not all climacteric fruits respond similarly to 1-MCP treatment. When applied at apples 1-MCP is particularly effective in delaying ripening, while in peaches it seems to slow down the rate of softening only during the incubation period but a quick recovery of ripening parameters occurs in the post-treatment phase. In order to elucidate the different behaviour, specific trials on peaches (cv. Summer rich treated with 1-MCP up to 1ppm for different times) and apples (cv. Gala and G. delicious treated with 1-MCP at 0.625ppm for 24h) have been performed.

As expected, apple fruits responded to 1-MCP remaining firm and producing little ethylene for several days at 20°C, whereas in peach fruits firmness quickly decreased and ethylene evolution dramatically increased after few hours from the end of the treatments. A molecular approach was used to investigate the sensitivity of the fruits to ethylene. In particular, ethylene receptors and CTR1-like gene expression was monitored all over the experiment for both fruits via RT-PCR. Md-ACO1 and Pp-ACO1 expression was studied as indicators of the modulation of ethylene biosynthetic pathway. Pp-ACO1 and Pp-ERS1 expression was decreased by 1-MCP treatment but sharply increased just few hours after the end of the treatment. Furthermore, expression of some of the genes encoding enzymes both ethylene up-regulated and involved in fruit softness was studied.

Polygalacturonase and Pectate lyase gene expression in peaches dramatically decreased after treatment but considerably increased just after few hours concomitantly with the increase of Pp-ERS1 expression. The relation between ethylene receptors and cell wall hydrolases transcripts is reported as a tool to describe differences in sensitivity to 1-MCP and ripening physiology in apples and peaches.

S8-10**INHIBITION OF DARK-INDUCED SENESCENCE OF PELARGONIUM CUTTING BY GIBBERELIC ACID AND THE INVOLVEMENT OF PeGAST-LIKE GENES.**Rosenvasser S.¹, Mayak S.², Friedman H.^{1*}¹Department of Postharvest Science of Fresh Produce, ARO, The Volcani Center, Bet Dagan, Israel; ²The Kennedy-Leigh Center for Horticulture Research, Faculty of Agriculture, The Hebrew University of Jerusalem, Israel.*Presenter (rschilo@hotmail.co.il)

Senescence of pelargonium cuttings is induced by darkness to which cutting are exposed during shipment. Dark-induced senescence of the cuttings' young leaves is manifested by both chlorophyll breakdown and increase in the cysteine protease homolog SAG12 expression. Dark-induced senescence is also associated with a gradual increase in reactive oxygen species (ROS) accumulation. Microscopic analysis revealed that ROS accumulate in the cell wall during early stages of dark treatment. Gibberellic acid treatment before or on the third day of the dark period inhibits the dark-induced senescence of the pelargonium cuttings and ROS accumulation, while treatment on the fourth day failed to inhibit senescence.

The possible involvement of GA-upregulated GAST-like genes in GA3-inhibition of dark-induced senescence has been examined. Genes of the GAST family which are probably secreted to the apoplast, contain twelve cysteine residues in their C-terminus that may function as redox modulators. Towards elucidating the role of PeGAST-like genes in GA3-inhibition of dark-induced senescence, two GAST homologs have been cloned from pelargonium leaves, and were found to be induced by GA3 in pelargonium cutting leaves under normal growth conditions. Darkening of pelargonium cuttings increased expression of at least one gene, which its expression subsided during the dark treatment. Gibberellic acid (GA3) treatment either before or at the third day of the dark period increased the expression of PeGAST-like genes, while on the fourth day it had only a marginal effect on PeGAST expression. We suggest that up-regulation of PeGAST like genes protect the tissue against accumulation of ROS possibly in the cell wall. Overexpression of these genes by GA3 treatment is probably one of GA3 mechanisms that protect pelargonium cuttings against dark-induced senescence.

S8-13**THE INTERACTION BETWEEN JASMONATES AND ABSCISIC ACID DURING RIPENING OF APPLE FRUIT.**Setha S.^{1*}, Kondo S.¹¹Graduate school of Applied Biosciences, Hiroshima Prefectural University, Japan.*Presenter (sutthiwal@hotmail.com)

Jasmonates [jasmonic acid (JA) and methyl jasmonate (MeJA)] and abscisic acid (ABA) have physiological similarity. The interaction of these substances which are involved in the ripening of 'Orin' apple fruit (*Malus pumila* Mill. cv. Orin) was investigated. A 1 mM MeJA or cis-ABA solution was applied at three stages of fruit development (pre-climacteric, climacteric, and post-climacteric) for 15 days via the shoots. Endogenous JA, MeJA, and ABA concentrations were quantified by gas chromatography-mass spectrometry-selected ion monitoring (GC-MS-SIM). The effect of exogenous jasmonate or ABA on ethylene and 1-aminocyclopropane-1-carboxylic acid (ACC) was also examined. MeJA treatment decreased ACC concentrations in the climacteric and post-climacteric stages. MeJA treatment increased ABA concentrations at the pre-climacteric stage, but it did not influence or decreased ABA levels after the climacteric stage.

This suggests that its effect differs with fruit maturation stage. Jasmonates may be used to regulate fruit ripening. In contrast, cis-ABA treatment did not influence ACC, JA, or MeJA levels regardless of fruit developmental stage.

S8-11**CAROTENOIDS BIOSYNTHETIC GENE-EXPRESSION DURING THE PEACH FIELD RIPENING AND INFLUENCE OF POSTHARVEST ETHYLENE CONTROL ON CAROTENOIDS CONTENT.**Cecchi F.¹, De Martino G.^{1*}, Giuliano G.², Bellincontro A.¹, Botondi R.¹, Mencarelli F.¹¹Department of Science and Food Technology, University of Tuscia, Viterbo, Italy; ²ENEA, Roma, Italy.*Presenter (demartino@unitus.it)

The carotenoids content in fresh fruits is very important for the health-promoting properties in human life. Peach is one the fruits with higher content in carotenoids. In this work, peaches (*Prunus persica* L.) from two cultivars were treated with 1-MCP (0.5 ppm for 20 h), CO₂ and N₂ (for 48 h), cold H₂O (1°C for 1 hour), stored at 10°C and then moved for two days at 20°C in order to investigate the control of ripening features and carotenoids content.

Flavor Crest and Springbell peaches picked respectively at an advanced and early ripening stage, benefited of 1-MCP treatment in term of firmness maintenance and good flavour (panel test). Hydrocooled peaches resulted firm but with poor flavour.

Total carotenoids increased during the postharvest period in control Springbell peaches while all the other treatments induced a loss of carotenoids. Peaches from morning sun exposure showed an increasing pattern of carotenoids content during the postharvest period; in contrast peaches from afternoon sun exposure tended to loose carotenoids. In Flavor Crest peaches, picked at an advanced ripening stage, carotenoids content decreased even in control fruit; hydrocooling reduced this loss. Moreover gene expression of the main enzymes involved in carotenoids biosynthesis is under study.

S8-14**RESPONSE OF *Lilium* sp. CV. STARGARZER TO EXOGENOUS ETHYLENE DURING POSTHARVEST.**Persico M.^{1*}, Krarup C.¹, Olate E.¹¹Pontificia Universidad Católica de Chile.*Presenter (mpersico@puc.cl)

There are variable reports with regard to the sensitivity of *Lilium* sp. to exogenous ethylene. According to some studies, the different types of *Lilium* sp. are sensitive to ethylene; however, the eastern type of *Lilium* sp. has been shown to have low sensitivity to ethylene. The objective of this research was to determine the eventual sensitivity of *Lilium* sp. cv. Stargazer to exogenous ethylene that could be present during the commercial postharvest period. For this purpose, an experiment with five treatments (ethylene concentrations of 0, 1, 10, 100, 1000 ppm) and six replications (floral spikes with unopened flowers), in a completely randomized block design was established. Ethylene was applied by spraying the spikes with an aqueous solution of 2-chloroethyl-phosphonic acid. Parameters measured were duration of the shiny green colour of the leaves, days to first flower and postharvest lifespan of the spikes. Results showed no significant differences between treatments for leaf colour or in days for the first flower to attain the fully opened stage. However, the lifespan of spikes is significantly reduced with ethylene concentrations of 100 and 1000 ppm. Such high concentrations are unlikely to occur and *Lilium* sp. cv. Stargazer should be considered for all practical purposes as a product that will not be affected by ethylene during postharvest.

S8-15

CHARACTERIZATION OF THE ETHYLENE RECEPTOR GENE HOMOLOGUES FROM APPLE FRUIT.

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Ethylene plays an important role in the initiation and continuation of ripening in all climacteric fruits, including apple. Ethylene perception and signal transduction have been studied at the genetic and biochemical levels in Arabidopsis and other species. Studies of ethylene perception have shown that ethylene receptors negatively regulate the ethylene response. To elucidate the role of ethylene receptors during apple ripening and storage, we isolated cDNAs of three putative ethylene receptor genes by RT-PCR using degenerate primers from ripening apple fruit. The nucleotide sequences of two cDNA clones were identical to that of Md-ETR1 and Md-ERS1 that were previously reported. The nucleotide sequence of another cDNA clone is similar to that of Md-ERS1, which lacked a response regulatory domain at its C-terminus. Thus, the cDNA was named Md-ERS2. We examined their expression patterns in two apple varieties, 'Orin' and 'Fuji', which have distinct characteristics in ethylene production and storage life. Although Md-ETR1 appeared to be constitutively expressed in two apple varieties, Md-ERS1 and Md-ERS2 expressed only at the climacteric fruit stage. In both apple varieties, treatment with 1-methylcyclopropene (1-MCP), a highly potent inhibitor of ethylene action, suppressed ethylene production and decreased expressions of three receptor genes. Md-ETR mRNA declined from 7 days after 1-MCP treatment, but Md-ERS1 and Md-ERS2 mRNAs rapidly decreased within 1 day after 1-MCP treatment. Ethylene receptor mRNAs accumulated more abundantly in 'Fuji', which has long storage life, than in 'Orin'. This result supports the model that ethylene receptors negatively regulate the ethylene response in apple.

S8-17

ACC SYNTHASE GENES RELATED TO COLD-DEPENDENT RIPENING IN PEAR FRUIT

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Late pear cultivars such as Passe-Crassane (PC) require a long chilling treatment before they are capable of ripening. Early cultivars such as Old Home (OH) have no cold prerequisite. The differential regulation of 1-aminocyclopropane-1-carboxylic acid synthase (ACS) genes was studied in OH, PC and in OH x PC hybrids in order to determine the role of this gene family in the cold requirement. Of the seven Pc-ACS cDNAs isolated, four (Pc-ACS1a/b and Pc-ACS2a/b) showed differential expression associate with the cold requirement. Pc-ACS1a transcripts accumulated throughout the cold treatment and, with Pc-ACS2a, during ripening of cold-dependent cultivars. Pc-ACS1b and Pc-ACS2b were detected only during ripening of cold-independent genotypes. Furthermore, Pc-ACS2a transcript accumulation was negatively regulated by ethylene while Pc-ACS2b was positively regulated by the hormone. Pc-ACS3, 4 and 5 transcript accumulation was similar in all genotypes. Genetic analysis of OH, PC, and 22 OH x PC progenies demonstrated that late, cold-dependent cultivars were homozygous for Pc-ACS1a and 2a while early, cold-independent cultivars were heterozygous for Pc-ACS1(a/b) and homozygous for Pc-ACS2b. A model is presented in which differences in Pc-ACS alleles and gene expression between cold- and non-cold requiring pears are critical in determining the ripening behaviour of the cultivars.

S8-16

COMMERCIALIZATION OF SMARTFRESH™ (1-METHYLCYCLOPROPENE) IN THE SOUTH AFRICAN DECIDUOUS FRUIT EXPORT MARKET, AND ITS EFFECT ON POST HARVEST HANDLING AND FRUIT QUALITY.

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SmartFresh™ (1-methylcyclopropene), an antagonist ethylene inhibitor in horticultural products, is an exciting new breakthrough in the post harvest storage of fresh fruit. Due to its ethylene blocking effect, SmartFresh™ maintains the quality of fresh produce during cold storage and shelf life. Registered for application on apples since 2002, SmartFresh™ has been successfully applied commercially within the USA and South Africa. Consistent with findings of overseas researchers, SmartFresh™ treatment on South African apples enabled maintenance of flesh firmness, skin colour and malic acid levels, and when applied under the recommended guidelines, complete superficial scald control. SmartFresh™ also extended shelf life and in some instances reduced greasiness.

From an extensive database of over 100 treatment rooms, the effects of commercially applied SmartFresh™ on fruit maturity at treatment, storage duration, RA vs CA storage, and different apple cultivars, were determined. Using the database, maturity parameters at treatment were compared with quality responses after storage. It was immediately evident that the most important factors effecting SmartFresh™ efficacy were starch levels, followed by flesh firmness. When fruit were treated with less than 40% starch break down, flesh firmness improvement at the end of cold storage was invariably greater than 1.0 kg. It was also evident that SmartFresh™ was no longer effective above a certain level of starch break down in the fruit.

Data was analyzed statistically in a forward stepwise regression procedure to develop a model to predict treatment outcome using maturity data at treatment. While still in the conceptual stage, results indicate promise, and the accuracy of this model should improve as additional data points are added. Extensive research on plums and pears resulted in SmartFresh™ registration for use on plums in 2003, and it is hoped that pear registration will follow shortly. The significance of these findings will be discussed.

S8-18

HIGH TEMPERATURE STRESS AND EXOGENOUS APPLICATIONS OF METHYL JASMONATE ON PEACHES.

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High temperature shocks has been useful in some peach cultivars to prevent chilling injury, although in occasions have caused undesirable side effects. Jasmonates are hormones that play a role in signal transduction cascades, on the defense mechanism that plants have developed against biotic and abiotic stresses. Jasmonic acid (JA) and Methyl Jasmonate (MJ) show similar physiological responses. MJ may be an essential link in the signal transduction chain between the external stimulus and the internal response to stress. In this way, it would be expected that exogenous application of jasmonates may elicit a response similar to stress, to defend against stress, but without the undesirable effects or damage to fruits that stress may cause.

The aim of this experiment was to compare thermal stress (40°C for 46h) against different exogenous applications of MJ. Fruits of 'Dixiland' were immersed into solutions of 0, 10, 100 and 1000 µM for 30s. 'Dixiland' has responded to heat shock treatments in previous experiments, diminishing chilling injury symptoms. In this experiment ethylene production was analyzed after the treatments every day up to ten days, and activities of polygalacturonase and pectinmethylesterase were evaluated on the first two days. Heat treated fruits and those treated with the highest concentration of MJ had a similar pattern in ethylene evolution, while on the other hand control fruits and those treated with 10 and 100 µM showed lower production of ethylene. This results may be an indication that, at least, some effects produced by heat treatments may be similarly induced by the external application of MJ.

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POSTHARVEST CALYX RETENTION OF CITRUS FRUIT.

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Abscission is an active developmental process occurring at the abscission zone of the fruit peduncle. The target cells in the abscission zone, which are involved in the process of separation, are located in the separation layer, which is organized in a few cellular layers. In general it is accepted that the increase in ethylene production in the fruit is followed by increased sensitivity of these cells to ethylene, which would lead to abscission. The abscission process is divided into two phases with respect to sensitivity to auxin and ethylene.

The auxin, 2,4-D (2,4-dichlorophenoxy acetic acid), has been used as a postharvest packhouse treatment to retard calyx abscission (to represses postharvest decay). Commercially the sodium salt 2,4-D (Deccomone[®]) is applied to the fruit in a dip treatment at 500 ppm. The aim of this experiment was to test three agrochemicals (aminoethoxyvinylglycine (AVG), 1-naphthylacetic acid (NAA) and 1-methylcyclopropene (1-MCP)) that could possibly replace the postharvest application of the auxin 2,4-D. AVG had a fruit firming effect but no significant effect on calyx retention. NAA resulted in a high percentage of abscission, probably due to auxin overdose. The 1-MCP at low concentrations of 100 ppb and 250 ppb resulted in calyx retention but had a desiccating effect on the calyx whereas at a high 1-MCP concentration of 500 ppb there was a significant increase in calyx abscission. There was no loss of internal quality or colour.

To conclude, according to what is known about the role of ethylene in abscission, 1-MCP and AVG should have prevented abscission of the calyx. Unfortunately the results show that this complex plant mechanism is not so readily manipulated and 2,4-D is the best product to inhibit calyx abscission of citrus fruit.

SESSION 9 (S9)

QUALITY ASPECTS

S9-01**POSTHARVEST MANAGEMENT BEYOND QUALITY MAINTENANCE.**Sanz C.^{1*}¹Dept. Physiology and Tecnology of Plant Products, Instituto de la Grasa (C-SIC), Seville, Spain.

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Most researchers, producers, consumers, marketers, and economists interested in fruit and vegetable quality have a reasonably clear concept of the term quality, although it is rarely defined. An integration of the different quality definitions through a better appreciation of quality orientations should lead to the development of adequate handling systems more responsive to consumer desires.

Traditionally, fruits have been classified according to their respiration rate and pattern into climacteric and non-climacteric, considering that, unlike climacteric, non-climacteric fruits do not ripen after harvest. This last assumption should be taken carefully since there are indications it is not so strict. Thus, non-climacteric fruits may follow an off-plant ripening, although slower and just for some quality attributes, that should be taken into account during postharvest management. Postharvest operations are currently aimed at maintaining harvest quality as well as possible for as long as practicable. Different techniques may be used for these purposes that might be, however, detrimental for product quality if reaching certain limits of temperature or gas concentration. A different point of view for postharvest management is considering it as a way to improve quality, especially organoleptic quality, thus making the product more attractive to the consumer.

S9-03**PREDICTION OF APPLE EATING QUALITY BY INSTRUMENTAL MEASUREMENTS.**Mehinagic E.^{1*}, Royer G.¹, Symoneaux R.¹, Bertrand D.², Jourjon F.¹¹ESA - Laboratory GRAPPE, Angers; ²INRA/ENTIAA Unite de sensometrie et de chimietrie, Nantes, France.

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In addition with taste, texture is a quality attribute that is critical in determining the acceptability of apple fruits by consumers (Daillant-Spinnler et al., 1996; Jaeger et al., 1998). The fruit wholesalers are therefore particularly interested in the measurement of fruit texture. However, the direct measurement of texture through sensory analysis is very complex and time consuming. For this reason, many attempts have been made for replacing sensory analysis with relevant instrumental measures. The final test of the validity of instrument measurements must evidently be appreciated by their success in predicting the sensory attributes.

Texture and taste of three different apple cultivars (Fuji, Braeburn and Golden) were analysed, by sensory and instrumental analysis (penetrometer, double compression, spectroscopy). The perception of eating quality of apples was investigated by trained panel at three different stages of maturity (3 weeks before commercial maturity, at commercial maturity and 3 weeks after commercial maturity). The main objective of the study was to investigate the possibility of predicting sensory perception of apple texture by instrumentally measured parameters.

This study showed that the parameters measured by penetrometer and compression were highly correlated with sensory textural attributes. The spectroscopic data were also significantly correlated to sensory attributes. In order to predict sensory quality of apples, PLS stepwise regression was performed on total penetrometer, compression and Visible-NIR data for 6 sensory attributes: crunchiness, chewiness, touch resistance, mealiness, juiciness and fondant.

S9-02**TOMATO FLAVOR AND AROMA QUALITY AS AFFECTED BY A SHORT ANOXIA TREATMENT.**Fallik E.^{1*}, Larkov O.², Ravid U.²¹Agricultural Research Organization, The Volcani Center, Dept. of Postharvest Science of Fresh Produce, Bet Dagan, Israel; ²Division of Aromatic and Medicinal Plants, Newe Yaar, Israel.

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Exposing fruit and vegetables to anoxia (N₂) after harvest has many beneficial effects, such as reducing respiration rate, inhibiting ethylene production and action, delaying ripening and reducing the incidence of some physiological disorders. A short-term (24 h) exposure to anoxia after harvest significantly reduced rot development in tomato fruit artificially inoculated with *Botrytis cinerea*, compared with control fruit.

The purpose of this work was to compare the sensory quality of tomatoes treated for 24 h under anoxia (99% N₂) with control fruit kept in air. Fruit were held for 12 days at 20 °C or at 12 °C for 10 plus 2 days at 20 °C. Human-sensory parameters (organoleptic analysis) and aroma volatiles (headspace SPME-GC-MS analysis) were tested at the end of storage and marketing simulation. Anoxia-treated fruit that were held at 20 °C for 12 days had organoleptic qualities similar to untreated fruit that were held at 12 °C for 10 plus 2 days at 20 °C. Of the 11 volatiles assayed, hexanal (grassy note), 2-isobutythiazole (tomato-like smell) and benzaldehyde (sweet note) were higher in N₂-treated fruits held at 20 °C than in controls, while 2+3-methyl butanol (unpleasant smell) and ethanol (fermented odor) were slightly higher in control. In anoxia-treated fruit held at 12 °C for 10 days, the amount of 2-isobutythiazole was lower than in control fruit, while 2+3-methyl butanol was slightly higher. This non-chemical and inexpensive treatment deserves further development and application, especially under commercial distribution systems where refrigeration is inadequate.

S9-04**EFFECT OF CERTAIN VOLATILES, ADDED TO BLAND TOMATO PUREE, ON PERCEPTION OF AROMA, TASTE AND AFTER-TASTE DESCRIPTORS.**Baldwin E.A.^{1*}, Plotto A.², Goodner K.¹, Pritchett K.³, Einstein M.⁴¹USDA/ARS Citrus & Subtropical Products Laboratory; ²USDA/ARS Citrus & Subtropical Products Laboratory; ³Syngenta Seeds, Inc.; ⁴Senstek, Inc., USA.

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The contribution of volatiles to tomato flavour is little understood. Coarse chop deodorized tomato puree was spiked with one to three levels of individual food grade volatiles reported to contribute to tomato flavour, and presented to a trained descriptive panel for flavor analysis. Based on descriptors resulting from these individual aroma compounds, volatiles were then grouped based on similarities of descriptors and again added to bland homogenate at three different levels and presented to the panel.

Six to eight panelists rated 5 aroma, 6 taste and 3 after-taste descriptors on a 15 cm unstructured line scale. Positive correlations were found for the "earthy" mix (3-methylbutanol, 3-methylbutanal, 2-isobutythiazole) with overall, green, vine, earthy and musty aromas, and a negative correlation with sweet aroma. The "green" mix (hexanal, trans-2-hexenal, trans-2-heptenal, cis-3-hexenal, cis-3-hexenol) correlated positively with overall and musty aroma, as well as overall aftertaste. The "fruity" mix (acetaldehyde, 2-phenylethanol, 8-ionone, geranylacetone, acetone, linalool, citral, 1-penten-3-one, ethanol, furaneol, and 6-methyl-3-hepten-3-one) showed significant positive correlations with overall, sweet tomato and tropical aromas, and a negative correlation to musty aroma, as well as positive correlations to sweet and fruity tastes, and a negative correlation to sour and bitter tastes.

Principal component analysis (PCA) was performed on means across panelists. Three factors were extracted, explaining 27.2, 16.6 and 11.7% of the variation, and spiking with 2-isobutythiazole, "earthy" mixes, 1-penten-3-one, and "green" mixes resulted in drivers for high loading on the earthy and green descriptors. The "fruity" mixes, furaneol and 2-phenylethanol were drivers for high loading on sweet and floral aroma.

REDUCTION OF LINOLENIC ACID AFFECTS TOMATO LEAF AND FRUIT AROMA.

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Some of the most important aroma 'impact compounds' in tomato fruits are cis-3-hexenal, hexanal, trans-2-hexenal, 1-hexanol, and cis-3-hexenol, which are produced by linoleic (18:2) and linolenic (18:3) acid peroxidation. We evaluated C6-aldehyde and alcohol production in the tomato cv. Castlemart and its mutant Lefad7, which has a reduced amount of 18:3, and performed sensory evaluations to determine whether the aroma volatile differences could be perceived. Volatiles were analyzed by GC-MS. Lipid composition was determined using FID gas chromatography. Aroma differences were tested by Triangle Test and Preference Test. Fatty acids from leaves and fruit of Lefad7 mutant differed dramatically from those of the wild type plants. The 18:3 content of the leaves and fruit of the mutant line was 15 and 10% of wild type respectively. Mutant leaves produced 20% of the amounts of cis-3-hexenal, trans-2-hexenal, and cis-3-hexenol, relative to wild type, and 10-fold higher levels of hexanal and 1-hexanol. Mutant fruit produced very reduced amounts of cis-3-hexenal (3%), trans-2-hexenal (7%), but 5-fold higher levels of hexanal relative to the wild type. Differences in the volatiles between wild type and mutant leaves and fruits were perceived by untrained sensory panels with a high significance (p-value <0.0005), and more than 50% of the consumers preferred the aroma of wild type fruits having higher unsaturated C6-aldehyde levels.

In conclusion, the ratios and amounts of C6 saturated and unsaturated aldehydes and alcohols produced by tomato are dependent on substrate levels, and these differences can be perceived by consumers, suggesting that altering the concentration of the hexenals or their precursors can influence tomato flavor.

MICROMECHANICAL BEHAVIOUR OF ONION EPIDERMAL TISSUE.

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Mechanical damage affects the quality of fruit to a large extent and leads to a considerable loss of its commercial value. It is therefore important to understand the mechanical properties of fruit tissue, in order to reduce or avoid damage. Fruit tissue is a complex conglomerate of cells, and its integrity depends on the presence of an adhesive middlelamella between individual cells, the cellular turgor pressure, the mechanical properties of the cell wall and the presence of intercellular spaces. Therefore a micromechanical approach is best suited to understand the relative importance of these cellular and histological attributes on the overall mechanical behaviour of the fruits.

As a first step towards the investigation of micromechanical properties of vegetative tissues we selected onion epidermal peels as a study object. Onion epidermis consists of only one cell layer and is easy to isolate and manipulate. Cellular turgor pressure of individual cells in the tissue was measured with the cell pressure probe. Techniques were developed for measuring micromechanical properties using a miniature tensile stage mounted under a microscope. Epidermis peels were subjected to tensile tests while the deformation of the individual cells in the tissue was followed and recorded.

Onion epidermal peels were found to produce a biphasic stress/strain curve, as also found for other biological cellular materials. A thorough investigation of cell structural parameters (dimensions of cells, thickness of the cell wall) in epidermis tissue originating from different onion layers was made to investigate the relationship between the measured mechanical properties and these structural characteristics.

INHIBITION OF ETHYLENE VIA DIFFERENT WAYS AFFECTS THE LOX, ADH ACTIVITIES, AND RELATED VOLATILES COMPOUNDS IN PEACH CV. ROYAL GEM.

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Ethylene effect and stage of ripeness at the harvest of fruits show a great influence on the qualitative and aromatic attributes of peaches. In this way, the opportunity to control the postharvest ripening was investigated on peaches (*Prunus persica* L.) cv. Royal Gem by using 1-MCP (1-ppm for 20 h at 20°C), gaseous N₂ (for 44 h at 20°C) or cold storage (3°C for 7 days). The peaches were harvested at two different stage of ripeness (early and commercial), and after treatments, during storage at 20°C, analytical data (SSC, firmness, colorimetric evaluation, respiration and ethylene production) were acquired. The results of this experimentation were studied through the activities of lipoxygenase (LOX) and alcohol dehydrogenase (ADH) enzymes, involved in the characteristics pathways of oxidative and fermentative metabolisms and correlated to the storage mechanisms. Moreover, the physiological and metabolic activities were investigated in relation to the aromatic profile, which was evaluated by SPME gas chromatographic technique. Results of C6 compounds (mainly hexanal, trans-2-hexenal, trans-2-hexanol) trends are reported and correlated to the ethylene effect and to the influence of anoxic treatment (N₂). This treatment induced an increase of alcohols (ethanol, methanol, hexanol) which was correlated to the rise of ADH activity. Lactones (octalactone and decalactone) and esters increased, regardless the pretreatment, with the progressive ripening of peaches.

CALCIUM AND DRY MATTER ACCUMULATION IN HAYWARD KIWI-FRUIT.

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Despite recognition of the link between kiwifruit internal quality and fruit dry matter (DM) and calcium (Ca) content, factors affecting DM and/or Ca accumulation are poorly characterised. Ferguson et al. (2003*) described a simple positive linear relationship between increasing Ca and increasing percentage DM, suggesting that similar factors influence accumulation of these two fruit components. The reason for this is not known, but is surprising considering that Ca travels primarily in the xylem, whilst carbohydrates are transported in the phloem.

This research further explored the link between Ca and DM accumulation. Fruit Ca, and to a lesser extent, carbohydrate accumulations patterns were altered by manipulations to the vine canopy and/or the application of TIBA. However, fruit from long, non-terminated laterals always had a higher DM and Ca content than fruit from short-terminated laterals, regardless of treatment applied. Specific canopy management practices may alter general fruit carbohydrate and mineral nutrient accumulation patterns directly by impacting on fruit metabolism or indirectly by altering the fruit hormone balance. Results suggest that these direct and indirect effects may be on the processes of cell division and enlargement, and/or vascular differentiation.

*Ferguson, I.B.; Thorp, T.G.; Barnett, A.M.; Boyd, L.M. & Triggs, C.M. 2003: Inorganic nutrient concentrations and physiological pitting in 'Hayward' kiwifruit. J. Hort. Sci. 78 (4) 497-504.

S9-09**LABORATORY AND SENSORY QUALITY EVALUATION OF STRAWBERRIES DURING STORAGE AS RELATED TO MICROBIOLOGICAL AND PHYSIOLOGICAL SPOILAGE PROCESSES.**Ragaert P.^{1*}, Devlieghere F.¹, Loos S.¹, Dewulf J.², Van Langenhove H.², Debevere, J.¹¹Laboratory of Food Microbiology and Food Preservation, Ghent University, Belgium; ²Research Group "Environmental Organic Chemistry and Technology", Ghent University, Belgium.

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In literature, there is little known about the contribution of microbiological processes on the quality degradation of fruits and vegetables. In this study, quality of strawberries during storage was evaluated through some quality factors by laboratory and sensory analyses. The latter was performed by means of a trained taste panel. The laboratory measurements consisted of headspace analysis of O₂, CO₂ and volatile compounds, microbiological analysis and analysis for pH, total acidity, suspended solids and sugars and acids by HPLC-analysis. It was the aim to investigate the influence of microbiological activity on the evolution of different quality factors. Two batches of strawberries were stored under different gas (EMA – air) and temperature (7°C – 22°C) conditions. The first batch was contaminated with low numbers of yeasts and moulds that, during storage, never exceeded the limit on which microbiological metabolite production or sugar consumption could affect quality. These microbiological activities of yeasts and moulds on strawberries were studied in previous experiments by means of simulation media. The second batch of strawberries was contaminated with higher numbers of micro-organisms, resulting in higher counts during storage that could influence the quality of strawberries. At the beginning of storage of strawberries from batch 2, only quality evolutions caused by physiological processes were detected. Thereafter, due to the increasing amount of yeasts and moulds in combination with the progress of physiological processes, quality as judged by sensory analysis reached an unacceptable level. Volatile compounds, such as ethylacetate and ethanol were produced both by microbiological and physiological processes. Quality evolutions could also be related to laboratory measurements. A different evolution pattern was observed from strawberries from batch 1, due to the lower microbiological contamination. Also some interesting evolutions due to different storage temperatures, different gas conditions and different degrees of damage could be observed.

S9-11**NUTRITION AND HEALTH PROMOTION: ROLE OF PHYTOCHEMICALS AND FUNCTIONAL FOODS.**Cestaro B.^{1*}, Cazzola R.¹¹Department of Preclinical Sciences "LITA Vialba", University of Milan, Italy.

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The diminished cellular efficiency in energy production is the molecular mechanism underlying the physiopathological processes of ageing and of the related dysmetabolic pathologies. This reduction in energy production (ATP) is due both to functional and structural alterations of the tissues and to damage to the blood vessels and their reduced efficiency in supplying oxygen and nutrients to the organs. The deficiency of ATP causes a reduction in the bioavailability of all the molecules whose biosynthesis requires the intervention of ATP itself. Therefore, one must expect a reduction of the ex-novo biosynthesis of proteins, nucleic acids and phospho- and glyco-lipids. The diminished efficiency of the cell in the synthesis of these compounds causes a slowing of the repair processes and replacement of the various lipid or glycoprotein molecules, which make up the bilayer structural organization of the cell membrane. This leads to progressive structural alteration of membrane, manifested by a progressive reduction of membrane fluidity. The consequence is the cause of secondary metabolic damage to the cells. All this results in reduced capacity of the proteins to collided with the ligands with which they must interact in order to carry out their own functional and biological roles, such as proteins interacting with their own specific substrate. There is thus a spiral of structural and functional damage to cells and tissues, starting with the reduced efficiency in ATP synthesis which is further amplified by the decreased rate of synthesis of membrane macromolecules and lipids, the increase in intracellular calcium and potassium, and the increase in peroxidation processes. How the onset of this spiral could be kept under control with either an adequate diet or supplying of functional foods will be the main argument of this presentation.

S9-10**TEXTURAL PROPERTIES AND CELL WALL METABOLISM OF WHITE ASPARAGUS SPEARS (*Asparagus officinalis* L.).**Huyskens-Keil S.^{1*}, Kadau R.¹, Herppich W.²¹Humboldt University Berlin, Section Quality Dynamics and Postharvest Physiology; ²Institute of Agricultural Engineering Bornim e.V., Germany.

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Texture is one of the predominant quality requirement for fresh fruits and vegetables and serve as an indicator of product quality. Textural properties are being attributed to various chemical and physical compounds and underlying complex biochemical and physiological processes during product development and during postharvest. In asparagus spears (*Asparagus officinalis* L.), changes in quality determining textural properties, i.e. cell wall carbohydrates and water status has not been fully elucidated or characterised.

The aim of the present investigation was to characterise the effect of varying postharvest temperature regimes (2 °C, 10 °C, 20 °C) on postharvest textural changes (cell wall carbohydrates, water status, physical texture measures) and to determine interaction between these properties which will be discussed in detail in terms of a better understanding of the dynamic of textural related physiological processes in postharvest.

S9-12**CHEMICAL AND BIOLOGICAL CHARACTERIZATION OF PROANTHOCYANIDINS WITH DIFFERENT MW PROFILES PREPARED FROM SEVERAL FRUITS AND LEAVES.**Matsuo T.^{1*}, Sato Y.¹, Chuchep K.¹, Nakamura Y.², Okamoto S.¹¹Dept of Biochem. Sci. & Technol, Faculty of Agriculture, Kagoshima University, Kagoshima, Japan; ²Dept of Food Sci. & Nutrl. Health, Faculty of Human Envril. Sci., Kyoto Prefectural University, Kyoto, Japan.

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Proanthocyanidin(PA) polymers, condensed tannins, are well known to show an intensive astringent taste, which consist of chains of flavan-3-ols linked through C4-C6 or C4-C8 bonds. They are widely distributed in plants and foods, such as immature fruits, woods, grains, roots and leaves. In old Japan, this unique polymer extracted from young persimmon fruits has been used like a plastic material to protect and strengthen fibers, papers, and woods against water-decay, insect chewing, or rubbing.

In our presentation, an establishment of SEC/HPLC analysis of native PA polymers and oligomers from various fruits and leaves (loquat, persimmon, guava, grape, and apple), without any chemical modification of the polymers, is mentioned. PA polymer extracted from young fruit of persimmon showed only a single and sharp peak with shortest Rt on the chromatogram among other analytical results. This chromatographic feature was quite unique in contrast to other preparations from persimmon leaves, apple fruit, and grape fruit, which showed more complex features consisting of various PA species (from monomer to HMW PA polymers).

Their chemical and biological characterizations of the purified PA polymers and oligomers have also been performed; colour development, protein-binding ability, thiolysis, astringency, effect of cultured cell growth. Correlation between structures in PA polymers or oligomers and biological properties is also discussed in details.

S9-13

EVOLUTION OF THE ALLERGENIC POTENTIAL IN PEACH AND NECTARINE FRUITS DURING RIPENING.

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According to recent epidemiological studies, food allergies enhanced during recent decades in many countries. Allergies to fruits represent also an increasing problem and studies should be addressed to produce hypoallergenic fruits. In peach the major allergen has been identified as a Lipid Transfer Protein (LTP) and in the present research the evolution of the allergenic potential of different peach and nectarine varieties has been monitored throughout ripening and in relation to postharvest treatments. Fruits of peach cv Royal Gemm, Zorzi, of nectarine cv Rita Star, Early Giant and Mariadorata, and of flat type (Platicarpa), were harvested in correspondence of commercial ripeness (T0) and maintained in air for few days at room temperature to reach the full ripe stage or at 4°C for 3 weeks. Treatments with propylene were also performed. Northern blot analyses were carried out on total RNA extracted from epicarp and mesocarp to study Pp-LTP1 gene expression. Immunological studies were performed by means of a polyclonal antibody raised against the purified protein.

Expression analysis showed that Pp-LTP1 transcripts accumulated only in the epicarp. With the exception of cv Rita Star the strongest accumulations have been detected in epicarp of all varieties at T0. A decreasing trend of expression was observed in all fruits kept in air and at 4°C, but not in Platicarpa. Excluding Mariadorata fruits, propylene treatment did not appear to affect Pp-LTP1 gene expression. Western blots revealed the presence of LTP only in epicarp of all varieties, but not in Rita Star, and showed that the protein markedly increased in full ripe fruits maintained in air: this might indicate the presence of a lag between gene transcription and accumulation of secreted functional LTP. According to these results, Rita Star appears to be a variety with a low allergenic potential.

S9-15

REDUCING CHILLING INJURY AND ENHANCING TRANSCRIPT LEVELS OF HEAT SHOCK PROTEINS, PR-PROTEINS AND ALTERNATIVE OXIDASE BY METHYL JASMONATE AND METHYL SALICYLATE IN TOMATOES AND PEPPERS.

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Tomatoes (*Lycopersicon esculentum* L.) and sweet peppers (*Capsicum annuum* L.) treated with vapours of methyl jasmonate (MeJA) or methyl salicylate (MeSA) had markedly increased resistance to chilling injury and decreased incidence of decay during and after low temperature storage. Accumulation of classes I and II small heat shock protein (HSP) mRNAs was increased significantly by treatment of tomato fruit with MeJA and MeSA. Treated fruit also accumulated higher levels of transcripts from the HSP 70 family as compared to untreated fruit. MeJA treatment also substantially enhanced mRNA levels of pathogenesis-related (PR)-2a, PR-2b and PR-3b. MeSA treated fruit had significantly increased accumulation of PR-2b and PR-3a mRNAs compared to the control fruit.

Two transcripts, 1.5 kb and 3.5 kb, of alternative oxidase (AOX) were detected by Northern blot analysis from sweet pepper fruit stored at 0°C. Both transcripts reached maximal levels first in MeSA treated fruit, second in MeJA treated fruit and last in control fruit. These results suggest that the treatment of tomatoes and sweet peppers with MeJA or MeSA induces the synthesis of some stress proteins, such as HSP, PR-proteins, and AOX, which leads to increased chilling tolerance and resistance to decay.

S9-14

INDUCTION OF CHILLING TOLERANCE IN GRAPEFRUIT: PHYSIOLOGICAL AND MOLECULAR ASPECTS.

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In previous studies, we found that various postharvest temperature manipulation treatments, such as curing (at 36 °C for 36 h), hot water dipping (at 53 °C for 2 min), hot water rinsing and brushing (at 62 °C for 20 sec) and low temperature conditioning (at 16 °C for 7 days) significantly increased fruit chilling tolerance and reduced the development of chilling injuries following cold storage at 2 °C.

In the current study, we further identified by PCR cDNA differential display and PCR cDNA subtraction analysis several stress-related cDNAs that are induced in the fruit peel tissue following a prestorage hot water rinsing and brushing treatment that increases fruit chilling tolerance. These identified cDNAs encode pathogenesis-related proteins, heat shock proteins, dehydrins and a sodium transporter protein thought to be involved in conferring salt tolerance. Evaluation of gene expression patterns revealed that many of these stress-related genes were only temporarily induced by the heat treatment alone when the fruit were kept at ambient temperatures, but constitutively expressed following the combination of heat followed by cold storage.

Overall, we identified various stress-related genes that are expressed in grapefruit peel tissue in response to exposure to high and low temperature stresses. Possible cross-tolerance mechanisms and the relations of these cDNAs to the acquisition of fruit chilling tolerance will be discussed.

S9-16

HEAT TREATMENTS REDUCE CHILLING INJURY AND MAINTAIN POSTHARVEST QUALITY OF 'CLEMENTINE' MANDARINS (*Citrus reticulata* BLANCO).

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'Clementine' mandarins (*Citrus reticulata* Blanco) were harvested at optimal maturity and dipped into hot water at 53°C for 3 and 6 min. and at 48°C for 6, 12 and 24 min. After these applications fruits were wrapped with HDPE. The fruits were not degreened, waxed, or treated with any postharvest fungicides before the storage. All fruit samples were stored at 1 and 3°C following the hot water treatments for 2 months. Relative humidity was held at 90-92% in all storage rooms. All hot water dip treatments used in this study reduced chilling injury and decay except the hot water treatment at 48°C for 24 min. and resulted heat injury. However chilling injury symptoms were observed on control fruits at 1°C. The most effective treatments in the study were dipping of fruit at 53°C for 3 min and at 48°C for 6 min. Weight loss, juice yield, titratable acid, soluble solids, ascorbic acid and peel colour were not different among different hot water treatments.

It was concluded that pre-storage hot water dip might be beneficial in preventing chilling injury and decay of 'Clementine' mandarins during 2 months of storage.

S9-17**INTERACTIONS BETWEEN POSTHARVEST LOW TEMPERATURE DISORDERS IN KIWIFRUIT.**Thorp T.G.^{1*}¹ The Horticulture and Food Research Institute of New Zealand Ltd., New Zealand.

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Kiwifruit experience two significant postharvest low temperature disorders: low temperature breakdown (LTB), in which the flesh appears grainy, darkened and/or water soaked with symptoms developing first in the outer pericarp near the stylar end of fruit; and physiological pitting (PP) in which small discrete depressions (2-3 mm in diameter) appear in the skin of fruit.

It has been our experience when assessing disordered fruit after cold storage that two distinct populations can be identified, one population of fruit with LTB and the other with PP. In this paper we propose a model to explain possible interactions between these two disorders.

S9-19**FOLIAR APPLIED POTASSIUM: EFFECTS ON CANTALOUPE QUALITY, SUGAR CONTENT AND RELATED COMPOUNDS.**Lester G.E.^{1*}¹ US Dept. of Agriculture, Agricultural Research Service, Welsaco, TX, USA.

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Cantaloupe fruit sugar content is directly related to potassium (K)-mediated phloem loading and unloading of sucrose into the fruit. Improving K content in melons, during fruit growth and maturation through soil applied fertilization, is a problem, as root uptake of K is poor at this stage of growth and K competes with the uptake of Ca and Mg, two essential minerals needed for melon fruit membrane structure, function and postharvest shelf-life. Netted, orange-flesh muskmelon [*Cucumis melo* L. (Reticulatus Group) 'Cruiser'] fruit were grown in the greenhouse during the spring of 2003 and 2004 and received regular N-P-K soil fertilization throughout the study. Three to 5 days after anthesis (fruit set) and up to 3 to 5 days prior to abscission (full-slip), amino acid complexed potassium (Potassium Metalosate 24% K) at 4.0 mL L⁻¹ was sprayed on the entire plant until run-off. Plants were sprayed either weekly, biweekly or not sprayed (control). Fruit from plants receiving weekly applications of foliar K matured two days earlier, and had significantly higher fruit K content, soluble solids concentration, total sugars, ascorbic acid (vitamin C), and beta-carotene content than fruit from plants not receiving foliar K applications.

S9-18**PHOTBLEACHING, LIGHT-INDUCED CAROTENOID DEGRADATION IN RED HOT PEPPERS.**Jung J.W.^{1*}, Lee S.K.¹¹ Department of Horticultural Science, Seoul National University, Seoul, Korea.

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The discoloration in pericarp of red hot pepper was observed as a result of exposure to high light and wet condition during sun drying. Bleaching mechanism was studied under simulated irradiation condition using the pericarp discs in MES-sucrose solution under halide lamp. When red hot pepper pericarp discs were floated on MES-sucrose solution under light or dark condition, electrolyte leakage occurred in discs exposed to light at the time when carotenoids were exhausted and fruit looked white.

Increase of malondialdehyde (MDA) level preceded electrolyte leakage in discs exposed to light. In contrast, no significant electrolyte leakage and MDA was detected in the dark treatment. Carotenoid degradation was markedly suppressed by the presence of ascorbic acid as a quencher of reactive oxygen species (ROS). The results suggest that carotenoid in red hot pepper may play a role in protecting the pericarp tissue against sunlight damage by eliminating ROS generated from certain endogenous photosensitizers, resulting in surface bleaching.

S9-20**IDENTIFICATION OF POTENTIAL BIO-MARKERS IN POTATOES TO IMPROVE POST HARVEST MANAGEMENT OF FRY COLOUR.**Lærke P.E.^{1*}¹ Danish Institute of Agricultural Sciences, Department of Agroecology, Tjele, Denmark.

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Potatoes for processing have special quality demands compared to ware potatoes. A low amount of reducing sugars in the tubers is necessary to prevent the non-enzymatic Maillard reaction between sugars and free amino acids. The Maillard reaction is responsible for development of undesirable dark coloured compounds with bitter taste. Moreover, it was recently discovered that intermediates in the Maillard reaction were responsible for the formation of the potential carcinogenic compound acrylamide.

A relatively high storage temperature and concomitant treatment with chemical sprout suppressant is the only possible storage technique used today in the effort to maintain an acceptable low concentration of sugars in potatoes of commercial cultivars used for processing. However, a large variation in suitability of potatoes for processing within and between years is normally seen. Potatoes from some fields/lots accumulate sugars much faster during storage than potatoes from other fields/lots.

Chemical monitoring of potato tuber quality at harvest and during storage is a very helpful tool in making management decisions in order to avoid discoloration problems of fried potato products and to minimise application of chemical sprout suppressants. However, there is a great need for identification of more long-term biomarkers in potatoes. These long-term biomarkers measured shortly after harvest should be able to predict the fry colour of the potatoes later during storage.

The presentation is based on a three-year study with the potato cultivar Saturna used for crisp production in Denmark. In this study various biomarkers were investigated for their potential application in identification of potato lots suitable for long-term storage.

S9-21**PRE-HARVEST GROWTH CONDITIONS AND POST-HARVEST QUALITY OF TOMATO: THE ROLE OF THE XYLEM SYSTEM.**Van Ieperen W.^{1*}, Van Meeteren U.¹¹Department of Plant Sciences, Horticultural Production Chains Group, Wageningen University, Wageningen, The Netherlands.

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Quality of fresh tomato fruits is basically determined during growth of the fruits on the plant. It is commonly known that factors such as greenhouse climate, irrigation strategy and water quality can largely influence fruit production and quality.

Import of water, nutrients and assimilates from other parts of the plant largely determine fruit growth. Previous research has shown that during fruit development 90% of all water entering the fruit is transported via the phloem. Water import via the xylem seems to cease after maximal growth rate of the fruit has been reached: 25 days after anthesis (DAA). This is remarkable because the hydraulic resistance of the xylem usually is much smaller than that of the phloem. It seems therefore logical to assume that somewhere along the xylem transport path between shoot and fruits a large hydraulic resistance exists.

However, restricting water import via the xylem also limits the import of calcium, which can cause local calcium deficiency in fruits and concomitantly blossom-end rot, a major quality problem.

In present research we investigated the xylem connection between plant and fruit during fruit development and its possible role on fruit water relationships. Special attention has been paid to the knuckle, a structure which is usually found midway along the pedicel connecting an individual fruit to the truss. These knuckles contain a future abscission zone which might cause a major hydraulic resistance for xylem water transport. Knuckle containing and knuckle-less cultivars are compared and impact of measured hydraulic resistances on xylem water transport between plant and fruit are discussed.

S9-23**ALTERNATIVES TO SULPHUR DIOXIDE IN TABLE GRAPE STORAGE: POTENTIALS FOR ETHANOL VAPOURS.**Chervin C.^{1*}, Westercamp P.², Latché A.¹, Pech J.C.¹¹UMR 990, INRA/INP-ENSAT, Castanet, France; ²CTIFL-CEFEL, Montauban, France.

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Experiments have been conducted over three years to optimise the application of ethanol vapours in order to prevent *Botrytis* development and stem browning, two of the major problems in postharvest quality of table grapes. Various strategies have been tested: modified atmosphere packaging, several concentrations of ethanol in the vapour phase, combination of sulphur dioxide or modified atmosphere with ethanol. Results show that small doses of ethanol alone (around 2 ml per kg of grapes) gave a sufficient control of *Botrytis* development to replace SO₂, without a concomitant increase in stem browning. Other results, e.g. berry shatter and consumer acceptability, will be discussed.

S9-22**USE OF ORGANIC COATING FOR MAINTAINING FRUIT QUALITY OF ORGANIC AVOCADO AND MANGO.**Pesis E.^{1*}¹Department of Postharvest Science of Fresh produce, The Volcani Center, Bet Dagan, Israel.

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Two organic coatings for post-harvest application in fruits have been recently developed in Israel and USA. One coating is colloidal solution based on beeswax and the other is based on carnauba wax. Both organic waxes are in the product list of the Organic Materials Review Institute (OMRI) as regulated processing products. The main distinguishing feature between the two wax coatings is that beeswax coated fruit had a lustreless look, while the carnauba wax coated fruit exhibited a shiny appearance.

Coating organic avocado and mango effectively reduced the water loss, shrinkage, chlorophyll breakdown, chilling injury symptoms and decay development in fruits, thereby, extending their shelf life.

Coating organic avocado cv. Ettinger prior to cold storage for 3 weeks at 5 °C followed by 8 days at 20 °C, retained its green peel colour and reduced chilling injury symptoms expressed as internal and external browning. Ripe uncoated Ettinger fruit produced significant amounts of acetaldehyde and ethanol, while in coated fruit these volatiles were not detected. The higher level of anaerobic volatiles was correlated with higher mesocarp discoloration. Exogenous application of ethylene for inducing faster ripening in Ettinger did not enhance the chlorophyll breakdown in the coated fruit. The organic coating was also effective for other organic avocado cultivars like Fuerte and Hass that exhibited higher firmness, delayed breakdown and lower electrical conductivity in the fruits due to better membrane integrity.

Similarly, in the organic mango cultivars Tommy Atkins, Kent and Keitt, coating the fruits delayed fruit softening, colour development, acid breakdown and weight loss, ensuring longer shelf life of fruits after storage. Organic coatings of mango fruit with natural based wax did not produce off-flavours or accumulation of anaerobic metabolites. Moreover, coating mango fruit reduced the internal breakdown to a great extent exhibiting better fruit texture.

S9-24**EFFECT OF STORAGE TEMPERATURE AND S-ALK(EN)YL-L-CYSTEINE SULFOXIDE ON GREEN PIGMENT FORMATION IN CRUSHED GARLIC (*Allium sativum* L.) CLOVES.**Lee E.J.^{1*}, Lee S.K.¹¹Seoul National University, South Korea.

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Green pigment formation called greening after complete maceration of garlic (*Allium sativum* L.) cloves was investigated using five cultivars stored at 0, 10, and 20°C, respectively. Regardless of the cultivar, harvest times, and sprouting, greening was observed only in garlic stored at 0 and 10°C for over 4 and 5 months, respectively. Garlic at 20°C did not develop greening under all experimental conditions. Longer low temperature storage increased the green colour intensity of crushed garlic cloves, and less time was required for green colour development after crushing them.

Three major flavour precursors, S-methyl- (MCSO), S-2-propenyl- (2-PeCSO or alliin), and S-1-propenyl-L-cysteine sulfoxide (1-PeCSO) were detected in garlic cloves. 1-PeCSO was detected only in greening garlic stored at 0 and 10°C, at which greening was observed after 4 and 5 months, respectively. Through the addition of S-alk(en)yl-L-cysteine sulfoxides (ACSOs) into the homogenates prepared from greening and non-greening garlic cloves, their possible roles for inducing greening were evaluated.

In greening garlic, the roles of 1-PeCSO and 2-PeCSO were confirmed with high positive correlations, showing an increased absorbance at 590 nm. While, the colour of homogenates prepared from non-greening garlic cloves was not changed into green by the addition of ACSOs, preserving their creamy color. An alliinase inhibitor, hydroxylamine at a concentration of 100 mM completely inhibited greening. Alliinase activity and the increased levels of 1-PeCSO and 2-PeCSO on which alliinase acted when garlic cells were finely disrupted, were required for greening. Greening in crushed garlic cloves was considered as one of the various physiological responses that could be induced by longer low temperature storage in plants, and flavor precursors were the necessary conditions for inducing greening but not the sufficient conditions.

THE EFFECT OF CALCIUM CHLORIDE IRRIGATION ON AGARICUS MUSHROOM YIELD AND QUALITY.

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It has been demonstrated by many workers that varying concentrations of calcium chloride, added to irrigation water, improve the quality of fresh and canned mushrooms. Addition of calcium chloride to irrigation water on mushroom yield, quality, shelf life, dry matter, bacterial population and EC of casing soil was studied. Each room was divided into two batches (right and left) with the same number of bags. Those bags in right side were irrigated with calcium chloride where as in left side watering was carried out with tap water. Calcium chloride was added to the irrigation water at the time of pin formation in concentration of 0.2%, 0.25% and 0.30%. The result of this study revealed that irrigation of calcium chloride increased the yield significantly. The quality, color, dry matter and shelf life was improved in all treatments. Analysis of the mushrooms for calcium shows a clear increase of the calcium contents. Bacterial population in casing soil and mushroom cap was significantly reduced in all the treatments compare to control. The evidences suggested that post harvest deterioration is directly related to the initial microbial population. Decrease in bacterial population could have a significant effect on shelf life and quality of mushroom. In later flushes very less number of diseases were observed when CaCl₂ added to irrigation water. This was very much obvious in case of bacterial blotch disease.

The salinity is the proportion of potassium and sodium ions to those of calcium. An excess of sodium and potassium ions in casing soil causes reduction of mushroom yield that can be counteracted by adding calcium compounds.

It has been suggested that calcium ions may prevent any possible harmful effects from an excess of other cations, like sodium, potassium and magnesium.

CHEMICAL AND SENSORY CHARACTERISTICS OF SOME SCORZONERA (*Scorzonera hispanica* L.) CULTIVARS.

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Scorzonera, a vegetable from the Asteraceae family, whose basic usable part is roots, is recommended to cure and prevent diabetes and alimentary canal diseases.

The cultivation area of this species in Europe is rather small. The appearing on the market within the last years of some short-rooted varieties, rich in biologically active substances and the fact of introducing scorzonera into the clinic diet, will probably contribute to promulgation of scorzonera cultivation. The promulgation of scorzonera cultivation depends to a large extent on the consumers' acceptance.

Presently the analytical sensory evaluation is widely applied by determining the dependence of the vegetables' sensorial quality on their genetic and morphological characteristics. The method providing the greatest amount of information is the sensory profiling method – QDA (Quantitative Descriptive Analysis).

The subject of our study was roots of 7 scorzonera varieties i.e. "Einjährige Riesen" (W.Legutko – Poland), "Lange Jan" (Bejo Zaden – Holland), "Prodo-la" (Rijk Zwaan – Holland), "Westlandia" and "Maxima" (Bakker Brothers – Holland), "Meres" (Flora Frey – Germany) and "Duplex" (Thomas Etty Esq. – England). In these roots the contents of saccharides, taking particularly into account inulin, cellulose and its fractions: ADF (Acid Detergent Fibre), NDF (Neutral Detergent Fibre) and ADL (Acid Detergent Lignin) and the amount of polyphenol acids has been marked. The sensory characteristics of the investigated material were provided using the QDA method. The correlation between the chemical compounds marked in the roots and the sensorial quality has been determined.

EFFECT OF GLUCOSE AND BIOCIDES ON VASE LIFE AND QUALITY OF CUT GLADIOLUS SPIKES.

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Postharvest quality and vase life of cut gladiolus (*Gladiolus gandavensis*) "Rose Supreme" and "Nova Lux" cultivars were significantly improved by placing the inflorescence in vase solutions containing antibiotics (200 ppm penicillin + 250 ppm streptomycin) and glucose (5, 10 or 20%). The addition of the biocide to the preservative solution reduced the bacterial counts in the solution, inhibited the microbial growth, improved flower-opening rates, and reduced flower deterioration rate. Although there were positive proportional relationships among sugar concentration (up to 10%) and total bacterial counts in the solution, however, the addition of the biocide reduced the bacterial counts, resulting in the improvement in postharvest quality of both tested cultivars. The highest number of opened flowers and lowest number of deteriorated flowers were achieved when the preservative solution contained a mixture of biocide and 20% glucose. Sugar concentrations in vase solution resulted in high leaf content of both chlorophyll and total carbohydrates, whereas, presence of biocide in the vase solution reduced both total carbohydrates and chlorophyll contents in the leaves of cut gladiolus spikes.

POSTHARVEST ASPECTS ON BIOACTIVE COMPOUNDS IN YELLOW ONION (*Allium cepa* L.).

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Onion (*Allium cepa* L.) contains high concentrations of flavonoids, especially quercetin, that has been proposed to have beneficial health effects which may be mediated by their antioxidative properties. Some results show that these phenolic compounds also may have anticarcinogenic effects and may prevent from cardiovascular disease. There is a large variation between the content of flavonoids in different onion cultivars. There are also indications that the amount of quercetin at harvest is affected by the growing conditions. Improving cultivation and storage techniques could be one way of obtaining onions with a higher content of quercetin, thereby getting an onion which satisfy consumer preferences of a healthy product. In general, present strategies for fertilization of vegetables lead to higher concentrations of e.g. nitrogen in the plant than is needed for optimal growth. This has negative effect on the environment. At the moment it is uncertain how the fertilization affects the amount of healthy antioxidants in field grown vegetables. To obtain onions rich in bioactive compounds there are some critical steps in the pre- and postharvest handling. Onion cultivar, fertilization strategy, harvesting time, curing methods and storage conditions seem to be the factors that have most impact on the concentration of flavonoids. From a growers point of view it is of interest to know which growing and handling techniques that affect the quality and how much effort is needed to achieve this quality in comparison to cost, time needed and potential outcome. It is important to find an acceptable balance between environmental aspects, product quality and productivity for onion cultivation. Product quality includes both outer and inner quality, which means that the onion should have a good appearance and maintain its good health effects even after a long time of storage and transportation to the consumer.

S9-30

POSTHARVEST QUALITY AND SENSORY EVALUATION OF UV-TREATED TOMATO FRUIT.

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Pre-storage UV treatment has potential to control diseases in postharvest crops. The objective of this work was to evaluate the quality of UV-treated tomato. Mature green tomato fruit were treated with a hormic dose of UV and stored at 13 °C for 21 days. Sensory related quality parameters such as sugar content, total soluble solids, titratable acidity and pH were assessed at regular intervals. At the end of the storage period, a random sample of fruit was kept at 20 °C for 72 hours simulating domestic handling. The latter fruit were used for sensory evaluation performed by a panel of graduate students and research assistants. Fruit from a local market were used as reference. Over the storage period at 13 °C no significant difference was observed between UV-treated fruit compared with the control for total soluble solids. A similar trend was observed for sugar content except on day 21 where UV-treated fruit displayed a significant decrease. The titratable acidity, expressed as citric acid, of UV-treated fruit tended to be lower than the control fruit, with a significant difference observed only on day 7 after treatment; whereas there was a significant increase in pH of UV treated fruit from day 4 until the end of the storage period. Sensory evaluation indicated that the UV-treated fruit had a moderately better texture and taste than control fruit, although the general appearance and colour were rated significantly poorer than those of the control fruit.

S9-33

EFFECT OF OXYGEN AND FREE FATTY ACIDS ON CUCUMBER FLAVOUR GENERATION.

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A real time monitoring of four key flavour volatile compounds released during the cucumber tissue disruption was measured by Atmospheric Pressure Chemical Ionisation-Mass Spectrometry (APCI-MS). The rapid generation of C-6 and C-9 aldehydes in cucumber were prevented by macerating under an atmosphere of nitrogen. After air was introduced, all volatiles were immediately produced with lower concentration by half compared with the control. The addition of linolenic acid (C-18:3) in cucumber tissues resulted in a large increase of nonadienal and hexenal. In contrast, nonenal and hexenal were significantly increased by adding of linoleic acid (C-18:2). The combination of both linolenic and linoleic acid increased the formation of both nonadienal and nonenal, but less was formed compare with when those fatty acids were added alone.

These results confirmed that the precursors of nonadienal and nonenal in cucumber were linolenic and linoleic acids, respectively. They were enzymatically produced during maceration of cucumber tissue in the presence of oxygen by the lipid oxidation pathway.

S9-31

CHANGES IN GLUTAMINE SYNTHETASE ACTIVITY AND CONTENTS DURING STORAGE OF VEGETABLE SOYBEAN.

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Vegetable soybean [*Glycine max* (L.) Merr., cv. Iwatemidori] deteriorates rapidly after harvest and is associated an decrease in the amino acid contents of the seed. In other plant systems it is thought that ammonia build up is toxic and causes tissue deterioration. Glutamine synthetase (GS, EC 6.3.1.2) is the key enzyme responsible for assimilating ammonia. As the first step towards controlling the loss of amino acid and possibly improving the postharvest life, the respiration rate, some amino acid and ammonia levels and the activity of GS in harvested vegetable soybean were examined. Vegetable soybean had been held at 5 and 20 °C up to 10 days.

The respiration rate of the seed declined rapidly and it was lower at 20 °C than at 5 °C. Although GS activity remained constant at both temperature, the amino acid contents decreased rapidly as the time proceeds. The amino acid up to 3 day storage showed higher content at 5 °C than that at 20 °C. GS activity was higher at 20 °C than that at 5 °C throughout storage period. It seemed that the decrease in total free amino acid was higher at 20 °C since GS activity was controlled at lower temperature storage.

S9-34

CHANGES IN FRUIT QUALITY, PHENOLIC COMPOUNDS AND ANTIOXIDANT CAPACITY OF FRESH PRUNE DURING STORAGE.

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Phenolic compounds, anthocyanins and some factors related to the quality of fresh prune were analyzed and their changes during storage at 1 °C and 5 °C were investigated. The fruit quality was maintained within 15 days at 5 °C but remarkable internal browning was observed after 21 days.

The fruit stored at 1 °C showed less internal browning than at 5 °C, however dehydration and softening were severe at this temperature. The increase of soluble solids and the decrease of titratable acid were observed at both temperatures. Total phenolics content of flesh decreased slightly at 5 °C but increased at 1 °C after 15 days of storage. Total phenolics and anthocyanins content in peel increased at both storage temperatures. 3-Caffeoylquinic acid was the major compounds in flesh while 3-caffeoylquinic acid, 5-caffeoylquinic acid (chlorogenic acid) and two major anthocyanins (cyaniding-3-glucoside and peonidin-3-glucoside) were major phenolics in peel. Cyanidin-3-rutinoside and peonidin-3-rutinoside were also detected in peel. DPPH radical scavenging activities of peel and flesh were higher than chlorogenic acid standard and remained stronger during storage period.

VEGETABLE PRODUCTION TECHNOLOGY AND POSTHARVEST QUALITY.

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Development of approaches for assuring the quality of vegetables depends on a better understanding of the influence of preharvest factors. Quality of vegetable crops during storage are influenced by the environmental conditions and the production technology. Some pre-harvest factors are closely bound and others act in independent form. To provide high quality and value added to the product, a high quality material and optimization in the different postharvest stages is required. Economic realities will also exert a strong influence on the type of crops grown and the methods used to produce the crops. Sustainable agriculture aims at preserving the environment, productive resources and meeting social requirements.

People demand a sustainable agriculture using low input productions and less toxic agrochemicals. In this way, we may foresee risks and take preventive measures during the crop production and the commercial chain towards the consumer. Organic and low input production systems maintain the soil and crop productivity for avoiding the environmental pollution. Also, soilless system allows the control of plant growth and development with an efficient utilization of resources and almost no environmental deterioration. Thus, the adjustment of water consumption crop, irrigation solutions and drainages allow less use of water and fertilizers. This production system is a suitable alternative technique of using soil fumigants in conventional vegetable production systems as open field as under greenhouse.

The aim of this study was to determine the influence of nitrogen fertilization and vegetable production systems on postharvest quality to develop technologies to enhance the storage life of whole and fresh-cut vegetables. Organic and low input production systems in lettuce and tomato cherry crops, and soilless systems such as nutrient film technique and floating system in lettuce crop were evaluated. Relationships between vegetable production systems and postharvest quality were found.

HARVEST MATURITY RELATED CHANGES IN ANTIOXIDANT POTENTIAL IN GOLDEN SMOOTHIE APPLES.

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Changes in non-enzymatic antioxidant potential (DPPH, ascorbate content) and in enzymatic antioxidant potential (SOD, CAT and POX activity) were assessed in Golden Smoothie apples in relation to harvest date. Fruits were harvested each week at six different dates (from 18th August to 22nd September) and from two different orchards. Changes in antioxidants were related to changes in maturity indexes in orchard. The main interest of the study was to know if a delay in harvest date cause an increase in the level of active oxygen scavenging activity and what was the optimal harvest date to have a maximal antioxidant potential in order to improve the postharvest storage behaviour of the fruit.

Total antioxidant potential increased significantly with increasing maturity in orchard. In contrast, ascorbate levels remained stable during the first four weeks and decreased later the last two weeks. This opposite behaviour for ascorbate and total antioxidant potential showed that ascorbate alone is not the most important antioxidant compound in determining the total antioxidant potential of the fruit. Others compounds such as phenols are involved and it is likely the changes in the solubility of these compounds during on-tree ripening which determine the apple total antioxidant potential. Changes in enzymatic antioxidant potential paralleled those of ascorbate, a result that showed the straight relationship existing between non-enzymatic and enzymatic antioxidant potential.

RELATIONSHIP BETWEEN PHYSICAL AND BIOCHEMICAL PARAMETERS IN APPLE SOFTENING.

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Postharvest softening of apple is one of the most important problems results in quality losses for growers and distributors all over the world. Factors affecting apple softening must be well known to provide a good quality apple to the market all year round. Therefore, our research was focused on the physical and biochemical parameters causing and related to apple softening. Rapid postharvest softening of apple is the result of an undesired, fast ripening process. The two main reasons for apple softening are water loss due to transpiration and cell wall breakdown due to enzymatic activities. The former has a considerable influence on the turgidity of the cells (thus on the stiffness of apple), while the latter affects mainly the firmness of the apple due to reducing the mechanical strength of cell walls. The apple cultivar Delbard Estival was studied during 2 months storage at 18°C, 80-90% relative humidity (shelf life conditions). The acoustic stiffness coefficient, water potential, Brix value, penetrometer firmness, bruise susceptibility and activity of polygalacturonase were investigated during this storage period.

Both the acoustic stiffness coefficient and penetrometer firmness decreased considerably during storage following the characteristic three phases softening curve. Waterpotential and bruise susceptibility also decreased during storage due to the decrease in turgidity of the apple tissue. The activity of polygalacturonase showed an exponential increase in the first 30 days. The acoustic stiffness coefficient is mainly related to the initial stiffness, but also correlates with penetrometer firmness and water potential. There were also correlations found between water potential and Brix-value. Bruise susceptibility was affected by both stiffness and the weight of the fruit.

MODEL FOR EVALUATION OF MATURITY INDEX OF DURIAN FRUIT (*Durio zibethinus* Murray cv. MONTHONG).

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Durian is one of the most popular and famous seasonal fruits in Southeast Asia. However, the fruit has more problem on maturity detection than any other fruits. A major problem in exporting Thai durian is that a large percentage are immature. Reliable maturity indices have not been fully developed. Sensory tasting of unripe durian pulp, panellist could significantly ranking the stages of maturity and correlated well with the ranking of the harvesters using the external characteristics of the fruit. Panellist and harvester ranking the maturity level into 5 levels from level of 50%, which is the immature fruit to 90%, which is fully mature. Objectively detection of maturity index was developed through assessment and measurement of changing patterns of physiochemical at different stages of maturity from three different growing locations.

It was found that dry matter content was significantly correlated to the maturity level and could separated the critical stage of immature fruit of 60% level from the minimum acceptable mature stage of 70%. Dry matter content could provide a useful index of maturity. However dry matter values show differed with growing location and harvesting year. Therefore, appropriate maturity indices are developed from mathematical model from location of various indices and external factors.

EFFECTS OF UV-C IRRADIATION ON THE STORAGE DECAY AND QUALITY OF EGGPLANTS.

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In this study, the effects of UV-C irradiation on the storage decay and postharvest quality of eggplants were investigated. Eggplants (*Solanum melongena* L. cv. Fasalis) were exposed to UV-C irradiation at 1.3, 2.4 or 3.6 KJ/m² and stored at 10°C temperature with 90-95% relative humidity for 20 days. Untreated fruits were used as control. UV-C irradiation at all dosages significantly reduced postharvest decay of eggplants without causing any UV damage. In the research a dosage of 3.6 KJ/m² was the most effective in controlling decay. UV-C treated fruits had lower respiration rates than controls. Titratable acidity and soluble solids content was higher in UV-C treated fruits than control fruits.

COMPLEMENTARY MEASUREMENTS FOR APPLE TEXTURE DISCRIMINATION: (1) 'FORCE-DISPLACEMENT' CURVES ANALYSIS.

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Among the apple quality criteria, the texture is a complex notion studied at several levels. Currently, the reference measurements consist in a group of mechanical tests, destructive for fruits. Moreover, the information given by these different mechanical tests seems not to be enough used to accessing to a better texture discrimination. More generally included in a European research program (HIDRAS) conducted to the INRA of Angers (France), this work compare the mechanical response of apple fruits using two usual tests: Penetrometric and Compression assays, for the texture discrimination of five apple hybrids.

Our study, allowed to see the difference of responses given by the two different tests showing the complementary information given by these two mechanical tests. Indeed, the discrimination (factorial discriminant analysis, 5 independent cross validation) of our five textures has been improved when the parameters extracted from the penetrometric and the compression data curves have been pooled in a same matrix. A discrimination accuracy of 83%, 93%, 80%, 92% and 88% has been obtained for the five apple hybrids. The same chemometric method processed with only penetrometric or compression data can't give a similar discrimination accuracy, confirming the complementary of these two kinds of measurements on textural properties.

This study permitted us to identify at least two different origins for the apple texture discrimination. These results could help us for a better comprehension of apple texture evolution which could occurred at several tissues levels, showing several rheologic behaviours.

PRE-STORAGE UV-C IRRADIATION REDUCES DECAY AND MAINTAINS QUALITY OF BELL PEPPERS.

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The objective of this study was to investigate effects of pre-storage UV-C irradiation on fungal decay and postharvest quality of bell peppers. Bell peppers (*Capsicum annum* L.) were exposed to UV-C dosages at 1.3, 2.4 or 3.6 KJ/m² and stored at 8°C temperature with 90-95% relative humidity for 38 days. Untreated fruits were considered control. During the storage period, various chemical and physical analyses were performed and fungal decay were determined by taking samples at certain intervals. Furthermore the changes in respiration rate of the fruits were examined.

All UV-C dosages tested reduced the percentage of decay. UV-C dosage of 3.6 KJ/m² was the most effective in controlling decay. UV-C treated fruits had lower respiration rate than control fruits.

POSTHARVEST QUALITY AND ANTIOXIDANT CONTENT OF BABY SPINACH (*Spinacia oleracea* L.) AS AFFECTED BY HARVEST TIME AND STORAGE CONDITIONS.

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Epidemiological studies show that a high intake of fruits and vegetables is correlated with a low incidence of diseases like cancer, diabetes and heart disease. These protective effects have been attributed to the wide range of bioactive secondary metabolites, including antioxidants, found in large amounts in most fruits and vegetables. Relatively high concentrations of several antioxidants are found in spinach and other leafy vegetables. Antioxidant content not only differs between species or cultivars, but is also affected by factors such as nutrient and water availability, light, temperature and time of harvest. Ageing processes starting immediately after harvest affect the content of these components. Preservation of freshness in vegetables and fruits is therefore not only a question of maintaining visual quality and texture, but also minimizing losses of bioactive compounds.

Postharvest research also indicates that the ageing process is affected by the contents of antioxidants within the product. How the content of antioxidants changes from harvest until consumption is still not well known. Vitamin C and carotenoid contents often decline in green leafy vegetables after harvest, but the knowledge of changes in contents of flavonoids and other phenolic compounds is still only fragmentary. Effects of genetic and environmental factors on the contents of antioxidants also need further investigation. The aim of this project is to investigate how harvest time and storage conditions affect the content of selected antioxidants and shelf life of baby spinach. Baby spinach (*Spinacia oleracea* cv. Emilia) was cultivated at Öllöv in southern Sweden. Leaves were harvested 2^o, 3^o and 4^o weeks after sowing, and stored in polypropylene bags at 2 or 10°C, for up to 9 days. Results indicate that ascorbic acid and total carotenoid contents vary during the growth period. Postharvest conditions affect visual quality and the content of some antioxidants.

S9-43

RESPIRATION RATE OF POSTHARVEST SUGARBEET ROOT IS UNRELATED TO RESPIRATORY CAPACITY OR ADENYLATES.

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Respiration is the primary cause of sucrose loss during postharvest storage of sugarbeet (*Beta vulgaris* L.). The factors that regulate respiration in sugarbeet root, however, are largely unknown, although substrate availability, respiratory capacity and adenylate levels have been shown to control respiratory flux in other plant species. The relationship of respiration rate to respiratory capacity and adenylates was investigated in harvested sugarbeet roots stored at 1 and 10°C with or without wounding.

Respiration increased in wounded roots stored at 10°C and in wounded and unwounded roots after prolonged storage at 1°C.

Differences in total respiratory capacity, cytochrome c oxidase capacity, alternative oxidase capacity, ATP concentration, ADP concentration, ATP:ADP ratio, and phosphorylation potential were also observed between treatments, although changes in these parameters were unrelated to root respiration rate. Additionally, uncoupling respiration from oxidative phosphorylation by treating tissue sections with carbonyl cyanide-m-chlorophenyl hydrazone (CCCP) resulted in no increase in respiration rate.

These results indicate that postharvest sugarbeet root respiration is not significantly regulated by respiratory capacity or adenylate levels.

S9-46

EVALUATION OF CHILLING DAMAGE IN TROPICAL VEGETABLES WITH THREE PROCEDURES.

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Most tropical plants, including vegetables and fruits, are sensitive to chilling, which cause chilling injury under lower temperatures in the range of 0°C to 12°C. A better procedure, which is more sensitive and not time-consuming has been required to evaluate the chilling damage. The aim of this investigation was to adapt the WST-1 assay into a simple new procedure for examining chilling damage in seedlings of tropical vegetables and to compare it with two traditional procedures: measurement of ion leakage and seedling growth.

WST-1, which produces a highly water-soluble formazan dye after reduced by metabolically active cells, was applied to measure cell viability of mung bean seedlings. The result showed high correlation between chilling damage and WST-1 reduction activity as quantified by spectrophotometer at 450 nm. The longer exposure of seedlings to chilling temperature the lower the amount of water-soluble formazan dye yield by WST-1 reduction was. The evaluation was also very close to the other results obtained by ion leakage and growth.

Our results indicated that this WST-1 assay becomes a useful tool to measure the cell viability or cell damage in tissues or organs of higher plants treated by chilling and freezing.

S9-45

HIGH CO₂ TREATMENT TO CONTROL DECAY ON PEACH FRUITS.

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This study was conducted to investigate the effects of short term treatment (24-72 hours) with high CO₂ concentrations (35, 60, or 100%) on growth of *B. cinerea* isolated from naturally infected peach fruit and decay of peach fruits at 25%. CO₂ concentrations at 35-100% provided a reduction in growth of *B. cinerea* and, at 100%, significantly delayed the lesion formation during the treatment periods. Decay of peach fruits was controlled by use of high CO₂ concentrations at 100% for 24 or 48 hours and 60% for 48 hours. Short term treatment of high CO₂ concentrations 35-100% did not affect SSC, but increased firmness and colour preference. In certain case, off-flavors were noted in fruits after treatment with 100% CO₂ for over than 24 hrs. CO₂ concentration of 60%, therefore, was the most effective to control decay and preserve freshness of peach fruits.

S9-47

AT-HARVEST FRUIT QUALITY ATTRIBUTES OF NEW ZEALAND FEIJOA CULTIVARS.

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At-harvest fruit quality attributes of four feijoa (*Feijoa sellowiana*) cultivars (Unique, Triumph, Apollo and Mammoth) were measured during the 2002 season. Fruit were supplied ungraded and unsorted at optimum maturity as determined by 'touch picking' and were sourced from four production regions within New Zealand. The measured quality attributes were grouped into four categories: (1) size and shape – characterised by mass, length; diameter ratio and surface area; (2) storage potential – characterised by skin water vapour permeance (WVP) and respiration rate; (3) taste and texture – characterised by firmness, density, brix (total soluble solids), dry matter (DM) content, titratable acidity and sensory analysis; and (4) fruit maturity – characterised by relationships between the parameters above and image analysis of sectioned fruit. The incidence of defects or disorders was also noted.

Large variations between individual fruit and fruit batches were observed for most quality attributes. The ratio of the translucent part of the fruit section to overall cross-sectional area appeared to be a potential indicator of maturity. Significant (P<0.05) differences in average WVP, titratable acidity, and 'brix to acid ratio' also showed potential to be linked in building an overall maturity index. A linear relationship observed between fruit density and DM content may have utility for segregating fruit based on taste.

S9-48
HYDROGENPEROXIDE CONTENT, SUPEROXIDE DISMUTASE AND CATALASE ACTIVITIES IN QUEEN AND SMOOTH CAYENNE PINEAPPLES DURING COLD STORAGE.

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It is well known that pineapples could easily develop chilling injury symptom during storage at low temperature, depending on maturity, cultivars, temperature and duration of storage. Queen pineapples are known to be more sensitive to chilling injury than other groups.

Low temperature is believed to cause oxidative stress in plant tissues leading to chilling injury symptom. Hydrogenperoxide content and activities of superoxide dismutase and catalase were determined in the flesh of mature green and half yellow pineapples cv.Phuket (Queen) and Pattavia (Smooth Cayenne) during storage at 10°C for 3 weeks. Phuket pineapples developed slight internal browning symptom after only one week of storage and more than 50% showed moderate symptom after 3 weeks, while there were very slight symptom in Pattavia after 3 weeks of storage. Hydrogenperoxide content in Phuket was higher than that in Pattavia pineapples before and during storage. The content in both cultivars declined slightly during storage. Superoxide dismutase activities in both cultivars were about the same and remained relatively stable before and during storage. Catalase activity in Phuket before storage was higher than that in Pattavia. After one week of storage the activity declined to about the same level as in Pattavia. The activity decreased slightly in both cultivars afterward.

The results do not support the hypothesis that low temperature causes oxidative stress in pineapples, and that the different in chilling injury symptom between the two pineapple cultivars is the result of the different in antioxidant enzymes activities.

S9-50

QUALITY EVALUATION OF RED AND WHITE CURRANT CULTIVARS.

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Quality of 7 red and 4 white currant cultivars was determined. The study was done in Dobeles HPBRS, Latvia, in 2002 and 2003. Contents of ascorbic acid, total anthocyanins, soluble solids of fresh and frozen berries were analysed, and average berry weight, and number of flowers per cluster were evaluated. The most remarkable red currant cultivars were 'Varshevicha' and 'Viksnas Sarkanas' because of high anthocyanin (berries were dark red) and ascorbic acid contents, and 'Rote Spätlese' and 'Rovada' because of many flowers per cluster. Latvian 'Viksnas Sarkanas' had high berry weight and many flowers per cluster as well. Latvian 'Cirvja Piets' had the largest berries and the highest ascorbic acid content from white currants, 'White Dutch' also had high content of ascorbic acid and 'Viksnas Baltas' – high berry weight. In total, only content of ascorbic acid changed significantly after frozen storage- 18.2 % loss in 2002 and 19.0 % loss in 2003. The most stable ascorbic acid was in white currant 'Cirvja Piets' (13.6 % loss) and red currant 'Viksnas Sarkana' (4.15 % loss).

S9-49

CHANGES IN FLAVONOIDS, ASCORBIC ACID, POLYPHENOL CONTENT AND ANTIOXIDANT ACTIVITY IN COLD-STORED "FORTUNE" MANDARIN.

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Dietary recommendations for healthy eating include the consumption of fruit and fruit juice whose beneficial health effect are ascribed, in part, to ascorbic acid (AA), a natural antioxidant which may inhibit the development of major clinical syndrome including heart disease and certain cancers. However, many fruits also contain phenolic compounds, some of which have antioxidant potential and whose intakes have also been inversely associated with heart disease and cancers.

In the present study we analysed the changes in flavonoids, ascorbic acid, polyphenol and antioxidant activity in "Fortune" mandarins during cold storage. Fruit were harvested in April and stored at 5°C and 95% relative humidity (RH) for 3 months. A high-performance liquid chromatographic (HPLC) separation with photo-diode array (PDA) was used to determine and quantify flavonoids, whose identification was based on retention time and UV spectra by comparison with commercial standards. The following compounds were detected: hesperidin, quercetin, rutin, naringin, naringenin, apigenin, didymin, Kaempferol, apigenin 7-o-neohesperidoside, poncirin, neohesperidin, eriocitrin, narirutin, neoeriocitrin, diosmin and isorhoifolin.

Folin-Ciocalteu reagent was used to determine the polyphenols content and antioxidant capacity was assessed using the free radical DPPH• (1,1-diphenyl-2-picrylhydrazyl) and expressed as the Trolox equivalent antioxidant capacity (TEAC). Flavonoids and polyphenols content remained unchanged during storage, while vitamin C and antioxidant capacity increased significantly. The correlation between TEAC values and AA, flavonoids and total polyphenol content in fruit confirmed that AA is the main antioxidant in citrus fruit.

S9-51

EFFECT OF PREHARVEST AND POSTHARVEST CALCIUM TREATMENTS ON CHILLING INJURY AND DECAY OF COLD STORED FORTUNE MANDARINS

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Fortune mandarins are very susceptible to chilling injury during cold storage. Calcium is reported to alleviate chilling injury in different horticultural products. In this experiment the effect of foliar application of calcium chloride and postharvest application of calcium chloride alone or in combination with soya lecithin on visual appearance, chilling injury and decay were studied. Trees were sprayed on 20 October, 19 November, 18 December 2002 and 21 January 2003 with a solution of 500 g h L⁻¹ of a commercial product containing calcium chloride. Fruit were harvested on 16 April and subjected to the following treatments as dipping in solution/emulsion of calcium, lecithin or calcium plus lecithin. Fruit were stored at 5°C for 1 or 2 months. Calcium reduced the severity of chilling injury either in preharvest or in postharvest application. Lecithin had also a beneficial effect on chilling injury and showed a positive interaction in combination with calcium. However the incidence of decay was higher in fruit treated especially in fruit subjected to both pre and postharvest calcium treatments. Very positive was the effect of lecithin in the maintenance of fruit freshness

S9-52

STORAGE EFFECTS ON VASE LIFE OF 'FIRST RED' AND 'AKITO' ROSES GROWN IN CRETE ALL YEAR ROUND.

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Storing cut roses (*Rosa hybrida* L.) at low temperatures may induce physiological damage that worsens over time. Low temperature stress perturbs the photosynthetic efficiency of susceptible chloroplast-containing plant tissues. Relative chlorophyll fluorescence (Fv/Fm) is a sensitive index of photosystem II (PS II) activity. Fv/Fm and vase life duration were measured for cut 'First Red' (red petals) and 'Akito' (white petals) roses harvested throughout the year and subsequently stored wet at 1, 5 and 10°C for 10 days.

Vase life was generally longer for 'Akito' versus 'First Red' roses. The short vase life of 'First Red' roses was associated with early flower wilting and petal blueing at around day 8 of vase life. 'Akito' roses were more susceptible to bent neck. Progressive senescence with increasing storage temperature for both cultivars at 5 and 10°C was evident as reductions in post-storage vase life. Vase life was longer after storage at 1°C as compared to 5 and 10°C.

However, post-storage Fv/Fm was lower indicating low temperature damage to PS II. This reduction in Fv/Fm after storage at 1°C was more intense for roses grown during winter. Fv/Fm value of both cultivars progressively decreased during vase life evaluation. Overall, these results suggest that physiological damage caused by storage at 1°C has less impact on post-storage vase life than greater rates of senescence during storage at 5 and 10°C.

S9-54

QUALITY ATTRIBUTES OF SEVEN TYPES OF CACTUS PITAYA FRUITS (*Stenocereus griseus*).Yáñez-López L.^{1*}, Armella M.A.¹, Fajardo M.C.¹, Díaz-De-León F.¹, Malpica F.¹, Soriano S.J.¹, Pelayo C.¹¹Department of Biotechnology, Universidad Autónoma Metropolitana, Iztapalapa, Mexico.

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Pitaya is a cactus fruit that has been used as a complementary part of diet since ancient times in Southern Mexico. In this region about 30 types of pitayas have been identified but none of them has been characterized for quality attributes. In the present work, seven types of pitayas were studied in order to select those with more potential for the fresh market.

Samples of mature pitaya fruits were collected for two years, evaluated for sensory and physical parameters, frozen in liquid nitrogen and kept at -20°C until chemical analysis. Postharvest parameters were analysed by standard methods, sugars by DNS method, pigments by spectrophotometric analysis and aroma compounds by GC-MS. Results indicated that "Olla" and "Jarra" pitaya types showed the best quality attributes (fruit weight, percentage of flesh, total soluble solids, total sugars, and aroma compounds with fruity notes). Pigments (betalains) were different both, qualitatively and quantitatively among the seven types with their flesh ranging from pink to red and purple color.

About sensory characteristics, 12 trained panelists and 334 consumers were asked to evaluate "Olla" and "Jarra" pitaya fruits for colour, taste, aroma, texture and preference. Principal component analysis was used to determine the variability sources in preference tests. In average, trained panelists described fruit aroma as fruity or herbaceous; a bright colour in peel and pulp as well as 65% of saturation in average were found with no difference between the two types of fruits. Colour and odour variables explained over 80% of variance among consumers survey, no significant differences in acceptability were found between the two types of pitaya fruits and 73% people said they would buy pitayas at the market. We concluded that "Olla" and "Jarra" pitayas will be accepted by Mexican middle class consumers based mostly on pulp colour and fresh aroma.

S9-53

EFFECTS OF 1-METHYLCYCLOPROPENE TREATMENTS ON MEALINESS IN EARLY RED ONE APPLES.

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Firmness is the most widely used attribute to describe fruit texture, but apples of similar instrumental firmness differ considerably in their acceptability by the consumer. This is because they may possess quite different textures in terms of crispness and juiciness. These last attributes obtained by Magness Taylor and Confined Compression procedures can be related to the mealiness of fruits. The objective of this study was to determine the effects of 1-Methylcyclopropene (1-MCP) on mealiness in Early Red One apples picked at different maturity stages.

Immediately after harvest, fruits were treated with 625 ppb 1-MCP and then stored in air at 0.5 °C for 6 months. Fruits firmness, juiciness and crispness were evaluated after removal and after 7 days of shelf life at 20 °C. Independently of harvest date, 1-MCP treated fruits exhibited higher values of firmness, crispness and juiciness. Only slight differences in mealiness were found between the untreated and 1-MCP treated fruits immediately after removal. In contrast after 7 d of shelf life, the 1-MCP treated fruits were significantly less mealy especially when harvested less mature. Collectively these results showed that 1-MCP may be an interesting tool for reducing mealiness in apple and improving their commercial quality.

S9-55

VARYING CROPPING STRATEGIES FOR LEAFY BRASSICAS CAN RESULT IN DIFFERENT MARKETABLE PRODUCTS.

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Brassica leafy crops have become very popular for fresh salads in western Europe. There is a big variation in shape, colour and taste between different species and this is appreciated by the consumers of these so-called Asian vegetables. Furthermore, the plants can either be marketed as baby leaves or as mature plants. The objective of this study was to study the effect of different cropping strategies for three varieties on quality for the marketable products. Three different Brassica species were selected with consideration of shape, taste and colour: Mizuna (*Brassica rapa* var japonica), Komatsuna (*Brassica rapa* var komatsuna), Red Mustard (*Brassica juncea* var rugosa).

All experiments were carried out in open fields with different strategies with respect to establishment time, field population density and harvest time. The transplant densities were 32 cm * 10 cm and 32 cm * 20 cm. Direct sowing densities were 28 cm * 2.5 cm and 28 cm * 5 cm.

The results show that four different marketable quality products can be obtained depending on plant population densities: Baby leaves, 8-15 cm high, all growing season, small plants for bunching, mature plants sold separately and a tasty product as a green mustard spice.

Cultivation of these leafy Brassica species in spring at low plant densities is not recommended. Plants grown at low densities are harvested at a late developmental stage and the risk of flower formation is high during spring since most Brassicas are short-day plants and some of them also need vernalization. Due to a high amount of harmful pests during springtime, we recommend that crops be established from plug plants rather than direct sown in the field. There are no problems in producing mature plants at low densities in the autumn. The plant establishment seems to be best at the beginning of August.

S9-56

HOT WATER DIP REDUCES SUPERFICIAL SCALD AND MAINTAINS QUALITY OF GRANNY SMITH APPLES.

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In this study, the effects of hot water dip treatments at various temperatures and durations on superficial scald development and postharvest quality of 'Granny Smith' apples (*Malus domestica* Borkh.) were investigated. Apples were dipped into hot water at 48°C for 12, 18 and 24 min and at 53°C for 1, 3 and 6 min. After hot water dip treatments all fruits were stored at 0 and 3°C temperature with 90-92% relative humidity.

During the storage period, various chemical and physical analyses (e.g. weight loss, flesh firmness, titratable acid, soluble solids, starch degradation, chlorophyll content and peel colour changes) were performed on the apples by taking at certain intervals. Furthermore, superficial scald incidence and decay development were observed. Experiment results showed that hot water dip treatments at different temperatures and durations could maintain fruit quality and prevent superficial scald development of 'Granny Smith' apples.

S9-58

STUDENTS' ATTITUDES ABOUT FRUIT AND VEGETABLE QUALITY AT SLIPPERY ROCK, UNIVERSITY OF PENNSYLVANIA.

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Agriculture in the United States has increasingly moved toward large-scale production, enhanced the use of off-farm inputs, while optimizing distribution efficiency, and centralizing food systems. These farming methods have offered benefits to some aspects of the foods sector but, whether quality of fresh produce can be maintained in the industry, constitutes a challenging field of inquiry.

In recent years, Slippery Rock University has been demonstrating support to a growing interest in food quality, in an effort of educating its campus community, while enhancing the economic viability of farming in the region. The purpose of this study was to assess the attitudes of students about food quality, with emphasis to fresh produce. A sample (n=365) representative for the student population at this campus was divided in five sub-samples of 73 students each, in order to study freshmen, sophomore, junior, senior, and graduate students. The subjects were randomly selected and asked to fill out the survey, during meal times, at the campus dining halls. Descriptive statistics of the demographic data (age, sex, major field of study, provenience) served as indicators of possible differences when the subjects were exposed to the ten quality attributes proposed by the survey.

An analysis of the data using a chi-square test for goodness of fit suggested that significant differences exist among students when consuming and purchasing fruit and vegetables (p=0.05). More discussion is presented to illustrate the findings in relation with the demographic characteristics of the respondents. Slippery Rock University has potential to enhance food studies focused toward quality. Its interest in the "Pennsylvania foods to school" program demonstrates a tangible support to a vision of sustainability and education in this part of the country.

S9-57

MODELLING VARIABILITY OF QUALITY KINETICS DURING POSTHARVEST STORAGE: A GENERIC APPROACH.

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Present methodologies for modelling fruit quality kinetics are extended to account for the large variability, which is observed during postharvest storage. The variability in fruit quality attributes at a given time point during storage mainly originates from biological variability, and variability in the physiological stage of fruit, ambient conditions and, eventually, the measurement techniques applied.

Instead of modelling the full chain of underlying biochemical and physiological processes, typically deterministic models of minimum complexity are developed to describe the basic dynamics of fruit quality changes by means of a limited number of – measurable – state variables and parameters. In order to account for natural and induced variability, the evolution of fruit quality is represented by means of a dynamic system in which the initial conditions and the model parameters are specified as random variables together with their probability density functions. A generic approach from stochastic systems theory is introduced to predict the propagation of the probability density functions of fruit quality attributes, which requires the numerical solution of the Fokker-Planck equation, i.e., the governing equation for stochastic evolution of a probability density function. As an illustrative example to demonstrate the main features of the developed concepts and stochastic methodology, the firmness evolution during storage of three tomato cultivars (Quest, Style, and Tradiro) was followed, and the propagation of its probability density function was predicted.

This research shows that probability and uncertainty analysis of fruit quality evolution during storage is a novel practical tool with great potential to identify critical points during storage and to help the decision making for product commercialization. Furthermore, a novel approach is developed to express and visualise the dynamics of quality evolution in terms of the probability that particular events during storage are likely to happen.

S9-59

CONSUMER EXPECTATIONS AND SOLUBLE SOLIDS, ACIDITY AND FIRMNESS OF PLUMS.

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Soluble solids content, acidity and firmness are important factors determining eating quality of fruit. Tests with consumers confirmed that acceptance can be predicted by instrumental measurements of total soluble solids (refractometer), titratable acidity and firmness measurements for plums.

The variety 'Cacaks Schöne' of acceptable eating quality should attain a minimum of 13.8°Brix. Acidity should be less than 10 g L⁻¹ (malate) and firmness should not exceed 35 Durofel units. A sugar acid ratio ranging between 16 and 18 seemed most acceptable. Soluble solids content and acidity of plums were related to crop load. Furthermore, acidity and firmness were dependant of picking time or ripening stage of plums. Plums picked at an early stage of ripeness and stored for four weeks were not liked by consumers. Although firmness and acidity decreased during storage. Hence control of crop load and picking at the optimal ripeness stage are decisive for the eating quality of plums.

ANTIOXIDANT ACTIVITY, PHENOLIC COMPOUNDS AND CHLOROGENIC ACID CONTENT IN ARTICHOKE (*Cynara scolymus* L.) HEADS.

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Three early and two late artichoke (*Cynara scolymus* L.) varieties were examined and compared for their total phenolic compounds (TPC) and free radical scavenging activity. TPC was determined with Folin-Ciocalteu reagent in the methanolic extracts of the edible parts of the main heads at harvest stage. Moreover the content of chlorogenic acid (CA), the major component of the polyphenolic fraction of artichoke, was determined by using an analytical method based on RP-HPLC purifications of the raw extracts and CA determination by means of GC/MS with CA methyl ester as internal standard. The free radical scavenging activity of artichoke heads extracts was evaluated by DPPH radical method. The results show that the extracts of individual varieties differ in their TPC and CA contents as well as free radical scavenging properties. The TPC content ranged from 7.31 µg mg⁻¹ f.w. in the variety Terom to 13.05 µg mg⁻¹ f.w. in the variety Grato 1. The CA content ranged from 1.003 to 2.464 µg mg⁻¹ f.w. at maturity, and constantly decreased during the development of the head until harvest stage. No significant differences were observed between early and late varieties in TPC and CA content and free radical scavenging properties of raw extracts. No correlation was observed between TPC content and free radical scavenging capability against DPPH. Boiling of the inner bracts of the heads, a common procedure in home cooking of artichoke, led to a loss of 44 % of the CA content.

CHARACTERIZATION OF GENES INVOLVED IN THE FORMATION OF AROMA VOLATILES IN CHARENTAIS MELON FRUIT.

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Volatiles esters impart distinct characteristics to the fruit quality. Charentais cantaloupe melon (*Cucumis melo* L., var. cantalupensis Naud) is characterized by abundant sweetness and aromatic flavour. Plant alcohol acyl-transferase (AAT) genes have been identified and shown to be involved in production of scents and aromas. Recently, two cDNAs (Cm-AAT1 and Cm-AAT2) putatively involved in the formation of aroma volatile esters have been isolated from melon fruit.

Cm-AAT1 protein exhibit alcohol acyl-transferase activity while no such activity could be detected for Cm-AAT2. Two new cDNAs (Cm-AAT3 and Cm-AAT4) have been isolated from melon fruit that showed 73% and 28% similarity, respectively, with Cm-AAT1. The percentage similarity over the whole amino acid sequences is 29%. Cm-AAT3 and 4 show the highest similarity to the tobacco Nt-HSR201 protein and the acyltransferase DAT of *Catharantus roseus*, respectively. Both of them share three conserved regions common to the BAHD acyltransferase gene superfamily.

Heterologous expression in yeast revealed that some of the encoded proteins have a wide range of specificity while others are specific to a narrow range of substrates. Spatial and temporal expression of the Cm-AAT genes during fruit development and ripening as well the effect of ethylene on expression will be presented.

SCAB RESISTANT APPLE CULTIVARS - QUALITY AND STORAGE.

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In the years 2001-2003 seven scab resistant apples cultivars ('Freedom', 'Ecolette', 'Free Redstar', 'Melfree', 'Redkroft', 'Medea' and 'Sawa') were investigated. Trees were planted in the spring 1995 in the experimental orchard at Dabrowice (central Poland). One-year old trees on M.26 rootstock were planted in a complete randomised design with 3 replications having 3 trees per plot.

Quality parameters of fruits (weight, percentage of blush, total soluble solids, titratable acidity and flesh firmness) were measured at harvest, after storage (+2°C), and after-shelf life (7 days at +18°C). Additionally at harvest starch index and internal ethylene concentration were measured. After storage and shelf life the incidence of storage disorders and diseases were assessed. Quality parameters (acidity and total soluble solids) at harvest and after storage of studied cultivars depended on the growing season.

The tree size of cultivars in the experiment, expressed as trunk cross sectional area (TCSA), indicated that the growth of 'Free Redstar' was significantly stronger, and 'Medea' weaker compared with other cultivars. Apples of 'Freedom' and 'Melfree' were susceptible to superficial scald. Soft scald and core browning were observed on 'Melfree' apples. 'Free Redstar' and 'Sawa' seem to be the most promising scab resistant cultivars for climate and soil conditions like Polish.

THE EFFECT OF LONG-TERM STORAGE ON PEONY FLOWERS.

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Peonies grown for cut flowers production tend to be of the herbaceous types and derived from species *Paeonia lactiflora* Pall. Peony is an expanding export crop for New Zealand, with most of the stems being sent to the USA. To compete on this market, consistent quality and post harvest performance are essential. Storage of cut stems will allow a broader market window and so we investigated the effect of long-term storage (8 weeks) on peony flower opening and vase life.

The work presented here is part of a program focussed on understanding how pre harvest factors influence post harvest performance and therefore consumer satisfaction. Carbohydrate (starch and soluble sugars) levels were determined in flowers at harvest and during opening through until senescence. Carbohydrate levels were also determined during and after long-term storage. The sugars detected were fructose, glucose, sucrose, inositol and sorbitol. At harvest starch and sugars concentrations were similar at approx. 120 mg g⁻¹ DW. As the flowers opened starch was hydrolysed and both fructose and glucose concentrations increased two fold. Buds took on average 5 days to open and had a total vase life of 14 days. During long term storage samples were collected at 2-weekly intervals and these showed that in flower buds no starch was detectable after 4 weeks. On removal from storage, flowers opened in 2 days and had a total vase life of 9 days.

The more rapid flower opening after storage is likely to be associated with the fact that starch hydrolysis was complete. We are currently manipulating peony plants in an attempt to increase preharvest starch concentrations in buds and ultimately increase vase life.

SEPARATION OF CELL WALL ASSOCIATED ENZYME SOLUTION OF SOUR CHERRY (*Prunus cerasus* L.).

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The softening of fruit during ripening has been associated with alterations in the cell structure of wall and middle lamella. The hydrolysis of the pectin catalyzed by different enzymes. b-galactosidase was selected for analysis. This enzyme appears to exist as both a constitutive enzyme involved in the turnover of cell wall associated galactose throughout fruit growths and development and for the degradation of galactose containing polysaccharides during senescence.

Different sour cherry cultivars (...rdi bitermő Kántorjánosi, Pándy 279) were investigated at harvest. Enzyme solution was prepared by Kovács et al. (1997). SDS-PAGE was performed using a mini gel system (Mini-Protein II Dual Slab, Bio-Rad). The protein bands were evaluated by a Biotec Fisher video densitometer. For identification b-galactosidase from *Saccharomyces fragilis* (EC 3.2.1. 23, Sigma) and molecular mass markers (Pharmacia) were used. Electrophoresis and Protein blotting was used for identification of b-galactosidase. Assays for b-galactosidase were used according to Kovács and Németh-Szerdahelyi (2002). The total protein content was determined according to the method of Bradford (1976).

The main observations were: the activities of b-galactosidase were different among cultivars; the enzyme consisted of different protein bands (16 kDa, 22 kDa, 50 kDa) separating by SDS-PAGE. The isoelectric focusing pattern of the crude enzyme solution showed differences of cultivars (Pándy 279 has less protein bands, than the others).

SOME EFFECTS OF 1-MCP ON THE QUALITY OF CLEMENTINE MANDARIN FRUIT STORED AT AMBIENT TEMPERATURE.

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The effect of 1-methylcyclopropene (1-MCP) an ethylene inhibitor on the quality of clementine mandarin (*Citrus reticulata* L.) fruit at relatively high (20°C) was evaluated. Fruit harvested at TSS/Acid ratio of 7.5 or higher with slight greenish colour of the peel were used on these studies. Only fruit, free from any external blemishes or disorder were used.

Trials consisted of fumigation of fruits with 1-MCP concentrations varying from 0, 500; 1000; 1500; 2000 and 2500 ppb exposure for a period of 20 h at 20°C. After application, one bunch of fruit was treated during the first three days of storage at ambient temperature with 20 ppm of ethylene and the other bunch was kept at the same temperature of 18 to 20°C for 15 days without ethylene treatment. Quality parameters were evaluated at a regular interval of 5 days. Firmness as well as colour losses were higher in non treated fruit and from the samples treated with ethylene in comparison to fruit treated with different 1-MCP concentrations.

The control with no ethylene treatment has lost more than 15% of firmness against 8.40; 8.49 and 8.04 respectively for 1500; 2000 and 2500 ppb. Higher acid content and lower TSS were observed in 1-MCP treated fruits followed or no with exogenous ethylene treatment comparatively to the control. After 15 days of storage at 20°C, TSS/Acid ratio was 10.38 and 12.99 respectively for the control treated or no with ethylene. High temperature of 20°C, tends to reduce the effectiveness of 1-MCP depending on the concentration. These effects and other results will be discussed.

CHANGES IN ACID-METABOLISING ENZYMES DURING LOW O₂ TREATMENT OF SATSUMA MANDARINS.

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New Zealand is a marginal climate for sweet citrus and we are studying postharvest treatments which alter the sweetness to acidity ratio of our cultivars. In association with this work we have been studying the metabolism of citric acid in order to refine enzyme targets and look for aspects of acidity control. Acid accumulation and release from the vacuole is dependant on relationships between acid metabolism in the mitochondria and the cytoplasm, and may also be controlled by transport functions across the vacuolar membrane. Our previous work has proposed that a shift to anaerobic respiration in mature citrus fruit may induce utilization of pH gradients across the vacuolar membrane and citric acid loss. Establishment of low O₂ atmospheres had little effect on aconitase or isocitrate dehydrogenase activity measured in extracts from juice sac cells 48 and 96 h after treatment establishment. The activity of the vacuolar pyrophosphatase (V-PPase) enzyme was maintained under anaerobic conditions but the activity of the vacuolar ATPase (V-ATPase) was increased compared to that of tonoplast enriched fractions from control fruit stored at 20°C. As result the V-PPase/V-ATPase ratio decreased in membranes extracted from fruit maintained in an anaerobic atmosphere. The total acidity levels increased between 48 and 96 h in anaerobic fruit but were reduced after 96 h for control fruit.

The results are discussed in relation to the role of the V-PPase/V-ATPase activity ratio in controlling citric acid content of the vacuole.

THE EFFECTS OF PRE-STORAGE TREATMENTS ON POSTHARVEST QUALITY OF ANEMONE (*Anemone coronaria*) CUT FLOWERS.

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This study was conducted to evaluate the effects of pre-storage treatments on vase life and other flower quality characters of Anemone cut flowers. Flower stems were collected from a commercial orchard. Pre-storage treatments were applied to the flowers. These were consisted of: A) holding stems in water containing 50 ppm silver nitrate plus 30 ppm sucrose; B) spray 50 ppm Gibberellins (GA3) on the flowers, one day before harvest; C) spray 50 ppm GA3 on the flowers after harvest. For treatments B and C, stems were held in the same solution of treatment A. D) spray 1% sucrose on the flowers after harvest; E) spray 1% sucrose on the flowers after harvest + spray 50 PPM Gibberellins on them one day after harvest. For treatments D and E, the stems were held in 50 ppm silver nitrate solution. F) holding the stems in pure water condition; G) holding the stems in normal water. During these experiments, light intensity was 300 Lux, temperature was 16±2 °C and humidity rate was 50%. Variables were included petal abscission rate, leaf yellowing rate, stem bending rate, flower wilting rate, number of marketable flowers, and flowers' vase life. The data of these experiments were applied in Completely Randomized Design (CRD), using a SAS statistics software program. Means of variables were tested, using Duncan test (0.05). Results indicated that the best period of storage was 8 days, to have good-quality flowers in aspects of vase life, leaf quality, petal quality and flower marketability. Furthermore, treatments of B and C influenced better preservation of the flowers quality. Lowest rate of the vase life was obtained via application of D, F and G treatments.

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EFFECTS OF SOME ROOTSTOCKS ON COLD STORAGE OF RED CHIEF APPLES.

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This study was carried out to determine the effects of MM106 and MM111 rootstocks on storage performance of Red Chief apple cultivar, new cultivars for Turkey and grown in a producer orchard in Sazlica County, Nigde Province. Fruits were harvested from trees grafted on MM106 and MM111 and stored at 0°C and 90% relative humidity (RH) for 6 months. Weight loss (%), fruit flesh firmness (kgf), total soluble solids (% TSS), starch level (1-10 scale) and titratable acidity (%) were determined on fruit samples taken at a monthly interval. According to data obtained, weight loss and TSS content increased while acidity and fruit flesh firmness decreased during the storage of 6 months. The conversion of starch to sugars was rapid after 3 months. Red Chief apples grafted on MM106 had higher fruit flesh firmness than those grafted on MM111 at harvest and during storage period. Red Chief apples grafted on both MM106 and MM111 were stored successfully at 0°C and 90% RH for 6 months.

S9-70

USING SCANNING ELECTRON MICROSCOPY FOR QUALITY EVALUATION OF APPLES AFTER COLD STORAGE.

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Changes in the cuticle, epidermis and pulp of apple fruits are studied after cold storage using scanning electron microscopy. The study makes use of 3 different apple varieties (Golden Delicious, Oregon Spur and Bravo de Esmolfe) subjected to different pre-storage treatments (hot water treatments and calcium chloride solutions). The main objectives concern to: the identification of structural differences among varieties; some explanations for individual behaviour along the storage period; and the relationship between pre-storage treatments and structure and quality evolution of the fruits. The thickness of cuticle and its waxes is quite different (less in Bravo de Esmolfe apples). The extension of cracks in cuticle wax is higher with long term storage than at the beginning of the storage. Heat treatments and calcium application will contribute to quality preservation of apples, particularly reducing fruit softening and diseases incidence.

S9-71

MATURITY INDEX OF CACTUS JIOTILLA FRUIT (*Escontria chiotilla*).Armella M.A.^{1*}, Domínguez S.J.¹, Yáñez L.L.¹, Fajardo M.C.¹, Díaz-De-León, F.¹, Malpica F.¹, Ponce-De-León L.¹, Soriano S.J.¹, Pelayo C.¹¹Department of Biology, Universidad Autónoma Metropolitana, Iztapalapa, Mexico City, D.F., Mexico.

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Jiotilla is a native fruit from the second poorest region of Mexico, being considered one of the three most exotic cacti from La Mixteca in the state of Oaxaca. The quality of harvested jiotilla fruit is quite variable because no harvest index has been identified. In the present work, physical, chemical and sensory analysis were conducted in four developmental stages of jiotilla fruits in order to identify potential parameters as maturity index.

Samples of jiotilla fruits were collected in La Mixteca Region in two harvesting seasons, transported to our laboratories in Mexico City, evaluated for sensory and physical parameters, frozen in liquid nitrogen and kept at -20°C until chemical analysis. For sensory analysis, samples were coded and presented to 250 consumers and flavour, colour, consistency, aroma and overall acceptability were evaluated based on a seven-point hedonic scale ranking. Additionally, a quantitative descriptive analysis was carried out by a trained sensory panel of 10 assessors, using a 100mm unstructured scale to evaluate 4 different attributes. Traditional postharvest parameters were analysed by standard methods, sugars by DNS method, pigments by spectrophotometric analysis and aroma compounds by GC-MS. Results indicated that rind thickness, fruit form (polar diameter/equatorial diameter ratio) and levels of sugars, pigments and aroma compounds, especially those with herbaceous and fruity notes, were the most indicative parameters of developmental stages. Sensory analysis showed that 86.9% of people interviewed did not know jiotilla previously, but 68.5% would buy it if they had the chance. Consumers identify herbaceous aroma as one of the most dominant aromatic note of the fruit, followed by a fruity note. Results are supported by histological studies conducted simultaneously with this study.

S9-72

ORGANIC PRODUCTION OF NEW APPLE CULTIVARS IN SWEDEN.

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Since the end of last century, increasingly demand on high-quality agricultural commodities that be produced by means other than using chemicals, enhanced the importance of the fruits organic production. Because of the insufficiency of suitable fruit production, fruit processing in Sweden depends on the consumption of the non qualified apples or on the import of 6000 tons a year. As a response to this requirement, we studied during 2000 – 2003, the organic production of sixteen apple varieties for processing. Tree vegetative growth, yield, ripening date, fruit size, shape, skin colour, flesh firmness and colour, SSC, acidity, pectin, phenol compounds, juicily, texture, C-vitamin, and resistance to fungal decay were controlled. According to the experiment results, ten varieties were suggested as suitable to Swedish conditions.

SESSION 10 (S10)

POSTHARVEST PATHOLOGY



S10-01**FUNGAL MECHANISMS MODULATING DISEASE DEVELOPMENT IN POSTHARVEST PATHOGENS INTERACTIONS.**Dov Prusky^{1*}¹Department of Postharvest Science of Fresh Produce, Agricultural Research Organization, Bet Dagan, Israel.

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In the long association with pest and pathogen, plants and specifically fruits and vegetables, evolved an impressive array of defensive tools. At the same time, pest and pathogen developed mechanisms to comprise plant resistant mechanism in what must have been an evolutionary game. From the early years when the gene-for-gene hypothesis was formulated and the first pathogenicity genes were reported and up to the recent isolation of disease resistance genes a significant amount of data at the molecular and cellular level has added to our understanding of how specific host interactions modulate the development of pathogen growth. Observations indicate that postharvest host-pathogen interactions are characterized by i. multiple factors of host response affecting resistance and ii. specific fungal factors that can modulate pathogenicity. Modulation of fungal pathogenicity can be obtained by activating the signal transduction mechanism, metabolizing inhibitory factors and changing the ambient pH where colonization takes place. Ambient pH is important in that it determines the ability of the pathogen to successfully colonize and invade the targeted host, with the aid of secreted pathogenicity factors. Since pH is a critical consideration in the attack strategy of postharvest pathogen it has developed environmental sensing mechanisms that enable it to tailor ambient conditions to best fit its offensive arsenal. What are the mechanisms used by the pathogen and how could them be modulated to affect fungal colonization? Recent achievements will be summarized and future challenges will be discussed.

S10-03**USE OF METHYL JASMONATE FOR SUPPRESSION OF BOTRYTIS ROT IN VARIOUS CULTIVARS OF CUT ROSE FLOWERS.**Meir S.^{1*}, Droby S.¹, Kochaneck B.¹, Salim S.¹, Philosoph-Hadas S.¹¹Dept. of Postharvest Science of Fresh Produce, ARO, The Volcani Center, Bet-Dagan, Israel.

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Gray mould, caused by *Botrytis cinerea* on flower petals, is a common disease of greenhouse roses (*Rosa hybrida* L.). The disease develops rapidly after harvest and causes a significant reduction of cut flowers value. Methyl jasmonate (MJ), known to induce plant defense responses, was examined for postharvest control of this disease in various cultivars of cut roses.

We have previously demonstrated that under laboratory conditions, pulsing of cut roses with 200 µM MJ for 24 h at 20 °C provided six rose cultivars with a systemic protection against *B. cinerea*. Spray application of MJ (> 300 µM) to rose petals provided local protection by direct inhibition of *B. cinerea* spore germination and germ-tube elongation. Based on these results, a practical application of MJ consisting of simultaneous pulsing and spraying, was developed for growers handling conditions. The treatment included MJ pulsing for 4 h at 20 °C and MJ spraying, followed by continuation of the pulsing for additional 20 h at 6 °C. The flowers were then packed and incubated for two days at 60°C for air transport simulation, transferred subsequently to water cylinders placed at 20 °C, and artificially inoculated with *B. cinerea* spore suspension. The optimal treatment under these conditions was pulsing with 350 µM MJ and spraying with 500 µM MJ. This combined MJ treatment neither increased ethylene production in petals, nor it was phytotoxic.

The MJ treatment effectively suppressed gray mould development following both natural and artificial infection in 11 rose cultivars ('Frisco', 'Jazz', 'Mercedes', 'Red Charm', 'Eskimo', 'Profita', 'Tamara', 'Sun Beam', 'Pink Tango', 'Carmen', 'Golden Gate'). In yellow, orange and pink cultivars, the MJ treatment improved petal colour by inhibiting colour fading during vase life. Collectively, our findings suggest a possible commercial application of MJ as a useful and environmentally friendly means for suppressing Botrytis rot in cut roses.

S10-02**CONTROL OF STORAGE ROTS OF TABLE GRAPES BY PRE- AND POSTHARVEST APPLICATION OF SALTS.**Nigro F.^{1*}, Schena L.¹, Ligorio A.¹, Gallone P.¹, Ippolito A.¹, Salerno M.¹¹University of Bari, Dept. Plant Protection and Applied Microbiology, Italy.

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The activity of 19 inorganic and organic salts in reducing both the in vitro growth of *Botrytis cinerea* Pers. and the incidence of storage rots on table grapes (cv Italia) was evaluated. Several salts reduced mycelial growth of the pathogen on amended (0.1% w/v) glucose-agar. Postharvest application of calcium chloride (CC), potassium carbonate (PC), sodium bicarbonate (SB) and sodium carbonate (SC) solution at 1% w/v, significantly reduced grey mould incidence on small bunches of table grapes. PC, SB, and SC behaved similarly on both in vitro (inhibition of mycelial growth and conidia germination of *B. cinerea*) and in vivo (reduction of grey mould incidence) tests, whereas CC was active only in vivo.

The effectiveness of preharvest application was evaluated by small-scale trials, conducted in 1997 and 1998 with CC, PC, SB, and SC, and by large-scale ones conducted in 1999 and 2000 with CC, SB, and SC. All salts proved their efficacy determining significant reduction both of field rots (mainly sour rot) and of storage rots (mainly due to *B. cinerea*). Moreover, in large-scale trials simulating practical conditions of vineyards in Southern Italy, two salt applications (30 and 90 days before harvest) resulted in a significant reduction of storage rots by 49 (CC), 45 (SB), and 54% (SC). Similarly, field rots were reduced by 60 (CC), 47 (SB), and 34% (SC). On the whole, salts showed an activity higher or comparable to that of conventional chemical treatments. The pH had a minor role in the mechanism of action of salts, whereas the inhibition of the polygalacturonase activity of *B. cinerea* induced by the four salts seems to play a major role. Salt treatments did not modify the epiphytic population of bacteria, yeasts, yeast-like fungi, and filamentous fungi naturally occurring on the berries.

S10-04**CONTROL OF POSTHARVEST DISEASES OF SWEET CHERRY WITH ETHANOL AND HOT WATER.**Karabulut O.A.^{1*}¹Uludag University, Faculty of Agriculture, Department of Plant Protection, Gorukle-Bursa, Turkey.

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Complete inhibition of the spores of *P. expansum* occurred after a 10 s exposure to 40% ethanol or more at ambient temperature, while spores of *B. cinerea* were completely inhibited by 30% ethanol or more. Mortality of the spores of *P. expansum* and *B. cinerea* in heated 10% ethanol was higher than in water at the same temperatures. Immersion of naturally inoculated fruits in 20, 30, 40, or 50% ethanol reduced the decay present after storage for 10 days at 20 °C similarly and by about 60 to 85%. Immersion of fruit that had been inoculated with the spores of *P. expansum* and *B. cinerea* reduced decay by both pathogens after storage for 30 days at 0 °C and 5 days at 20 °C when 30% or higher concentrations of ethanol were used.

The incidence of decay after immersion in water alone for 30 seconds at 24, 50, 55, or 60 °C was 57.8, 44.8, 46.3, and 35.7%, respectively, while 10% ethanol at these temperatures the decay incidence to 52.3, 33.9, 32.8, or 14.8%, respectively. Water treatments at 50, 55, or 60 °C alone were not effective against *P. expansum*, while their efficacies were significantly increased by the addition of 10% ethanol. The most effective treatment was immersion in 10% ethanol at 60 °C. Ethanol treatments at 20, 30, 40, or 50% and water treatments at 55 or 60 °C significantly reduced natural fungal populations on the surfaces of fruits in all of the experiments. Addition of 10% ethanol to water significantly increased the efficacy of water in reducing the fungal populations at elevated temperatures. None of these treatments caused surface injury to the fruit or adversely affected stem colour.

S10-05**INTEGRATED CONTROL OF SWEET CHERRY STORAGE ROTS BY PRE- AND POSTHARVEST APPLICATIONS OF *Aureobasidium pullulans*, CALCIUM CHLORIDE, AND SODIUM BICARBONATE.**Ippolito A.¹*, Schena L.¹, Pentimone I.¹, Nigro F.¹¹Dipartimento di Protezione delle Piante e Microbiologia Applicata, Università di Bari, Italy.

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Calcium chloride (CC) and sodium bicarbonate (SB) were selected among 17 salts as the most effective against *Botrytis cinerea* in in vivo trials on wounded sweet cherries. Under the same conditions, the combination of CC and SB with a known biocontrol agent (*Aureobasidium pullulans*, strain L47) reduced *Botrytis* rot by 98 and 94% respectively.

Tests with pre and postharvest treatments were conducted in 2000 and 2001 using CC, SB, and L47, alone or in combination. In both year trials, postharvest treatments gave significant reductions of rot incidence compared to the control. In particular, the combinations L47+CC and L47+SB were the most effective with a reduction of total rots ranging from 62 to 75%. The application of Limpel's formula proved the presence of a synergistic effect of combined applications of antagonist and salts.

Compared to the untreated control, preharvest applications of the antagonist and salts alone resulted in a significant reduction of rots ranging from 24 to 58%; however, their combined application did not improve the level of control. CC and SB did not show any in vitro toxic effect on *A. pullulans* and did not modify the epiphytic population of yeasts, yeast-like fungi, and filamentous fungi on fruit surface. In postharvest applications, the population of the antagonist was not reduced by the presence of salts, whereas, on fruits treated before harvest the colony forming units (CFU) of yeast-like fungi was lower on fruits treated with a combination of antagonist and salts, compared to fruits treated with the sole antagonist.

S10-07**OVEREXPRESSION OF A PEACH DEFENSIN GENE CAN ENHANCE THE ACTIVITY OF POSTHARVEST BIOCONTROL AGENTS.**Wisniewski M.¹*, Droby S.², Bassett C.¹, Janisiewicz W.¹, Artlip T.¹¹USDA-Agricultural Research Service, USA; ²ARO- The Volcani Center, Israel.

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A defensin gene (PpDfn1) was cloned from a cDNA library of peach bark tissues collected in midwinter. The open reading frame of 237 bp codes for a 79 amino acid peptide related to the defensin family of proteins. The gene is seasonally expressed in bark tissues and is also expressed in early fruit development. A recombinant version rDFN1 was expressed in the yeast, *Pichia pastoris*.

It was found that rDFN1 inhibited germination of the postharvest pathogens, *Penicillium expansum* and *Botrytis cinerea*. Partially-purified peach defensin protein obtained from the recombinant yeast strains also exhibited antimicrobial activity. Constitutive expression of a defensin in a selected yeast antagonist may be a suitable approach to augment postharvest biocontrol efficacy. One drawback in the use of the peach defensin gene, however, is that it exhibited fungistatic rather than fungicidal activity.

Additionally, this approach would require the development of a transformation for a microbial antagonist identified as having antagonistic activity since the antagonist must be extremely well adapted to compete against the pathogen in the ecological niche of fruit wounds. Such a transformation system exists for the biocontrol yeast, *Candida oleophila*, the antagonist used in the product, Aspire. Recombinant studies utilizing peach defensin are in progress.

S10-06**METABOLITE PROFILING USING GC-MS TO STUDY CORE BREAKDOWN IN RELATIONSHIP TO BIOCHEMICAL CHANGES DURING LONG-TERM STORAGE OF PEARS.**Franck C.¹*, Lammertyn J.¹, Nicolaï B.M.¹¹Flanders Centre/Laboratory of Postharvest Technology, Katholieke Universiteit Leuven, Leuven, Belgium.

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'Conference' pears are susceptible to core breakdown, characterised by internal browning and cavities. Nowadays, growers apply certain postharvest treatments in order to minimise this disorder. However, the biochemical background of physiological storage disorders is still not fully understood.

The objectives of this study were (1) to reveal biochemical differences between two cultivars with different susceptibility, (2) to investigate the characteristics of brown and sound tissue and (3) to study the effect of four different controlled atmosphere (CA) conditions during long-term storage.

To induce core breakdown, pears ('Conference' and 'Doyenné') were stored immediately after harvest at 1% O₂, 10% CO₂. To study the effect of CA conditions, pears were stored under four different CA conditions. After tissue homogenisation, MeOH extraction and drying, the residues were derivatized with methoxyamine and MSTFA. GC-MS analysis was carried out using a SPB-50 column (Supelco). Each sample was injected with two different GC methods to optimise detection of sugars and lowly concentrated compounds. Multivariate statistics were used to analyse the data.

Brown-induced 'Conference' pears are characterised by fumarate, which was not found in 'Doyenné' pears (stored under similar conditions). The latter cultivar is richer in succinate and malate. Brown tissue differed from sound tissue by different sugar ratios, lower acid concentrations and the appearance of fumarate. Comparison of different CA storage conditions revealed that succinate accumulates in fruits exposed to high CO₂ conditions, whereas its concentration is zero in low CO₂ conditions. The O₂ concentration seems mainly to affect the sugar metabolism: more disaccharids were found in low O₂ conditions, the high O₂ conditions contained more C5 sugars. From these results, there is evidence that high CO₂ conditions block succinate dehydrogenase and that fumarase is inhibited in brown tissue, resulting in fumarate accumulation and malate deprivation.

S10-08**COMBINATION OF ULTRAVIOLET-C LIGHT AND BIOCONTROL AGENT TREATMENTS TO CONTROL GREEN MOULD IN ORANGE FRUIT.**D'hallewin G.¹, Arras G.¹*¹C.N.R., Istituto di Scienze delle Produzioni Alimentari, Sezione di Sassari, Sassari, Italy.

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Biological control yeast isolate '13L' and *Bacillus subtilis* isolate 160B were used separately or in combination with ultraviolet light (1.5kJ m⁻²) to control citrus green mould.

Twenty-nine and fifty-two % of the inoculated wounds were infected when treated with yeast and bacteria respectively. When 13L was combined with UV-C this percentage dropped to 11%, while with the bacteria it remained the same. UV-C treatment alone had 32% of rotted wounds.

Population dynamic studies in vitro and in vivo combined with scoparone quantisation suggest that scoparone induction by UV-C light may be the reason of the negative interaction between UV-C and bacteria.

S10-09**SYSTEMIC ACQUIRED RESISTANCE AS A STRATEGY FOR POSTHARVEST DISEASE MANAGEMENT ON ROCKMELON (*Cucumis melo* VAR. RETICULATUS)**Nguyen P.T.¹, McConchie R.M.^{1*}, McDonald K.L.¹, Anwaral B.², Morris S.C.²¹University of Sydney, ²University of Sydney, Sydney Postharvest Laboratory, Australia.

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Systemic acquired resistance (SAR) has been intensively investigated for control of field diseases in many crops. However, there are very few reports considering SAR for postharvest disease control. An investigation of SAR and the potential for use in rockmelon postharvest disease control was conducted in this study.

In glasshouse experiments, preharvest applications of the SAR activator Bion® (l-acibenzola-S-methyl) or BTH - Benzothiadazole on rockmelon plants at different physiological growth stages, led to a significant increase in leaf chitinase activity immediately after application. Chitinase activity peaked approximately 7 days after each application before declining back to control levels. BTH sprayed plants were protected against powdery mildew (*Sphaerotheca fuliginea*) infection, suggesting that chitinase played an important role in disease resistance.

In a field experiment, rockmelon plants were treated with BTH at 50 ppm (a.i.) at male flowering, 2 weeks after male flowering and 5 weeks after male flowering. The pattern of chitinase induction was very similar to that of the glasshouse experiments, except in the last application at 5 weeks after male flowering, in which no significant induction of chitinase was measured within 7 days. The preharvest application of BTH on rockmelon plants protected rockmelon fruit from postharvest disease infection of *Fusarium equiseti*, *Alternaria alternata* and *Colletotrichum* spp. A synergistic effect was observed between SAR and the dipping fungicide guazatine in controlling rockmelon postharvest diseases, providing better disease control than either treatment alone. Preharvest application of BTH had no phytotoxic effects on the growth of plants as measured by leaf area, fruit yield and sugar content of treated fruit. The results indicate that preharvest applications of BTH to rockmelon plants has potential for integration into a program of postharvest disease control of fruit.

S10-11**EFFICACY OF THE MYCOFUMIGANT ARABESQUE™ (*Muscador albus*) IN POSTHARVEST PATHOGEN CONTROL ON FRUIT-VEGETABLES.**Suslow T.V.^{1*}, de Freitas P.M.¹, Mercier J.²¹University of California Davis; ²AgraQuest, Inc., USA.

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Arabesque™ is a unique biological control product concept that is at an advanced stage of registration with the U.S. Environmental Protection Agency for use within postharvest handling systems of horticultural commodities. The active biological agent is a selected isolate of *Muscador albus* anam. sp. Nov. that has been shown to release a broad range of antimicrobial volatiles. The process, termed mycofumigation, has a spectrum of efficacy that includes important postharvest pathogens.

We have recently extended this evaluation and demonstrated efficacy in postharvest decay reduction or prevention of *Botrytis cinerea*, *Geotrichum candidum*, *Pectobacterium carotovora*, and *Alternaria* spp. on wounded and non-wounded tomato, bell pepper, and melons. In addition, we have demonstrated up to 5 log-cycle reductions of pathogenic bacteria of concern in the food safety of horticultural products including multiple *Salmonella* serotypes, *Escherichia coli* O157:H7, *Shigella sonnei*, *S. boydii*, and *S. flexnerii*, and *Listeria monocytogenes*. Efficacy evaluations are defining the practical limits of treatment and modes of delivery in simulated postharvest handling and transportation situations. Mycofumigation is likely to have broad appeal to grower and handlers of horticultural products at all scales of operation. Preliminary experiments strongly suggest that Arabesque™ may substantially reduce postharvest losses for bacterial and fungal pathogens. Both conventional and organic producers will likely see this product as compatible to their crop management system. One clear appeal for postharvest applications is that the mode of action involves liberation of a complex of volatiles from a contained substrate. No viable form of the biopesticide will come in contact with the treated product. In addition, many systems of postharvest handling preclude the use of a disinfectant or fungicidal wash step and, therefore, a short-duration 'fumigation' will provide an incremental method for reducing crop loss and minimizing the risk of food borne illness for consumers.

S10-10**DEVELOPING A NOVEL ENVIRONMENTALLY FRIENDLY MICROBIOCIDAL FORMULATION FROM PEEL OF CITRUS FRUIT.**Ben-Yehoshua S.^{1*}, Rodov V.¹¹Dept. of Postharvest Science, ARO, the Volcani Center, Israel.

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A new formulation of a microbicide was developed from natural compounds extracted from citrus ilavedo. The formulation prevented the development of decay in *P. digitatum* – inoculated citrus fruits and in other fruits and against several other fungi and bacteria. This formulation also inhibited microbial development in the household either alone or together with commonly used detergents and was found to be active against human pathogens such as *Staphylococcus aureus*, *Candida albicans*, *Listeria monocytogenes* and others.

A major advantage of this new formulation is its own non toxic food grade characteristics and high chances of easy approval for use for household and fresh agricultural produce by the health authorities. The new formulation has both a direct fungicidal activity and elicits the fruit to build its endogenous defence mechanisms against decay. These combined modes of activity of both direct microbial inhibition as well as elicitation of the endogenous resistance mechanisms against pathogens give this formulation high potential to control decay.

The major active components of these formulation were already identified and a procedure for the synthesis of the most active biocide was developed. This novel finding was submitted as patent in Israel.

S10-13**INTEGRATING CURING TREATMENTS IN DEGREENING PROCESS TO CONTROL POSTHARVEST DISEASES OF MANDARINS.**Torres R.^{1*}, Plaza P.¹, Usall J.¹, Sanbruno A.¹, Lamarca N.¹, Pons J.², Viñas I.¹¹Postharvest Unit, CeRTA, Centre UdL-IRTA, Lleida, Catalonia; ²Estació Experimental de l'Ebre, IRTA, Amposta, Catalonia, Spain.

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The practical integration of curing treatments in currently degreening process was evaluated on 'Clemenules' mandarins harvested at two different maturity stages. Fruits were inoculated with *Penicillium digitatum*, *P. italicum* and *Geotrichum candidum* before degreening at 20°C and 90% RH, with 5-10 ppm of ethylene (standard degreening); degreening at 33°C for the first 65h of the degreening process; and degreening at 40°C for the first 24h of the degreening process. Control fruits were kept at 20°C without exogenous ethylene exposure. Fruit quality during the degreening period and the subsequent marketing period at 20°C for 7 days was also evaluated.

Seven days after inoculation, both degreening treatments using curing conditions successfully controlled green and blue mould decays, regardless of harvest date. Sour rot was significantly reduced by the degreening treatment at 40°C for the first 24h on lately harvested fruits. Commercial colour index (CI₁₋₆) was achieved one and three days later on fruits degreened at 40°C for the first 24h in comparison with standard degreened fruits on early and lately harvested fruits, respectively.

Higher firmness loss and lower acidity were observed on lately harvested fruits degreened at 40°C for the first 24h compared to standard degreened ones after marketing period. No significant differences were observed on total soluble solids between these two degreening treatments for both harvest dates. A curing treatment at 40°C for 24h can be integrated in the current degreening process to successfully control green and blue mould decays without deleterious effects on fruit market quality on early season mandarins.

HIGH CO₂ INDUCES TRANSLUCENT SCALE IN STORED ONIONS.Purvis A.C.^{1*}, Paulk J.T.¹¹University of Georgia, USA.

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Controlled atmosphere (CA) storage has been used successfully to extend the postharvest shelf life and marketing period of Vidalia sweet onions. Low (3%) O₂ in the CA storage room maintains dormancy and reduces sprouting of the bulbs, while elevated CO₂ reduces decay. We have reported that although CA does not reduce the growth of *Botrytis allii* in previously inoculated onions, CA does inhibit sporulation and the spread of the disease to sound onions. However, some early studies suggested that high (≥ 10%) CO₂ may cause a physiological disorder in stored onions. The internal breakdown is characterized by a clearing and water-soaking of the normally opaque cells of the fleshy internal scales and has been called watery or translucent scale. Although high CO₂ was implicated as the causal factor in the development of translucent scale, the studies were confounded by low O₂ concentrations in the storage room atmosphere.

During the 2001-02 and 2002-03 seasons, 'Savannah Sweet' onions were stored in air or air + 10% CO₂ in 32-L plastic containers at 1 °C. After 13 weeks, all onions that had been stored in air + 10% CO₂ exhibited translucent scale, while no onions that had been stored in air only exhibited any internal breakdown. However, the surface of most of the onions stored in air was covered extensively with sporulating *Botrytis allii* but none of the onions stored in air + 10% CO₂ exhibited any surface fungal growth. Clearly, translucent scale is caused by high CO₂ and not low O₂ in the storage room atmosphere. Translucent scale may be a greater problem in storage rooms without CA than in CA rooms unless the CO₂ produced during respiration of the onions is monitored and the levels controlled.

S10-16**DECREASED SWEETPOTATO DECAY AFTER STORAGE BY ALTERNATIVE TREATMENTS.**Afek U.^{1*}, Orenstein J.¹, Droby S.¹, Fallik E.², Di Primo P.², Zur K.M.³

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'Georgia Jet' is the predominant sweetpotato [*Ipomoea batatas* (L.) Lam] cultivar grown in Israel. This cultivar is susceptible to diseases during storage and shelf life (20°C). After 6 months of storage plus 50 days of shelf life (in all of the experiments the treatments were applied after storage of 6 months), the percentages of decay caused by *Rhizopus* spp. following treatment with yeast (Ex. No. 25-03) was 7% compared to 35% in the nontreated control. The percentages of decay following treatment with yeast (Ex. No. 20-03) after 21 days was 0% compared to 7% in the nontreated control. The percentages of decay following treatment with yeast (Ex. No. 18-03) after 35 days was 12% compared to 28% in the nontreated control.

In other experiments the effect of hot water and hot water plus yeast were tested on sweetpotato decay caused by *Rhizopus* spp. during shelf life (20°C). Percentages of decay following treatment with hot water 55°C for 18 s after 31 days of shelf life was 15% compared to 30% at 50°C and 76% in the nontreated control. Percentages of decay following treatment with hot water at 55°C for 18 s plus yeast after 31 days of shelf life was 2%.

S10-15**HIGH-CO₂ FOR THE CONTROL OF *Botrytis cinerea* ROT DURING LONG TERM STORAGE OF RED CHICORY.**Bertolini P.^{1*}, Baraldi E.¹, Mari M.¹, Chierici E.¹, Lazzarin R.²

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Red chicory (*Cichorium intybus* var. *silvestre* Bischoff), has been cultivated for a long time in northern Italy. In recent times its production has increased also in Europe, United States and South America due to the marketing success of freshly cut salad mix of which is a basic component. Red chicory is a winter crop and its quality decreases when harvested in late spring and summer, storage technology has potential to extend the marketing season of the heads picked at the best time. However during storage heavy losses are caused by rots, shrivelling and senescence. The effects of CO₂-enriched atmospheres on the infections of *Botrytis cinerea* in red chicory cv Radicchio rosso di Chioggia were studied during storage at 0°C for 150 days. *B. cinerea* growth, conidial germination and sclerotial production were evaluated also in vitro. Mycelial growth on PDA decreased linearly with increasing CO₂ concentrations from 5, 10, 15 and 20% CO₂. A reduced production of sclerotia in air, by the colonies formerly exposed to various CO₂ concentrations, was also detected. Conidial germination and germ tube elongation was delayed with increased CO₂ and inhibited at 20% CO₂. In artificially inoculated heads, lesion area caused by *B. cinerea* decreased with increasing concentrations of CO₂, up to 60 days' storage, later only 10 and 15% CO₂ were really effective, while after 120 days all the concentration tested showed a low efficacy. In naturally infected heads the effect of 5 and 10% CO₂ was remarkable even after 150 days' storage as it was prevented not only the growth of *B. cinerea* in each single head but also the spread of the disease to adjacent plant (ne-ting), thus reducing the overall losses. Phytotoxic effects combined with a higher vulnerability to rots were detected in heads kept at 15% CO₂ for 150 days.

S10-17**HEAT TREATMENT: A NATURAL WAY TO INHIBIT POSTHARVEST DISEASES IN ROCKMELON.**McDonald K.L.^{1*}, Anowar B.², Morris S.C.², McConchie R.M.¹

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The export of rockmelons from Australia to neighbouring countries has increased over the past few years. However, the rate of decay is high due to postharvest diseases such as *Fusarium* spp, *Alternaria* spp and *Colletotrichum* spp., if these fruits are not treated with chemical fungicides. We examined the use of hot water fruit dipping as an organic way of preventing postharvest diseases.

In studies conducted, we found that by dipping rockmelons in 50, 55, 60 and 65°C water for one minute, disease development was dramatically inhibited at all temperatures in comparison to the control (22°C). A one minute exposure to 60°C was the optimum temperature, resulting in 97% of fruit being disease free after 3 weeks storage at 5°C (simulated export conditions for Australia) compared to only 7% when dipped in 22°C. An increase in peroxidase activity and enhanced lignification of the cell walls on the rind were correlated with the hot water dipping effect. The levels of peroxidase were increased ten-fold when exposed to 60°C heat in comparison to the control (22°C). Both the extent of lignification and the increase in peroxidase activity correlated with the increase in temperature. Importantly, the taste and physical appearance of the melon was not altered in response to the high temperatures.

IMPROVEMENT OF BIOCONTROL YEAST ACTIVITY AGAINST POSTHARVEST PATHOGENS: RECENT EXPERIENCES.

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Control of postharvest diseases of fruits and vegetables by means of biocontrol agents (BCA) applied alone under commercial conditions resulted frequently unsatisfactory if compared with protection displayed by synthetic fungicides. This lack of consistence is also due to the scarcity of research on both formulation and possible integration of BCA with other control strategies.

Here we report some recent research experiences aimed at enhancing and stabilising the activity of the biocontrol yeasts *Rhodotorula glutinis*, isolate LS11, *Cryptococcus laurentii*, isolate LS28, and *Aureobasidium pullulans*, isolate LS30, by combining them with different adjuvants as food-grade additives, antioxidants or low dosage of fungicides. Several compounds among food additives or antioxidants consistently enhanced the antagonistic activity of the BCA against postharvest fungal pathogens in small-scale experiments. Moreover, the activity of antagonists was significantly improved combining them with a low dosage of synthetic fungicides on apples in semi-commercial conditions. The improvement of effectiveness of BCA in combined treatments resulted additive or synergistic when compared with activity of BCA and adjuvants applied separately.

The potential application of selected compounds in formulations of yeast-based biofungicides as well as the implications related to combinations of BCA with other control strategies are discussed.

POSTHARVEST CONTROL OF ESTABLISHED INFECTION OF *Penicillium digitatum* ON LEMONS BY COMBINING THE BIOCONTROL AGENT *Pantoea agglomerans* CPA-2 AND A CURING TREATMENT.

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Biological control using microbial antagonists has gained considerable attention as a promising alternative to chemicals. Studies with *Pantoea agglomerans* CPA-2 have demonstrated its efficacy to control green and blue mold on oranges and on mandarins. Recent studies carried out in our laboratory had demonstrated that a curing treatment at 33°C for 65 h controlled effectively green and blue mould on oranges and lemons stored under ambient conditions.

In this work, the effectiveness of the strain *P. agglomerans* CPA-2 alone or combination with a curing treatment at 33°C for 65 h to control green mould was evaluated on lemons stored at ambient and cold storage. Furthermore, the efficacy of this biocontrol agent to control established infections of *Penicillium digitatum* in wounded-inoculated lemons was determined. Our results have showed that an application of *P. agglomerans* CPA-2 at 2.108 cfu ml⁻¹ effectively reduced green mould incidence on recently inoculated lemons stored at different temperatures from 5°C to 25°C. However, it failed to control established infections of green mould of more than 24h. Combining the biocontrol agents and curing treatment at 33°C for 65 h controlled 24-h old infections on artificially inoculated lemons stored at 20°C for 14 days and on naturally infected lemons stored at 10°C for 3 weeks plus 7 days at 20°C (shelf-life period).

The improvement obtained combining *P. agglomerans* and the curing treatment compared to each treatment alone indicates a synergistic effect between them. Population dynamics of *P. agglomerans* in wound fruits were evaluated to know the effect of the application of curing treatment before or after biocontrol agent applications. *P. agglomerans* applied before curing grew in wounds at a similar rate as fresh wounds kept at 20°C. When this bacterium was applied after curing, *P. agglomerans* populations did not increase.

INVOLVEMENT OF LYTIC ENZYMES IN THE MODE OF ACTION OF THE YEAST *Candida oleophila* USED TO CONTROL POSTHARVEST DISEASES. Drobny S.^{1*}, Bar-Shimon M.², Yehuda H.³, Cohen L.², Daus A.², Goldway M.³, Wisniewski M.⁴

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Considerable research effort has been devoted in recent years to identifying microbial antagonists that effectively control postharvest diseases of fruit and vegetables. Among these, the yeast antagonist *Candida oleophila* was developed as a commercial product under the trade name Aspire™. Although the biocontrol activity of *C. oleophila* was demonstrated on a variety of commodities in commercial applications, its mode of action has not been fully elucidated. The current study was aimed at characterizing the ability of the yeast *C. oleophila* to produce variety of lytic enzymes as well as defining their role in its mode of action.

C. oleophila is capable of producing and secreting various cell wall degrading enzymes including exo-B-1,3-glucanase, chitinase and protease in the growth medium as well as fruit surface wounds. Production of these enzymes was influenced by the presence of cell-wall fragments of *Penicillium digitatum*. Exo-B-1,3-glucanase (CoEXG1) and chitinase (CoCH1) genes was cloned and fully characterized. Initially, the role of exo-glucanase in the biocontrol activity of *C. oleophila* was tested by using CoEXG1-knockouts and double-CoEXG1 over-producing transformants. Exo-glucanase activity was completely lost in the CoEXG1-knockouts, whereas, at least two fold activity was detected in the over-producing transformants. CoEXG1-knockouts transformants showed lower inhibitory activity against *Penicillium digitatum* in vitro and in vivo tests.

C. oleophila was found, also, to produce and secrete a ribonuclease (RNase) into the growth medium. The T2-RNase gene in *C. oleophila* was amplified using PCR with degenerative primers that were derived from relatively homologous sequences in T2 RNase of *C. albicans*, cloned and sequenced. In vitro assay, spore germination of *P. digitatum*, *P. italicum* and *P. expansum* was readily inhibited by yeast ribonuclease

EFFICACY AND MOLECULAR CHARACTERIZATION OF *Metschnikowia pulcherrima* STRAINS AGAINST POSTHARVEST DISEASES OF POME FRUIT

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During the last decade several yeast strains have been selected for their antagonistic properties on postharvest biological control of fruit. Recently some strains of the yeast *Metschnikowia pulcherrima*, which proved to be effective in containing *Botrytis* and *Penicillium* spp. rots in apple were selected and studied. The main mode of action involved in the biocontrol is competition for nutrients or space although a direct interaction can not be excluded. In this study twenty-six strains of *M. pulcherrima* coming from different sources were studied for their biocontrol activities: nine strains were isolated from the carposphere of pome fruit, two from the carposphere of stone fruit, eleven from different steps in the wine production chain, four from unusual or unknown origin.

The strains were tested for their efficacy in the control of *Botrytis cinerea* and *Penicillium expansum*, causal agents of grey and blue mould on apple. In general the strains were more effective against *B. cinerea*. It was shown that antagonistic properties for biological control in the carposphere can be possessed by microorganisms isolated from the same source where they will be applied as antagonists but these features can be owned also by microorganisms of different origin.

Molecular tools can assist to monitor the genetic and environmental fate of these agents after releasing. Moreover suitable and reproducible strain authentication methods are necessary in commercial procedures such as filling patents and product licensing. The selected strains were compared for their genetic diversity, using AFLP and RAPD technique. Starting from AFLP markers, STS (sequence tag site) primers for PCR-amplification of genomic DNA are under development.

S10-22
INVOLVEMENT OF ENZYMATIC BROWNING AND PEROXIDASE ACTIVITY AS RESISTANCE MECHANISMS IN GOLDEN DELICIOUS APPLES.
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In this study different experiments were carried out to determine if enzymatic browning is involved in the resistance of Golden delicious apples against *Penicillium expansum*. For this purpose and in order to have samples with different sensitivity to pathogen, fruits were picked at different maturity stages. Immediately after harvest, fruits were inoculated with a conidial suspension (10^4 conidia mL⁻¹) of *P. expansum* and the percentage of altered fruits determined after 7 days of incubation at 20°C. Browning potential was determined in situ using a colorimetric method and determining the changes in DE. Concomitantly, the activity of the browning-related enzymes polyphenoloxidase (PPO) and peroxidase (POX) were determined for each maturity stages. To better determine the specific role played by these enzymes, fruits were also previously treated before inoculation with ascorbate (to inhibit the browning process) or with their specific substrates (to activate this process). For each maturity stage a clear correlation was found between browning capability and disease resistance. In this process PPO and POX activity were not limiting but substrate availability was clearly determining. When incubated with ascorbate or 4-methyl-pyrocatechol a clear increase in sensitivity to pathogen was observed. In contrast pre-incubation with guaiacol led to increased resistance especially in the less mature fruits. Collectively these results provide evidence that enzymatic browning and POX enzyme activity may be considered as important factors involved in defence mechanism in apples.

S10-24
EFFECT OF HEAT TREATMENT ON THE FUNGUS, *Colletotrichum gloeosporioides* AND ANTHRACNOSE OF MANGO FRUITS.
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An effect of heat treatment on *Colletotrichum gloeosporioides* Penz., causal pathogen of anthracnose of mango, was conducted. Conidia treated with hot water 55°C for 5 min produced 1 % of appressoria whereas untreated produced 100% of appressoria after 36 hr of incubation. Disease severity on mango fruits inoculated with hot water treated conidia was 1.3% whereas 14.9% on untreated. At the depth of 1 mm from fruit surface, an infection was reduced by 80% after treated with hot water at 55°C for 5 min. Disease incidence on inoculated mango fruits which were treated with hot water at 55°C for 5 min, vapor heat at 46.5°C for 10 min, hot water at 55°C for 5 min and vapor heat 46.5°C, and untreated was 0.4, 0.5, 0.2 and 29.4 % respectively. Fruits treated with these treatments showed no significance difference in weight loss, total soluble solid, and total acid.

S10-23
REACTIONS OF DIPHENYLAMINE AND DIPHENYLAMINE DERIVATIVES IN 'GRANNY SMITH' APPLES AND RELATIONSHIPS TO CONTROL OF SUPERFICIAL SCALD.
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Control of apple superficial scald (scald) using diphenylamine (DPA) is a common practice in many of the world's apple producing regions. While scald control conferred by DPA is thought to be related to its antioxidant capabilities, the specific mechanism has not been characterized. In this study, apple fruit were treated with aqueous emulsions containing DPA or DPA derivatives including 4-hydroxydiphenylamine (4OHDP), 3-hydroxydiphenylamine (3OHDP), n-nitrosodiphenylamine (NODPA), and 2-nitrodiphenylamine (2NO₂DPA). Scald incidence and severity were evaluated and peel diphenylamine and diphenylamine derivative content characterized and quantified using LC/MS. 4OHDP, 3OHDP, NODPA, and 2NO₂DPA (listed in decreasing quantity) were among the derivatives found in peel of apples previously treated with DPA. Treatment with DPA or 4OHDP provided the best scald control with slight scald control conveyed by NODPA. Derivatives formed from these compounds during storage will be reported and their relevance to scald control discussed.

S10-25
ON-ORCHARD FACTORS THAT INFLUENCE THE LEVEL OF STORAGE ROTS ON *Actinidia chinensis* 'Hort16a' IN NEW ZEALAND.
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ZE-SPRI GOLD kiwifruit (*Actinidia chinensis* var *chinensis* 'Hort16a') can experience fungal rots in storage. The prevalence of these rots is influenced by the susceptibility of the fruit, the presence and amount of inoculum, and the harvest and storage regime. This abstract reports research on on-orchard factors that influence fruit susceptibility and the prevalence of the fungal pathogens. Fifteen orchards within the North Island of New Zealand were included in this trial.

Necrotic leaf discs and last seasons fruit peduncles were collected from each orchard and assessed for the presence of rot fungi. Information on shelter type, canopy structure and rating, orchard layout, irrigation, and contour in each orchard was also collected. Immediately after clearance to pick, 500 fruit were harvested from each orchard and placed into storage. The fruit were assessed regularly for rots and other storage disorders. Fruit with rots were removed and the causal pathogen(s) identified. The mean °Brix, flesh colour, firmness, dry matter, and mineral composition were also determined for each orchard. There were considerable differences in the incidence of the various fungi on the orchards sampled. The range of fungi was greater on leaf discs than on peduncles.

The incidence of post-harvest rots was low, with the majority of rots being associated with chilling injury. The main fungi associated with rots were *Phomopsis* spp. and *Cryptosporiopsis actinidaeae*. In some cases, the incidence of storage rots and the incidence of *Phomopsis* spp. on necrotic leaf discs were related. In general orchards with higher levels of rots had denser canopies. Further analysis also suggested linkages between a higher prevalence of rots and particular shelter species, warmer temperatures, higher rainfall and specific fruit nutrient levels. In addition more mature fruit tended to be less susceptible to rots associated with chilling injury.

S10-26**ANTIFUNGAL COMPOUNDS IN THAI MANGO FRUITS LATEX.**Kumpoun W.^{1*}, Chansri P.¹, Supyen D.², Somsrivichai J.³¹Institute for Science and Technology Research and Development, Chaing Mai University; ²Department of Chemistry, Faculty of Science, Chaing Mai University; ³Department of Biology, Faculty of Science, Chiang Mai University, Thailand.

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Anthrachnose disease is the major postharvest disease of mango fruits in Thailand. This pathogen cause by *Colletotrichum gloeosporioides*, which infects the fruits before harvesting, and the symptoms appeared later. Antifungal compound from each part of mature green of Thai mango fruits was investigated. Preformed antifungal compounds were detected in the peel and latex extracted in dichloromethane fraction by using thin layer chromatography (TLC) and bioassay. The active compound in latex showed the same R_f as found in the peel, which has been identified as resorcinol derivatives. The active compounds are being purified and identified by using preparative TLC, UV-spectrophotometer and gas chromatography mass spectrometry.

S10-28**TWENTY YEARS OF RESEARCH ON POSTHARVEST BIOLOGICAL CONTROL: RESULTS AND FUTURE PROSPECTS.**Mari M.^{1*}, Casalini L.¹, Bertolini P.¹¹Criof, Department of Protection and Improvement of Agricultural Food Products, University of Bologna, Italy.

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Fruit and vegetable losses during postharvest phase are of relevant economic importance. In the most developed countries like USA they can amount up to 25% of the total production and exceed 50% in developing ones. Chemical treatments and improved storage technologies have greatly extended the postharvest life of fresh fruit and vegetables but the appearance of pathogen resistance to fungicides and health concern over residues of pesticides have stimulated the research for alternative strategies. Within the production chain the postharvest phase is suited to the application of biological control methods as during storage and transport most of the environmental parameters such as temperature, relative humidity and gas composition can be easily controlled.

During the past 20 years an extended research have been done at CRIOF on biological control of postharvest diseases by antagonistic microorganisms and natural compounds. This paper presents an overview of the results obtained and the problems that will have to be overcome before biocontrol can be applied by the industry. Among the numerous microorganisms isolated and tested, mainly bacteria and yeasts proved to be quite effective against *Penicillium* spp., *Monilinia* spp., *Rhizopus stolonifer* and *Botrytis cinerea* in laboratory and pilot trials at commercial level. However the lack of efficacy in some trials evidenced the need to improve the research on the influence of the environmental conditions, of the host and of the formulation. Attempts to improve the efficacy of this strategies by integrating with physicochemical treatments (hot, GRAS, elicitors, sanitizing products, genetic engineering) are promising.

S10-27**RELATIONSHIP BETWEEN O₂ LEVELS, 1-METHYLCYCLOPROPENE (1-MCP), CONJUGATED TRIENES (CT) AND SUPERFICIAL SCALD IN GRANNY SMITH APPLES.**Folchi A.^{1*}, Pratella G.C.¹, Gregori R.¹¹Criof, Department of Protection and Improvement of Agricultural Food Products, University of Bologna, Italy.

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Granny Smith apples were stored for 180 days at 0°C in 0.3%, 0.6%, 0.9%, 1.2%, 2.0% and 21% O₂ (air) plus 0.01% CO₂, same lots were postharvest treated with 625 ppb 1-methylcyclopropene (1-MCP). The influence of these treatments on conjugated trienes (CT) and superficial scald as well as on ethanol content in the fruit tissue was evaluated.

At harvest the CTs content in the peel, expressed as optical density (OD₂₆₈), was 0.22 OD₂₆₈. During storage, the OD remained substantially unchanged in apples exposed to 0.3% O₂ (<0.35 OD₂₆₈), and increased moderately in apples exposed to 0.6%, 0.9% and 1.2% O₂ up to 1.42, 1.83 and 1.94 OD₂₆₈ for 180 days. In apples stored in 2.0% O₂ and in air (21% O₂), CTs contents had the highest increase and reached 4.6 and 11.5 OD₂₆₈ respectively. In apples treated with 625 ppb 1-MCP the CTs content in the peel was 0.66 OD₂₆₈ at the end of storage.

The first symptoms of superficial scald appeared after 60 days in air and after 120 days in 2% O₂. At the end of storage period no symptom was detected on the apples treated with 1-MCP and with 0.3%, 0.6% O₂, whilst from 10 to 14% of the fruit kept in 0.9% and 1.2% were affected.

Low-O₂ conditions induced the accumulation of ethanol in the tissue, the rate being considerably more marked in the 0.0% to 0.6% range and linearly correlated to the time in storage. After 60 and 120 days of storage in 0.3% O₂, the apples showed symptoms of hypoxic injuries and off flavour while at higher values were undamaged.

S10-29**EFFECTS OF HARVEST MATURITY ON QUALITY, PHYSIOLOGICAL AND PATHOLOGICAL DISORDERS DURING STORAGE OF GALA APPLES.**Neri F.^{1*}, Gualanduzzi S.¹, Brigati S.¹¹Criof - Department of Protection and Improvement of Agricultural Food Products, University of Bologna, Italy.

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The "Mondial Gala" and "Royal Gala" apples were picked at different stages of maturity (early, commercial and late harvest) and stored at 0°C for 60, 120 and 180 days. The trials were carried out for two years. The maturity indices were measured at harvest, during cold storage and after 7 days at 20°C. At the end of shelf-life, the incidence of diseases and disorders was determined as well as sensory evaluations. "Mondial Gala" apples were also evaluated after 60 days of storage at 0°C and 14, 21 days of shelf-life at 20°C.

The best picking time for "Mondial Gala" and "Royal Gala" apples seems to be when starch degradation is 3.5-4 (scale 1-5). At this stage of maturity the fruits exhibited the best storability and quality. The incidence of superficial scald was low until 60 days of storage in all maturity stages. With differences between the years of experimentation and cv, the severity of superficial scald increased for longer storage periods and was higher in early harvested fruits. The fruits susceptibility to fungal diseases increased with the period of storage; late harvested fruits were more susceptible to rots. Internal breakdown appeared after 180 days of storage. Acceptable-good preference was attributed to fruits assessed at harvest and after 60 days of storage. Quality decreased noticeably when fruits were stored more than 120 days, due to the extreme loss of firmness, crispness, juiciness, acidity and fruity aroma with the increase of meakiness.

Shelf-life periods longer than 7 days at 20°C, experimented in "Mondial Gala" apples after 60 days of storage, led to quality loss and increased the fruits susceptibility to rots and shrivel.

S10-30

STORAGE OF PINK LADY APPLES: QUALITY AND BIOPATHOLOGICAL ASPECTS.

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"Pink Lady" apples were picked at different stages of maturity (early, commercial and late harvest) and stored at 0°C for 60, 120 and 180 days. The trials were carried out for three years. The maturity indices were measured at harvest, during cold storage and after 7 days of shelf-life at 20°C. The incidence of diseases and disorders was determined at the end of the shelf-life as well as sensory evaluations. In the first year of study quality evaluation of apples was also performed during a long period of shelf-life (7, 14, 21 days at 20°C). The best picking time for "Pink Lady" apples seems to be when starch degradation is 3 (scale 1-5) and hardness between 7.5 and 8 kg. Fruits picked at this stage of maturity showed better storability and quality. Superficial scald appeared on early harvested fruits after 120-180 days of storage. Only in the 2nd year of experimentation, the commercial and late harvested fruits were susceptible to superficial scald after 180 days of storage. Symptoms of internal breakdown were observed in the 2nd and 3rd year of experimentation. The incidence of this disorder increased with the stage of maturity at harvest and the period of storage. The susceptibility to fungal diseases increased with the period of storage. Better acceptability was attributed to fruits assessed after a period of storage (60-120 days), because of the high acidity, hardness, vegetative aroma and chewiness that characterized the cv at harvest. After 180 days of storage quality decreased, due to juiciness, crispness and fruitiness loss. When shelf-life was extended to 21 days after 60 days of storage, an increase of mealiness was noted.

S10-32

USING THE RESPIRATION RATE OF 'PINK LADY'TM APPLES AS AN INDICATOR OF THEIR SUSCEPTIBILITY TO THE FLESH BROWNING DISORDER.East A.R.¹, Maguire K.M.², Jobling J.J.³, Tanner D.J.^{4*}, Mawson A.J.¹¹Institute of Food, Nutrition and Human Health, Massey University, New Zealand; ²ZESPRI Innovation Company Ltd., New Zealand; ³Sydney Postharvest Laboratory, Australia; ⁴Food Science Australia, Australia.

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'Pink Lady'TM apples are susceptible to flesh browning in storage. The symptoms of this disorder are browning in a radial pattern from the core into the cortex and softening of the fruit. The disorder is sporadic in nature with only some growers in some seasons being affected. It is likely that the disorder is the result of a combination of factors. Other work has shown that 'Pink Lady'TM apples are susceptible to CO₂ injury. Fruit with severe browning symptoms had 35% higher respiration rates ($P < 0.0001$) and a greater than 60% reduction in the ability to produce ethylene ($P < 0.0001$) at the end of storage. Fruit that had high rates of respiration at 80 days had a higher risk of developing browning symptoms later in storage ($P < 0.0001$). High fruit respiration rates indicate high internal CO₂ concentration (assuming that fruit permeances are equal). This work shows that it may be possible to use the rate of respiration as a diagnostic tool to determine the susceptibility of a sample of fruit to flesh browning later in storage.

S10-31

DEVELOPMENT OF PYRIMETHANIL AS A POSTHARVEST FUNGICIDE.

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Pyrimethanil (PENBOTECTTM) is a modern and specific anilinopyrimidine fungicide which was developed for postharvest uses in citrus and pome fruit. Due to its high efficacy on *Penicillium italicum*, *P. digitatum*, *P. expansum* and *Botrytis cinerea*, the most important storage diseases of citrus and pome fruit are controlled. Besides, interesting side effects are discovered on secondary pests as *Phlyctaena vagabunda* on apple.

Evidence is obtained for a preventive, curative and anti-sporulant activity. Pyrimethanil is active on strains which were shown to be insensitive for the currently used fungicides as thiabendazole (*Penicillium* spp. and *Botrytis*) and imazalil (*Penicillium digitatum*). The compound can be used in different ways as aqueous (drencher, dip, CDA, NRS, in line spraying) or wax (storage and pack) applications. Tank mix compatibility, cultivar selectivity, optimal dose rates and its relation with fruit residue will be discussed. Possibilities for implementation of pyrimethanil in postharvest anti-resistance strategies will be explained.

After more than 20 years of practicing the existing fungicides, pyrimethanil will be a valuable tool in controlling postharvest storage diseases due its new mode of action, its high biological efficacy, its low risk profile and the possibility to implement this fungicide in most of the current application technologies.

S10-33

INFLUENCE OF HARVESTING DATE, DPA TREATMENT AND STORAGE CONDITIONS ON SCALD APPEARANCE ON GRANNY SMITH FROM SANDY SOIL.

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Scald is economically most important nonparasite disease which can occur in storage chamber. In conditions of Suboticko-horgoska sandy terrain (north of Serbia) on sandy soil ripening of Granny Smith is much faster than in other regions with black soils. Practically, scald is unavoidably in these conditions unless we use post ripening in storage chambers and store apples. With this option fruit quality decrease especially because of reduced acids content and change of fruits colour.

As we had known that the end of October is critical when observing first frosts in this region, we set a trial with three picking dates in October two DPA concentrations (1200 and 1800 ppm) with adding Irol and storage in NA and CA conditions.

Trials had shown that for apples from sands both DPA concentrations were very effective in all three picking times in NA and CA conditions of storage. Although scald appearance in control treatment in CA conditions was highly reduced in terms of intensity and number of appearance, treatment with DPA is needed probably with lower concentration than it is used.

EFFECT OF 1-METHYLCYCLOPROPENE ON KIWIFRUIT SOFTENING.

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Premature softening induced by ethylene is a serious commercial problem limiting storage life of kiwifruit. The objective of this study was to evaluate the effectiveness of 1-MCP in extending storage and shelf life and preventing postharvest softening of kiwifruit. Exposure to 100 nL L⁻¹ 1-MCP at room temperature for 12 h or at low temperature (< 5°C) for 24 h was applied with a single or double treatment before or/and after storage. Fruit were also treated with a single application at 250 nL L⁻¹ 1-MCP. Following storage at 0°C fruit were kept at 20°C. The results show that exposure to 100 and 250 nL L⁻¹ 1-MCP delayed softening in kiwifruit after shelf life. An application before storage was more effective than treatment after storage. Double treatment was slightly more effective compared to single application. Furthermore, a single application of 1-MCP at room and low temperature was equally effective in delaying the loss of firmness.

In a separate experiment, kiwifruit were treated three days after harvest, after curing, with 100 nL L⁻¹ 1-MCP at room temperature for 12 h and stored in air at 0°C with or without ethylene absorber. Following storage fruit were kept at 20°C. 1-MCP treated fruit were significantly firmer than untreated fruit after storage and shelf life. Kiwifruit treated and stored without ethylene absorber had comparable or superior value of firmness to untreated stored with ethylene absorber.

In both trials, 1-MCP had no effects on soluble solids content and acidity. No significant differences in fruit rot, caused by *Botrytis cinerea*, were observed.

S10-36

ANTIFUNGAL POTENTIAL OF RAW PLANT EXTRACTS TO REDUCE ANTHRACNOSE DISEASE OF PAPAYA.

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Use of raw plant extracts with antifungal activity might be an alternative for the control of postharvest diseases because they are biodegradable and not very toxic. In this research, the fungicidal effect of 40 raw extracts from various plant species was evaluated on the germination of spores of two strains of *Colletotrichum gloeosporioides* isolated from papaya (*Carica papaya* L.) fruit obtained from two different states of Mexico (Veracruz and Guerrero). Similarly, those extracts presenting fungicidal effects on in vitro studies were later evaluated on in situ.

Results showed that after 14 or 18 h incubation, spores of the two different strains treated with night-blooming Jessamine (*Cestrum nocturnum*) and cherimola (*Annona cherimola*) extracts had the highest spore germination percentage inhibition (95%). The activity of *C. nocturnum* might be related to the presence of flavonol and phenolic glucosides and a steroidal saponin already reported in leaves. For a *A. cherimola*, isolations of alkaloids and flavonoids have been reported as well. With the remainder 38 extracts, spore germination inhibition, following the two incubation periods to both strains was lower than 65%. For in situ experiments, only extracts of *C. nocturnum* and *A. cherimola* were tested on papaya fruit. Compared to the control and thiabendazol treatments, no significant differences were observed in percentage infection and disease severity when extracts were applied. In general, similar fruit quality i.e. total soluble solids was recorded in fruit for all treatments, although percentage weight loss was lower in fruit treated with cherimola extracts.

S10-35

BIOCONTROL OF POSTHARVEST BLUE MOULD ON PEAR AND APPLE FRUITS WITH THE COMBINATION OF *Candida sake* (CPA-1) AND *Pseudomonas syringae* (CPA-5).Nunes C.¹*, Usall J.², Manso T.¹, Teixidó N.², Viñas I.²¹ Universidade do Algarve, Centro de Desenvolvimento de Ciências e Técnicas de Produção Vegetal, Campus de Gambelas, Faro, Portugal; ² Unitat de Poscollita, CeRTA, Centre UdL-IRTA, Rovira Roure, Lleida, Spain.

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Blue mould caused by *Penicillium expansum* is the most important postharvest disease of pome fruit worldwide. Synthetic fungicide use has been curtailed because of the development resistance pathogens and the concern of public and environmental safety. There is a clear need to develop new alternative methods for controlling postharvest diseases. The development of biocontrol agents has been the most study area in the last few years. The yeast *Candida sake* CPA-1 and the bacterium *Pseudomonas syringae* CPA-5 were isolated from apple surface. These microorganisms have been tested, for many years, for their control activity against the major postharvest diseases of pome fruits. They were effective in controlling *Penicillium expansum*, *Botrytis cinerea* and *Rhizopus stolonifer* on apple and pear fruits. However in any biocontrol system the efficacy of a single biocontrol agent is inconsistent and variable. One approach to improve the efficacy of the biocontrol system is applying mixed cultures of microorganisms with antagonistic activity.

In this study the effectiveness of *Candida sake* (CPA-1) in combination with *Pseudomonas syringae* (CPA-5) for controlling *P. expansum* on pears and apples was determined. The concentrations tested were 5_106 for *C. sake* and 2_107 and for *P. syringae*. At room temperature the two antagonists were combined in proportions of 0 to 100% in 25% increments. The best combinations were chosen for the assays under cold temperature and different atmosphere conditions. Population dynamics of *C. sake* and *P. syringae* in mixture or individual application in wounded fruits were determined.

From the experimental results it can be concluded that the combination of *C. sake* and *P. syringae* improves the control of *P. expansum* in apple and pears fruits and allows the required concentration to achieve control to be reduced, with the consequent reduction in the cost of the treatment.

S10-37

POSTHARVEST APPLICATION OF THE YEAST *Cryptococcus laurentii* REDUCES FRUIT ROTS OF APPLES.Blum L.E.B.¹*, Amarante C.V.T. do ², Valdebenito-Sanhueza R.M.³¹ Dept. Fitopatologia, Universidade de Brasília, Brasília, Brazil; ² Dept. Fitotecnia, Universidade do Estado de Santa Catarina, Lages, Brazil; ³ Uva e Vinho, Bento Gonçalves, Brazil.

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Rots might be responsible for substantial postharvest losses on apples (*Malus domestica*). The blue mold caused by *Penicillium expansum*, the bitter rot caused by *Glomerella cingulata*, and the 'bull's-eye rot' induced by *Pezizula malicorticis* are among of the most common rots. Great attention has been given to less environmental damaging alternatives for the control of postharvest diseases. The postharvest application of yeast-like fungi, such as *Cryptococcus laurentii*, is one of the options to control fruit rots. This study was carried out to test the efficiency of *C. laurentii* on fruit rots control in 'Fuji' and 'Gala' apples.

After application of treatments, by immersion, the fruits were stored in laboratory (15-20°C / 60-70% RH) or in cold storage (1°C / 90-95% RH). The pathogens were applied at the concentration of 102 conidia mL⁻¹, the yeast at 107 cells mL⁻¹, and the fungicides at 150 mg (a.i.) L⁻¹. *Cryptococcus laurentii* was as efficient as the fungicides (thiabendazole and iprodione) to reduce apple fruit rots (*G. cingulata*, *P. expansum*, and *P. malicorticis*). In cold storage trials, *C. laurentii* was as efficient as the fungicides (thiabendazole, iprodione, chlorhexidine digluconate, sodium dichloro-s-triazinetrione, sodium dicloroisocyanurate, and sodium hypochloride) to reduce *P. expansum* fruit rot. The application of *Cryptococcus laurentii* did not affect flesh firmness and total soluble solids content (°Brix) of the fruits.

S10-38

BIOCONTROL ACTIVITY OF BIO-COAT AND BIOCURE AGAINST POSTHARVEST ROTS OF TABLE GRAPES AND SWEET CHERRIES.

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The efficacy of two postharvest biocontrol products under commercial development was determined in semi-commercial tests on table grapes and sweet cherries. The products consist of the yeast *Candida saitoana* combined with either chitosan (Bio-Coat) or an antifungal, lytic enzyme (Biocure).

On table grape (cv Italia) field applications of the two biocontrol products 21 days and 1 day determined significant reduction of grey mould rots after storage and shelf-life ranging, from 33 to 46%. Field rots (mainly sour rot) were also reduced on bunches of grapes treated 21 days before harvest. The level of control was comparable to that of a conventional chemical fungicide (Mepanypirim). On sweet cherries (cv Lapins) postharvest dipping treatments significantly reduced total rots (mainly grey and brown mould) by 59% (Bio-Coat) and 64% (Biocure). Similar results were obtained on sweet cherries cv Moreau.

The two biocontrol products did not cause any phytotoxic effect and did not modify the fruit appealing on both table grapes and sweet cherries.

S10-39

CONTROL OF POSTHARVEST DISEASES IN LONGAN FRUIT BY OZONE.

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To determine the effects of ozone treatment on longan postharvest pathogen, cultures of *Lasiodiplodia* sp. and *Cladosporium* sp. on potato dextrose agar were exposed to 200 ppm of ozone. The ozone gas was applied for both fumigation to mycelia (gaseous ozone), and passing through spore suspension (ozonated water) for 15, 30, 60 and 120 minute. The fungal colonization, spore size, spore germination and microscopic observation of the fungi were investigated.

It was found that ozonation at longer exposure time was more effective to inhibit fungal colonization and spore germination. Moreover under microscopic observation, abnormal mycelia after fumigation with ozone was obviously observed. Therefore, the application of ozone could be considered as a possible method to control postharvest decay and prolong storage life of longan fruit.

SESSION 11(S11)

POSTHARVEST PEST MANAGEMENT

POSTHARVEST PEST MANAGEMENT OF HORTICULTURAL CROPS BY COMBINED HEAT THERAPY AND FUNGICIDE TREATMENTS. CURRENT TRENDS AND FUTURE OUTLOOK.

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Extensive research has been done in recent years to reduce the strong dependence of agrochemicals used for postharvest pest control of horticultural crops. Attention is focused on alternative strategies based on improved cultural practices, biological control, plant-defence promoters and such physical treatments as microwave irradiation, radiofrequency treatment, heat treatments (heat therapy) and storage technologies.

Among these, postharvest heat treatments (hot water treatment, short hot water rinsing and brushing and hot air treatment) have proved capable of reducing rot development and enhancing fruit resistance to chilling injury in sensitive cultivars while retaining fruit quality during cold storage and shelf-life. Indeed, they are currently being applied to various horticultural crops on a large scale in several countries also to meet consumer demands for 'organic' crops.

Yet, in spite of heat therapy's beneficial effects, fungicides play a key rule in pest management and cannot at present be completely replaced by other, 'alternative', methods. Novel, low-risk, broad-spectrum fungicides, with a diverse mechanism of action compared to other approved pesticides in a crop group, are available on the market and may also be used to cope the problems due to resistant strains to 'older' fungicides. These chemicals have proved to be very effective in decay control, and very low doses of active ingredients are required for complete suppression of pathogens when fungicide mixtures are applied as warm mixtures, due to the synergistic action of heat, enhanced active ingredient uptake, better encapsulation and diffusion of active ingredient in the cuticular wax.

The present article highlights the recent research advances in heat therapy of horticultural crops, with emphasis on beneficial effects of heat treatment and agrochemicals applied in combination.

EVALUATION OF COLD TREATMENT AGAINST MEDITERRANEAN FRUIT FLY IN "TAROCCO" ORANGES.

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Citrus intended for export to some overseas markets requires post-harvest treatment to suppress the presence of insect pests that are of quarantine significance. Several importing countries allow fresh citrus from competing regions if it has undergone cold treatment, which, involves storage of fruits at low temperature for specified periods to ensure their freedom from insects. This paper addresses the effectiveness of cold treatment against Medfly (*Ceratitis capitata* Wiedemann) infestation in "Tarocco" oranges. In a large scale disinfection test a static trial with simulation of transport was simultaneously carried out using a set of three different full equipped van containers with bottom air delivery system under a 14-days, 1.0-1.5°C cold treatment schedule. The containers were loaded with "Tarocco" oranges. Infested fruits, containing the most tolerant Medfly stage (third instar), were packaged and stuffed inside the container, randomly distributed on three different levels and among boxes containing non-infested fruits. At the end of cold treatment all infested fruits were removed and dissected to determine the number of survivors and dead larvae. After 1 week of shelf-life, at 15°C, fruits were inspected for visible blemishes and decay. Severity of chilling injury (C.I.) was evaluated using a four-grade scoring system (none, light, moderate and severe). Decay incidence was assessed as rots caused by *Penicillium digitatum* Sacc., *P. italicum* Wehmer and minor decay. In order to evaluate the effect of cold treatment on the fruit quality, initially (just before loading fruits into the container) and after cold treatment plus 1 week shelf-life, physicochemical and sensory parameters were determined. Experiments provided 100% larval mortality. Very low incidence of fruits with light C.I. was found, whereas the percentage of fruits with moderate symptoms of C.I. was negligible. Results from quality parameters are reported.

RADIO FREQUENCY HEATING OF WALNUTS AND SWEET CHERRIES TO CONTROL INSECTS AFTER HARVEST.

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Radio frequency (RF) heating has been explored as a potential non-chemical method to control insects in harvested walnuts and as a quarantine treatment for 'Bing' sweet cherries. Walnuts (2.5 kg) were heated until the walnuts reached 50 to 90°C. Heating walnuts to 55°C or higher resulted in 100% mortality of navel orangeworm. Heating walnuts with RF energy to 80°C had no negative effects on walnut quality. Moisture content had a significant influence on the heating rate of the walnut kernels. For industrial applications, walnuts could move on a conveyor through one or more RF systems with mixing of nuts between systems.

'Bing' sweet cherries (50) were heated in a polyethylene container holding 10 L of circulating distilled water with 2.3 g of NaCl. Fresh fruit must be treated in a saline solution to prevent burning at fruit contact points, and circulation improves heating uniformity within the RF field. Cherries were equilibrated in 35°C water for 6 minutes, then heated with RF energy to target temperatures between 50 and 54.5°C and held for 0.5 to 6 min. before hydro-cooling. Fruit were stored for 1 day at 5°C or 14 days at 0°C to simulate air or sea shipment, respectively. Shorter treatments at higher temperatures were better tolerated than longer treatments at lower temperatures. Cherry fruit infested with codling moth larvae were subjected to the same treatments. Mortality was 100% in all treatments except those at 50°C. However, fruit quality was unacceptable following sea shipment and marginal following air shipment. Treatment times would be significantly longer to provide for Probit 9 security (99.9968% population mortality) required for export to Japan and therefore RF treatments do not appear promising for sweet cherry fruit.

VAPORMATE™: A FUMIGANT FOR DISINFESTATION OF FRESH PRODUCE.

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Vapormate™ has potential as a niche methyl bromide replacement for disinfection of fresh produce. It contains 16.7 % (by weight) of ethyl formate dissolved in liquid CO₂ (equivalent to 11% by volume when vaporised). Ethyl formate is a GRAS compound approved as a food additive by the USDA. It has long been registered in Australia for use as a dried fruit fumigant (registered by Orica as Eranol®).

Ethyl formate occurs naturally in foods, kills insects rapidly, has low human toxicity and breaks down quickly into natural products. Vapormate™ is one of BOC's EnviroSol® products which uses liquid CO₂ as a solvent-propellant to dispense bioactive compounds either as non-flammable gaseous mixture (such as Vapormate™) or as aerosol particles. In addition to eliminating flammability, the synergistic effects of CO₂ may enhance the efficacy of the active compounds. Registration of Vapormate™ is proceeding in Australia and New Zealand. Crop & Food Research in New Zealand and UC Davis in California are investigating the efficacy of Vapormate™ for fruit and vegetable disinfection and CSIRO in Australia are evaluating its potential for protecting stored grain from insect pests.

This paper will review research regarding efficacy of Vapormate™ on a range of quarantine pests and summarise produce tolerance for a range of fruits and vegetables. In addition, an update will be provided on application methods and on progress with registration.

S11-05

POSTHARVEST BIOCONTROL AGENTS: KEY MECHANISMS OF ACTION FOR ENHANCEMENT OF THEIR ACTIVITY AND POTENTIAL FOR PREVENTION/DETOXIFICATION OF MYCOTOXIN ACCUMULATION IN APPLES AND WINE GRAPES.

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Biological control of postharvest diseases based on antagonist yeasts is a promising alternative/integration to chemical approach. However, higher reliability of performances of these biocontrol agents (BCAs) is needed for encouraging their utilisation and commercialisation. For this purpose, knowledge of their mechanisms of action is crucial to identify pivotal traits, whose enhancement could boost BCAs' activity. Evidence will be shown on the role of resistance of postharvest BCAs to oxidative stress as a key mechanism to successfully outcompete wound pathogens such as *Botrytis cinerea* and *Penicillium expansum* in stored apples, and as a potential enhancer of BCAs' activity.

Besides their use for reducing chemicals in the control of fungal diseases, some BCAs display a potential activity in addressing another major issue of food safety, recently considered by U.S. and EU legislation (EU Regulations 472/2002 and 1425/2003): contamination of apple-based food products destined to childhood with Patulin, mycotoxin produced by *P. expansum*, and contamination of wine with Ochratoxin A, produced by *Aspergillus carbonarius*, fungal pathogen of grape. Evidence is presented showing the in vitro and in vivo - i.e. during antagonistic interaction with the mycotoxigenic fungus - active reduction of these mycotoxins by BCAs.

S11-07

CONTROL OF POSTHARVEST DECAY IN ORGANICALLY GROWN APPLE CULTIVARS BY HOT WATER DIPPING.

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Organically grown apples (*Malus x domestica* Borkh.) suffer from up to 30% decay during storage due to the lack of chemical fungicide treatments. Preliminary hot water dipping of apples had shown that a water temperature about 50 °C and dipping times from 60s up to 180s were required to inhibit Gloeosporium rot (*Pezicula alba*, *P. malicortis*) on apples.

In the present investigation different ranges of temperatures (49 °C, 51 °C, 53 °C) and time periods (60s, 120s, 180s) were studied to determine suitable hot water treatments for five apple cultivars, i.e. 'Boskoop', 'Elstar', 'Jonagored', 'Ingrid Marie', 'Topaz', especially to evaluate fruit quality (firmness, skin symptoms) and decay pathogens (*Botrytis cinerea*, *Penicillium* spp., *Monilia fructigena*, *Nectria galligena* and *Fusarium* spp.).

Monilia fructigena was reduced to 83% in the cultivar 'Ingrid Marie' by the hot water treatment at 53 °C and 180s dipping time. With this treatment Gloeosporium rot was reduced to 92%. The incidence of *Nectria galligena* increased in the 60s duration at all temperatures. Skin symptoms occurred on 'Ingrid Marie', 'Boskoop' and 'Elstar', at 51 °C with 180s, 53 °C with 120s, 53 °C with 180s, respectively. Heat treatments had no effect on fruit firmness in all cultivars.

From the present results it is concluded that for the reduction of postharvest decay the heat treatment "180s at 53 °C" can be recommended for all apple cultivars. For cultivars with a high sensitivity to skin symptoms it is recommended to dip for 120s or 180s at the maximum cultivar specific temperature showing no symptoms.

S11-06

ANTIFUNGAL EFFECT OF ENANTIOPURE IMAZALIL ISOMERS ON GREEN MOLD, *Penicillium digitatum*, IN CITRUS FRUIT.

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Where consumers and health issues are involved, lowering the amount of chemicals on fresh perishable fruit and vegetables is a priority. Our research promises significant reduction of fungicide concentration in water solutions and wax emulsions used for treating fruit in packinghouses, thus reducing fungicide residues on the treated fruit.

Penicillium digitatum is a post-harvest wound parasite, which inoculates and infects citrus fruit in the grove, in packinghouses and storage rooms. The fungicide Imazalil belongs to the Imidazol group, an Ergosterol Biosynthesis Inhibitor (EBI) that effectively controls most anatomical stages of *Penicillium digitatum*. Imazalil is worldwide use for postharvest treatment in Citrus Banana as well as other fruits and vegetables.

The aims of the research were twofold: to separate the optical isomers of common Imazalil and distinguish between them, and to select the most effective isomer which, at lowest concentration, would effectively control the disease.

Imazalil enantiomers (R) and (S) were separated via diastereoselective crystallization from the common (RS) imazalil salt formed between racemic imazalil and camphor sulfonic acid. Preliminary in vitro examination revealed that the separated (R) isomer inhibited mycelial growth and sporulation of *P. digitatum* better than the original (RS) imazalil. While both the (S) isomer and the commercial (RS) imazalil inhibited the fungus at 5.0 ppm, the (R) isomer completely inhibited the fungus at 1.0 ppm. Further in vitro and in vivo examinations supported the above results.

S11-08

EFFECT OF SURFACE STERILIZATION AND WASHING METHODS ON MICROORGANISM AND QUALITY OF THE MINIMALLY PROCESSED CHICORY (*Cichorium intybus* L. VAR. FOLIOSUM).

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The more demand for fresher and safer convenient foods have been increasing, the more minimally processed vegetables have been developing. However, minimally processed vegetables are highly perishable and should be treated carefully due to the foodborne pathogens originated from vegetables. The objective of this study was to enhance the surface sterilization effect of fresh Chicory by various surface sterilization and washing methods. Minimally processed chicory was washed in tap water (TW), 100 mg L⁻¹ chlorinated water (CW) and 3 mg L⁻¹ ozonated water (OW) by a mechanical washing instrument for 3 minutes and then packed with 40mm OPP(bi-axially oriented polypropylene) film and stored for three weeks at 4 and 10 °C.

TW washing resulted in approximately one log reduction of microbial load. OW and CW treatments resulted in another two log reduction in addition to TW. Treatment with higher ozone concentration enhanced inactivation, however excessive treatment with over 3 mg L⁻¹ ozonated water deteriorated the textural quality. Microbial population was increased, regardless of treatment, with about one to two log scale during 3 weeks at 4 and 10 °C storage. There was no significant difference in visual quality within various treatments.

S11-09**POTENTIAL NON-CHEMICAL METHODS FOR USE AGAINST THRIPS IN GREEN ASPARAGUS: QUALITY CHANGES IN RESPONSE TO HEAT TREATMENTS AND HIGH CONCENTRATIONS OF CARBON DIOXIDE.**Simantara, P.^{1*}¹ Natural Resources Institute, University of Greenwich at Medway, Chatham Maritime, Chatham, Kent, UK.

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Quality changes induced in fresh green asparagus were determined after exposure to a combined post-harvest heat treatment followed by high CO₂ atmospheres at low temperature. Asparagus samples obtained from Thailand were subjected to three heat treatments: control, hot water (45°C for 15 min) and hot air (45°C for 15 min). After that, they were transferred to sealed glass jars with atmospheres of low (1%) and high (52 - 83 %) CO₂ concentrations at 4°C and 0°C for 24 h, followed by 10 days storage at the same temperature under air.

Quality tests were performed, 1) before heat treatment, 2) after heat treatment, 3) after CO₂ treatment, 4) after 5 days storage and 5) after 10 days storage to evaluate weight loss, colour, overall appearance, decay, off-odour and texture. There were significant effects of hot air on weight loss, overall appearance, decay and texture, and significant, but much lower effects of hot water treatment. High CO₂ atmospheres of 52 - 83 % did not reduce observed quality of asparagus at all. No difference was seen between the two storage temperatures.

S11-11**ALTERNATIVE TO CHEMICAL POST-HARVEST CONTROL EFFICACY OF THERMOTHERAPY AND ESSENTIAL OILS THE CASE OF POME FRUITS (DISEASES) AND POTATOES (SPROUTING).**Bompeix G.^{1*}, Cholodowski-Faivre D.¹, Amiri A.¹¹ University P. and M. Curie, Parasitologie Végétale, Paris Cedex 05, France.

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In the case of pome fruits in European countries, heavy losses are caused by *Phlyctema vagabunda* (*Pezicula alba*). Many resistant strains to thiabendazole (usually used as post-harvest control) appeared, in several producing areas. The alternative methods of control can be implemented: thermotherapy (hot water) is very effective: 48.5°C - 3 min. on susceptible varieties to heat injury (Golden delicious) up to 50°C - 2 to 3 min. on most of the varieties tested. In the case of an exceptional tolerance to heat (var. Topaze) a complete control can be obtained.

In order to achieve a better control on susceptible varieties to heat injury, clove oil (*Syzygium aromaticum*, eugenol is this active ingredient) and lecithin combined with thermotherapy (48.5°C - 3 min.) can be used. Under these conditions, a remarkable efficacy was obtained (Golden delicious, Pinova, Falstaff, Belchard Chanteclerc).

With regard to disorders, for example to fight potato sprouting, clove oil and mint oil (*Mentha spicata*, carvone is this active ingredient), can be applied by thermofogging. The efficacy is similar to that obtained with synthetic chemical compounds. Essential oils residues are negligible after some weeks of storage.

S11-10**REDUCTION OF *Aspergillus carbonarius* GROWTH AND OCHRATOXIN A BIOSYNTHESIS IN GRAPES BY BIOCONTROL YEASTS AND AN ANTIFUNGAL NATURAL COMPOUND.**Favilla M.¹, Altomare C.^{1*}, Pascale M.¹, Ricelli A.¹¹ Institute of Sciences of Food Production, CNR, Bari, Italy.*Presenter email: claudio.altomare@ispa.cnr.it

Aspergillus carbonarius infection of grapes is emerging as a major problem in the Mediterranean Area. Infections may lead to the occurrence of the carcinogenic, teratogenic, and mutagenic mycotoxin ochratoxin A (OTA) in wine. Preventive treatments against *A. carbonarius* are the only strategy capable of overcoming contamination of the harvested grapes and wine. Biological control of plant diseases offers many benefits in disease management, because it is environmentally non hazardous and it does not induce pathogen resistance. The aim of this study was to investigate the capability of three biocontrol agents (*Rhodotorula glutinis*, *Pichia guilliermondii*, *Candida oleophila*) and of fusapyrone (FS), a natural antifungal compound, to inhibit *A. carbonarius* on grapes and OTA biosynthesis.

Artificially wounded grapes (cv. Negroamaro) were inoculated with a toxigenic strain of *A. carbonarius*, and treated with a solution of FP at the concentration of 50 or 100 mg L⁻¹, with the biocontrol yeasts, or a combination of FP at 50 mg L⁻¹ and yeasts (n = 4 replicates per treatment). Grapes were incubated in moist chambers at 25 °C in the dark for 10 days.

A significant inhibition of fungal growth was observed in the 100 mg L⁻¹ FP-treated grapes. Ergosterol content was 72% less than control and conidiation was almost completely inhibited. This treatment also resulted in a 99% reduction of OTA content. At the dose of 50 mg mL⁻¹, FP significantly reduced both the viable mould count (by 99%) and OTA production (by 79%), but not the production of fungal biomass. Among the biocontrol yeasts, only *C. oleophila* and *P. guilliermondii* were effective, resulting in a reduction of both production of conidia (94% and 96% of inhibition, respectively) and OTA biosynthesis (12% and 18% of reduction, respectively). However, neither additive nor synergistic effect was observed when biocontrol yeasts were applied along with 50 mg L⁻¹ of FP.

SESSION 12 (S12)

**NON-DESTRUCTIVE
QUALITY MEASUREMENTS**

NONDESTRUCTIVE TECHNIQUES FOR MEASURING QUALITY OF FRUIT AND VEGETABLES.

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In this presentation an overview will be given of nondestructive techniques for measuring quality of horticultural produce. First vibration based techniques to measure mechanical properties of fruit will be reviewed. These techniques are based on the measurement of the vibration spectrum of a fruit after impact. Several commercial firmness measurement devices based on this principle are currently available. Related techniques such as the laser puff firmness sensor and other impact-based devices will be discussed as well. Optical techniques have been used extensively for the measurement of quality attributes such as colour, soluble solids content and firmness of fruit and vegetables. Here we will concentrate on the potential and limitations of NIR infrared spectroscopy. Several grading machines with online NIR sensors for soluble solid content are currently commercially available, as well as dedicated standalone sensors. We will also discuss some novel techniques such as space resolved and time resolved spectroscopy for the estimation of light scattering in vegetable tissue, as well as NIR imaging techniques. Aroma is traditionally measured using headspace GC-MS. Electronic noses have been introduced as a fast alternative to measure aroma. We will review some electronic nose principles and applications, as well as some recent advances in headspace fingerprinting mass spectroscopy. Tomographic techniques allow to visualise the internal structure of fruit and vegetables. The potential of laser confocal microscopy, magnetic resonance imaging and X-ray CT will be summarised.

VISIBLE-NIR SPECTROSCOPY AS A TOOL FOR VARIETAL DISCRIMINATION AND CHARACTERISATION OF THE HARVEST STAGE IN APPLES.

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The objective of the study was to evaluate the interest of Visible-NIR spectroscopy as a fast method for the non-destructive assessment of the degree of maturity of apples. The sample collection consisted in fruits belonging to 6 commercial varieties (Gala, Elton, Golden, Jonagold, Braeburn and Fuji) collected at 3 degrees of maturity. For each condition (variety x degree of maturity), 30 apples were studied by Visible-NIR spectroscopy. The spectra were recorded in duplicate on a Visible-NIR spectrometer (NIRS system) fitted with a fibre optic probe. The spectra were acquired at wavelength ranging from 400 nm to 2200 nm at 2 nm intervals, leading to 900 data points. The raw spectral data were processed by principal component analysis (PCA) and stepwise discriminant analysis (SDA), in order to classify the fruits according to their varieties or their maturity stages. SDA were achieved using a cross validation procedure. In 8 independent cross-validation tests, more than 90% of the fruits were correctly classified in their actual varieties. The spectral absorption bands which played a major role in the discrimination were detected at 454, 537, 669 and 1925 nm. In the same way, SDA was applied on the whole collection in order to discriminate the degree of maturity of the fruits. In cross validation tests, about 260 fruits among 300 were correctly classified according to their actual maturity stage but the accuracy of the discrimination varied from one variety to another. In further study, it would therefore be interesting to perform SDA separately on each variety. The study showed the interest of NIR spectroscopy as a rapid method for the characterisation of the ripeness of apples. Further data processing will be achieved on the sole NIR range, in order to avoid using chlorophyll as a marker of maturity.

NIR PORTABLE DEVICE USE IN A LOGISTIC PLATFORM: PRODUCTIVITY AND PERFORMANCE ANALYSIS.

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Today the NIR spectroscopy is one of the most interesting technology for the not destructive evaluation of vegetables and fruit. From several years the specifically literature shows the strength of this principal but are not many the researches which evaluate the commercial devices from the productivity and performance point of view.

Aim of the present research is the evaluation of a commercial device used in a logistic platform for vegetables and fruit distribution: the analysis is done making particularly attention to the performance aspects and the productivity during the acceptance phase. The research, made during the 2003, considers different fruits and vegetables types: apples, pears, peaches, plums, grapes, kiwi, strawberries and tomatoes. For every product it was analysed different lots, making both destructive test, made during the usually acceptance phase, and the not destructive ones assuming like references the limits used in the protocol of the logistic platform.

The result demonstrates that the reliability of the device is similar of that obtained with the traditional destructive method, but in a shorter time and without breaking any product.

SPECTRAL IMAGING VIS-NIR SYSTEM TO FORECAST THE CHILLING INJURY ONSET ON CITRUS FRUITS.

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Cold storage is one of the most important and useful opportunities to preserve citrus fruit quality and to extend the sales period. Citrus fruits, however, are susceptible to chilling injury (CI) depending on species, cultivar, and the length of exposure to low temperatures. Susceptibility is also influenced by many preharvest factors and harvest date. Blood oranges and lemons may develop chilling injury when held at temperatures below about 8 and 12°C respectively. Symptoms of chilling injury include pitting, brown staining, increased decay and quality deterioration.

Aim of the work was to forecast the chilling injury development by non-contact hyperspectral VIS-NIR imaging on the fruit rind at least 10 days in advance before its visual appearance. The analysis was made on 129 fruits of "Femminello siracusano" lemons (*Citrus limon* [L.] Burm.) stored at 5°C and high relative humidity for 94 days. Spectral images were made 12 times. The opto-electronic system for the images acquisition was made by a VIS-NIR spectral scanner (DV Padova), which can acquire bidimensional spectral images with a very good optical (250 Kpixels) and spectral (115 l) resolution. The acquired image allows readings of the standard reflectance values (white and standard illuminating or illumination) for the VIS-NIR spectral range (400-970 nm), with a 5 nm bandwidth.

After 94 days, 79% of the fruits showed damaged areas. Partial least squares (PLS) regression analysis was applied for constructing a predictive model based on the spectral normalized response, constructing the model on a sub sample and verifying the model (test) on independent ones. Hyperspectral PLS model allows to predict chilling injury onset on lemons 20 days before the visual appearance with a percentage of 70%.

S12-05

DETECTION OF BRUISES ON APPLES BY NEAR INFRARED REFLECTANCE SPECTROSCOPY.

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The objective of the study was to evaluate the interest of near infrared reflectance spectroscopy (NIRS) to detect the bruises caused on apples by a definite compression test. Three varieties (Elstar, Gala, Smoothie) and six stages of fruit development were compared. The spectra were acquired on a NIR spectrometer at wavelength ranging from 800 nm to 2200 nm.

Six harvest were achieved, from mid may to mid September, with thirty fruits per harvest for each condition (variety x date). Spectra were first acquired on the less coloured side of the intact fruits. Two successive compressions at constant speed (3 mm s^{-1}) were then applied on each apple to reach a strain equal to 10% (first samplings) or 5% (samplings at harvest) of the fruit diameter. This stress was applied with a texture analyser (TA.XT.Plus) fitted with a circular flat probe (5cm Ø). One hour after compression, a second spectrum was recorded on the same face.

Discriminant analysis (FDA) with cross validation procedure were applied on the spectral collections. In most of the cases, these analysis have shown good discriminations between apples before and after compression. Nevertheless, the capacity of NIR spectroscopy to detect bruised apples has been variable according the variety and the stage of development. The spectral absorption bands which played a major role in the discriminations were defined. The relations between the evolution of spectra after the compression and the energy absorbed during this compression were studied.

S12-07

THE RELATIONSHIP BETWEEN CHLOROPHYLL FLUORESCENCE AND FRUIT QUALITY INDICES IN 'JONAGOLD' AND 'GLOSTER' APPLES DURING RIPENING.

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A study was conducted to characterize the relationship between chlorophyll fluorescence (CF) and quality indices in apple fruit. Fruit of 'Jonagold' and 'Gloster' apples were harvested at commercial CA storage maturity. Half of the fruit were treated with 1-MCP for 16 hours at 20°C. Fruit were stored at 20°C. Untreated fruit were sampled every 7 days for 35-42 days, while 1-MCP treated fruit were evaluated every 14 days for 84 days. CF parameters, Fo, Fv, and Fm, as well as fruit quality indices, firmness, soluble solids (SS), titratable acidity (TA), SS/TA, and aroma production were measured on sixteen individual fruit at each sampling period. Significant relationships between CF and the fruit quality parameters, firmness, TA, SS/TA, and aroma volatile content were found. Among the CF parameters, Fm, Fv, Fv/Fm, Fv/Fo, and Fo/Fv showed a significant relationship with the quality parameters of firmness, TA, SS/TA, and butyl acetate (BA) and 2-methylbutyl acetate (2MBA) content. No significant relationship was found between CF and SS. Treatment with 1-MCP did not alter the relationship between CF and most quality parameters in 'Gloster'. In 'Jonagold', the relationship between CF and firmness was weaker in 1-MCP treated fruit when compared to untreated fruit. Results indicate CF can provide a meaningful non-destructive measure of internal quality. The relationship between CF and firmness, TA and SS/TA is promising and may lead to the development of a non-destructive fruit quality detector to sort fruit based on eating quality prior to fruit being shipped to consumers.

S12-06

IMAGE CLASSIFICATION OF BANANAS (*Musa cavendish*) DURING RIPENING BASED ON APPEARANCE FEATURES.Mendoza F.¹*, Aguilera J.M.¹¹Department of Chemical Engineering and Bioprocesses; Pontificia Universidad Católica de Chile, Santiago, Chile.

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In the trade, the ripeness of bananas is normally assessed visually by comparing the colour of the peel to standardized colour charts that describe seven ripening stages, and sometimes by instrumental techniques (i.e., colorimeters). Human visual inspection is a highly subjective and tedious process. In contrast, colorimeters allow accurate and reproducible measurements of the colours. However, the surface colour must be homogeneous and many locations must be measured to obtain a representative colour profile. In addition, in the case of bananas these techniques are usually destructive requiring the removal of the peel for the measurement.

The objectives of this study were: (i) To implement a computer vision system to characterize quantitatively colour changes during ripening of bananas; (ii) To identify features of interest which can be related with the later ripening stages such as development of brown spots and textural features of the images; and (iii) To develop a statistical model to identify the ripening stages of bananas from samples previously classified by expert visual inspection. Nine simple features of appearance: L*a*b* values, brown spots area percentage (%BSA), number of brown spots cm^{-2} (NBS cm^{-2}) and homogeneity, contrast, correlation and entropy of image texture were evaluated for classification purposes.

Results show that parameters a*, %BSA, NBS cm^{-2} , and contrast better depicted the appearance characteristics as an indicator of banana ripeness. Thus, in spite of the inherent variability of banana samples the proposed computer vision technique combined with a simple classification technique has great potential to differentiate among ripening stages of bananas as professional visual perception. Using L*a*b* bands, %BSA and contrast it was possible to classify 49 banana samples in their seven ripening stages with an accuracy of 98%. Computer vision shows promise for on-line prediction of ripening stages of bananas.

S12-08

MULTISPECTRAL LASER INDUCED FLUORESCENCE IMAGING TECHNIQUES FOR NONDESTRUCTIVE ASSESSMENT OF POSTHARVEST FOOD QUALITY AND SAFETY.

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The use of spectral sensing has gained acceptance as a rapid means for non-destructive inspection of postharvest food produce. Current technologies generally use color or a single wavelength camera technology. The applicability and sensitivity of these techniques can be expanded through the use of multiple wavelengths. Reflectance in the visible (Vis)/near-infrared (NIR) regions is the prevalent spectral technique. Fluorescence, compared to reflectance, is regarded as a more sensitive technique due to its dynamic responses to subtle changes in biological entities. Our laboratory has been exploring fluorescence as a potential means to detect quality and safety aspects of postharvest food produce.

We have developed several fluorescence imaging platforms including hyperspectral imaging, and laser-induced fluorescence (LIF) and steady-state fluorescence imaging systems with multispectral capabilities. Because of relatively low fluorescence quantum yield from biological samples, a system with a powerful and fast pulse light source such as a laser coupled with a gated detection device is used to harvest fluorescence in the presence of ambient light.

The versatility of fluorescence techniques are demonstrated with recently developed multispectral LIF imaging systems, including nanosecond-scale time resolved fluorescence imaging, for the assessment of food quality and detection of fecal contamination on fruits and vegetable.

NON-DESTRUCTIVE ASSESSMENT OF PIGMENTS IN APPLE FRUIT AND CARROT BY LASER-INDUCED FLUORESCENCE SPECTROSCOPY (LIFS) MEASURED AT DIFFERENT TIME-GATE POSITIONS.

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During recent years consumers and producers request to objectively determine quality of horticultural products along the entire supply chain has been increased. In this context innovative, optical techniques would provide the opportunity to examine qualitatively and quantitatively changes in compound contents of single fruits and vegetables. Commercial methods used up to now are mostly destructive, which renders further utilizations or long-term investigations of the products impossible.

In the present study laser-induced fluorescence spectroscopy (LIFS) was applied on apple fruit and carrot for determining changes in pigment contents such as chlorophyll, carotenoids and polyphenols. The Laser Fluoroscope (LF 301 Lambda, I.O.M., Germany) used was equipped with a fibre-optic probe and a nitrogen laser emitting short pulses at 337 nm to trigger fluorescence recorded in a wavelength range from 350 nm to 820 nm.

The application of LIFS was aimed to point out the possibilities of this method for a non-destructive, rapid and objective screening of fruit and vegetable qualitative compounds along the supply chain. Data processing was carried out by derivative spectroscopy to analyse appearances and disappearances of peaks in the spectra and variances in the fluorescence intensities due to changes in fruit pigment contents. Furthermore, according to the specific lifetime of fluorescence molecules the spectra were taken with time-resolved readings to separate overlaid signals. It was found that specific fluorescence intensity maxima appearing in the blue-green wavelength range can be attributed to variances in carotenoid and polyphenol contents. Additionally chlorophyll degradation due to mechanical impact such as bruise became visible in the red fluorescence of apple fruit.

These results show the potential usage of LIFS for a rapid and non-destructively monitoring of fruit and vegetable quality.

THE ACOUSTIC IMPULSE-RESPONSE OF APPLES IN RELATION TO THE FRUIT'S POSITION DURING THE TEST, REDUCED WATER LOSS, AND APOPLASTIC ACIDITY.

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The fruit and vegetable business has an increasing demand for objective quality testing to ensure reliable and fair evaluation of crops and food safety. Stiffness, measured by means of the non-destructive acoustic impulse-response technique is a known parameter for evaluating food texture.

The objective of this research was to examine possible influences on apple stiffness by means of fruit-position, reduced water loss, and apoplastic pH. Regarding fruit-position: apples were either placed on soft foam or suspended from a laboratory stand. Other apples were covered with cocoa butter immediately after picking to inhibit water loss and were tested after storage. The MT-firmness and osmotic potentials were measured to monitor the effect of the cocoa butter. The apoplastic fluid was collected as indicator of enzyme activity around the cell walls. In addition to the apoplastic fluid, the water status of the apples was examined during storage. As a result no significant difference was found between impulse-responses of apples measured lying or hanging respectively (t-test >5%). The deviation of the stiffness values from the water-loss-inhibited apples compared to the control group was significant (t-test <5%) on all five test dates. The firmness was significantly different at the four last test dates. The osmotic potential was significantly different at the last three test dates. The stiffness and apoplastic pH of fresh apples at different maturity stages was approximately constant. However, storage induced a decrease.

It can be concluded that the stiffness of a harvested apple could differ because of the disconnection from the tree and its water supply, but not because of the position during the test. On the tree stiffness seems insensitive to changes of fruit. However, in storage an effect of water loss and cell wall changes on stiffness is suggested.

DOES ACOUSTIC FIRMNESS RELATE TO SENSORY PERCEPTION OF APPLE TEXTURE?

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Apple samples covering a wide range in texture were produced by storage in different regimes and by using two varieties (Cox's Orange Pippin and Gala). Fruit was graded into 3 size bands prior to storage. Acoustic firmness was measured using an AFS unit (AWETA BV) and penetrometer measurements were made using a Lloyd LRX materials testing machine fitted with an 11 mm probe. A trained panel at Leatherhead Food Research Association, UK, carried out the sensory assessments. Measurements were made on three replicate sets of samples to correspond with three sensory panel sessions. Separate samples were used for penetrometer measurements and sensory tests but acoustic firmness was measured on all samples of fruit. In Cox the penetrometer measurements showed a general decline with increasing fruit size and with increasing store oxygen concentration. A decline in acoustic firmness index with increasing fruit size and oxygen concentration was observed though with an apparent reduced sensitivity compared to the penetrometer measure. The sensory assessment of crispness showed a similar overall trend with oxygen concentration, but without a consistent effect of fruit size. For Gala apples similar trends with storage atmosphere for sensory crispness and penetrometer measurements were observed, though there was a clear trend of declining values with increasing fruit size for the penetrometer which was not evident for sensory crispness. There appeared to be little effect of storage atmosphere or fruit size on acoustic firmness index for this variety. When data for the two varieties was combined, there was a good relationship between penetrometer readings and scores for sensory crispness for values below ~60N, though less good above 60N. The relationship between acoustic firmness and sensory crispness was poor, as was that between acoustic firmness and penetrometer readings particularly between 60-70N.

HIGH-CONTRAST NEUTRON IMAGING TO OBSERVE WATER DISTRIBUTION IN INTACT PLANTS.

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Neutron radiography is not only a high sensitive but also high resolution non-destructive imaging for water distribution. The authors are studying low-energy neutron radiography which provides a high contrast images of hydrogen due to the large absorption cross-section of neutrons.

The method is very sensitive for observing small changes in water distribution in plant materials. Because the water content of plants is more than 80%, most hydrogen is present in water. Further, changes of the water content in a plant are usually larger and earlier than changes in substrates such as sugars and fibers. Thus, a change in hydrogen measured in a short period by means of neutron radiography indicates a change in water in the plant. Low-energy neutron radiography is suitable to observe the delicate water status in intact plants. However, neutron images depend on characteristic of neutron beams and neutron detection systems. For example, lower-energy beam produce images of higher contrast, however, a longer exposure time is necessary.

The long exposure time doesn't suit rapid water changes in plants. Thus, proper selection of the factors is necessary when we conduct low-energy neutron radiography. However, there are many unresolved points in applying this new method for plant materials. This study reports several attempts using the low-energy neutron radiography facilities at Kyoto university reactor, and evaluates a proper methodology to measure water distribution in intact plants.

CHARACTERIZATION OF CARROT CULTIVARS BY SPECTROCOLORIMETRY.

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Colour and its homogeneity are an important factor of visual quality of carrots. The characterization of colour is important, for the appreciation of quality inside the orange cultivated type or for the assessment of accessions with various colours. The quantification of pigments by HPLC is a tedious task and a rapid method would be useful. Colorimetry based on the L*, a*, b* colour space coordinates of Hunter has been widely used with various success. In order to obtain a more precise information, we used a spectrophotometer which provides the colour spectrum.

Samples of 20 stored carrots from several cultivars were analyzed. Spectra of the external, phloem and xylem parts were recorded. Significant differences were found among cultivars. The analysis of spectra allowed to assess the uniformity of carrots inside a cultivar. Moreover, we analyzed the spectra at specific wavelengths corresponding to the maximum absorbance of the pigments responsible for colour in carrot in order to better evaluate the observed variation and potentially find a relationship with the pigment content in carrot tissues. The spectrophotometer proved to be a useful tool to assess the colour in carrots with a higher precision.

PREDICTING HARVEST LABOUR ALLOCATION IN BELL PEPPER PRODUCTION.

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In the production of bell peppers large fluctuations exist in number of fruits ready to pick. That makes it very difficult for growers to allocate sufficient labour force at a certain time in production. Both allocating too many and too few pickers will have financial consequences for the grower. The development of bell pepper ripening has been followed by colour imaging in the greenhouse. A commercial digital camera was used to record in time the development of colour for two cultivars (4 samplings in two seasons). The images were analysed by image processing to obtain the R, G and B values. The time to harvest was recorded for the same fruits. A model was developed to describe the colour development, expressed as R/G ratio, and to predict the optimal harvest date of the fruits.

By using a commercial digital camera under non-standardised conditions large variations will be introduced. Using a ratio of colour aspects reduces this variation. For one cultivar, repeated data were recorded in time for the same individuals. Non linear regression analysis of these data resulted in an explained part of 95%.

Assuming for the time being that the rate constant would be applicable to all cultivars and all growing season, the anticipated harvest time for the other 6 data sets was calculated, using these estimated parameter values. These data sets contained only one or a very limited number of measurements in time for individual fruits, and could therefore not be used to calibrate the exponential model. The difference between measured and estimated harvest time was 1 week or less for more than 80% of the measured individuals. In view of the assumptions used and the frequency of harvest time determination (1 week), this was rated as satisfactory.

Research is going on to validate the viewpoints.

A NOVEL CORRELATION PARAMETER BETWEEN ETHYLENE EMISSION AND SKIN COLOUR CHANGES DURING PAPAYA (*Carica papaya* L.) FRUIT RIPENING.

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The skin colour changes and ethylene emission rates were monitored during papaya (*C. papaya* L.) fruit ripening. The skin colour changes were measured with a commercial colorimeter and ethylene emission with a commercial CO₂ laser driven photo-acoustic set-up.

Two groups of papaya ('Formosa' and 'Solo') were applied in this study and for both a strong change of the reflectance spectra in the wavelength range from 400 to 700 nm during the ripening was observed. The total colour difference was used as measured parameter and the corresponding half time of its saturation was used as correlation parameter. A high correlation factor between the saturation half time and corresponding climacteric peak time was found. It was concluded that high ethylene emission rate in 'Solo' fruit promotes a quick change of the total colour difference.

This study is important from the agricultural and commercial point of view because it indicates methods to monitor fruit ripening during production, storage and transport, contributing to improve quality and reduce losses during these processes.

FRUIT QUALITY OF VESUVIAN APRICOTS HARVESTED AT DIFFERENT RIPENING STAGES AFTER A COLD-STORAGE PERIOD.

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The cultivation of apricot trees in the Campania region (Southern Italy) has long years of tradition, as demonstrated by the wide range of autochthonous cultivars. All of them, despite their good organoleptic characteristics, have been little investigated about the post-harvest fruit quality.

The present work aimed to evaluate fruit quality of seven of these cultivars, grown in the Vesuvius area (Bocuccia, Ceccona, Pellicciella, Portici, Prete, Prevetearella e Vitillo), at harvest and after a cold-storage period (7 days at 4°C). Moreover, the effectiveness of a non-destructive method (NIRs) in measuring fruit flesh firmness and solid soluble content was evaluated and compared to the destructive method. Fruit were harvested at three ripening stages (unripe, commercial ripe and ripe fruit) defined by a visual determination of different fruit ground colours (green-yellow, yellow-green and yellow-orange skin). In addition, fruit weight and skin colour were determined for each treatment. The latter was obtained by the fruit chromatic values L*, a* and b* measured with a Minolta colour-meter.

Fruit skin colour was affected by cold-storage at each ripening level for each cultivar. In detail, the a* parameter, representing the green-red colour axis, resulted to be increased after the cold-storage period, whereas b* tended to decrease.

After the cold-storage period for all the cultivars and colour classes, fruit flesh firmness decreased. Solid soluble content was also affected by the cold-storage period.

NIRs was an effective methodology in estimating correctly fruit solid soluble content at harvest, but it slightly underestimated this parameter for most of the cultivars when measurements were performed on cold-stored fruit. The effectiveness of the non-destructive method appeared to be lower in the measurements of flesh firmness of fruit both at harvest and after the cold-storage period.

SOLUTION STRUCTURE OF IMAZALIL / β -CYCLODEXTRIN.Consonni R.^{1*}, Recca T.¹, Dettori M.A.², Fabbri D.², Delogu G.²¹Istituto per lo Studio delle Macromolecole, Lab NMR, Milano, Italy; ²Istituto CNR di Chimica Biomolecolare, sez. Sassari, Italy.

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In a previous article we have used the β -cyclodextrin (bCD), a commercially cheap cycloheptaamylose, as biopolymeric matrix for the inclusion of imazalil (IMZ), a valuable fungicide used in post-harvest treatment¹. A simple, efficient and non expensive preparation of complex inclusion, in equimolar ratio, has been perfected in water. It involved not functional modification neither in the active agent nor in the bCD.

Controlled release of the IMZ, included into the biopolymeric no toxic matrix, had an efficacy comparable or better than IMZ fungicide in the post-harvest treatment against *Penicillium* decay in citrus fruit, it reduced mammalian toxicity, reduced pesticide contamination of the environment and extended duration of effectiveness of agrochemical at a constant level.

The present research has involved the investigation of the bCD-IMZ complex in aqueous solution by NMR techniques in combination with computational methods². Reasonable water solubility of the inclusion complex gave feasible spectroscopic experiments and it provided further experimental evidence of the true complex since free IMZ is water insoluble.

Two diastereomeric bCD-IMZ complex have been observed as well as the presence of a privileged conformer. The solution structure of the complex was determined by NMR techniques in combination with computational methods that allowed to obtain important information concerning the entrance of the IMZ into the bCD toroid. The aromatic ring is deeply inserted in the cavity while the imidazole ring and the allyl group should be excluded from the cavity but, involved each other in a strong interaction.

APPLE QUALITY ASSESSMENT: RELATIONSHIP BETWEEN OPTICAL PROPERTIES, MECHANICAL MEASUREMENTS AND ACOUSTIC MEASUREMENTS.

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Physic-chemical assessment of textural quality of fruit requires setting up several techniques. Some of them such as the compression tests are well known and are easily interpretable in a professional context. They are unfortunately destructive. Based in a low mass impact, the acoustic technique is an alternative method developed in the two last decades. More recently developed, the non-invasive determination of the optical absorption and scattering properties of biological tissues is useful. Setting up those three approaches leads to a very large set of characteristics.

Included in a large program which studies the potentiality of laser use in fruits and vegetables quality control, this work was a first attempt to establish the correlation between a) the optical properties and mechanical parameters, and b) the optical properties and the acoustic firmness index. In the present study, optical measurements were based on a spatially resolved model in continuous wave.

First results obtained from PLS regression techniques show that optical approaches may become a good indicator of textural properties.

ASSESSMENT OF APPLE SKIN THICKNESS BY INSTRUMENTAL AND HISTOLOGICAL APPROACHES ON A LARGE RANGE OF APPLE CULTIVARS.

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Skin thickness is a factor which can depreciate dramatically apple fruit taste. There is a very high variability for this trait amongst apple cultivars. Some unpublished studies report that many consumers have got the feeling that skin of most of the new released scab resistant cultivars is sensorially thicker than that of classical commercial cultivars – generally susceptible to apple scab. The first aim of the study has been to set up methods and process to assess for the skin thickness. Eight commercial cultivars and six scab resistant hybrids and cultivars have been assessed by both penetrometric and histological studies. The Force/deformation curves obtained penetrometry by using a texture analyser (TA.XT Plus by SMS) show slight differences between cultivars and between coloured and uncoloured sides within a fruit. For histological observations, various fixing and staining methods have been tested: they give complementary information on the thickness of the cuticle, the structure of the epidermis and the underlying parenchyma cells and their wall thickness. Statistical analyses have been achieved to quantify the effect of the controlled factors (cultivar, fruit side) on the measured traits and to answer the question: do the scab resistant cultivars have a thicker skin?

TIME-RESOLVED REFLECTANCE SPECTROSCOPY AS A NON DESTRUCTIVE TOOL TO ASSESS THE MATURITY AT HARVEST AND TO MODEL THE SOFTENING OF NECTARINES.

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The quality (flavour, texture) of peaches and nectarines is dependent on harvest maturity, related to background colour. In the new cultivars the background colour is masked by blush, preventing the identification of the maturity stage. A new non-destructive technique, Time-Resolved Reflectance Spectroscopy (TRS), can measure separately the optical properties of absorption and scattering at selected wavelengths in diffusive media. In a previous trial with nectarines, the absorption coefficient at 670 nm (ma670) measured at harvest was correlated to fruit maturity and to softening after harvest.

The aim of this research was to model the softening during shelf-life of 'Springbright' nectarines measured by TRS. Fruits of two sizes were picked on 16 July 2003, and ranked by decreasing ma670 (increasing maturity). Ranked nectarines were randomly assigned to each sample for analysis at harvest and during shelf-life, in order to ensure that fruit from the whole range of ma670 were available in each sample. Fruit were stored at 0°C for 3 or 10 days, then at 20°C for 5 days. Firmness was measured destructively (pressure test) twice a day during shelf-life. Firmness did not change significantly during cold storage. Softening during shelf-life after cold storage was modelled by non linear regression analysis. Softening followed a logistic model in function of ma670 at harvest and of time at 20°C (R²=0.89).

The results of the previous trial were fully confirmed. The effects of fruit size and of cold storage were not significant. The logistic model had already been used to model the colour evolution in horticultural products, but not yet, in our knowledge, to model fruit softening. By using this model and knowing the ma670 at harvest of nectarines, it is possible to predict their softening rate at 20°C, and so to choose their marketing destination.

S12-22

THE QUALITY AND STORABILITY OF APPLES CV JONAGORED SELECTED AT HARVEST BY TIME-RESOLVED REFLECTANCE SPECTROSCOPY.

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Apple maturity at harvest is a critical factor which affects ripening and determines the post-harvest utilization of fruits. A new non-destructive technique. Time-Resolved Reflectance Spectroscopy (TRS), which measures separately the two optical properties of absorption and scattering at a depth of 1-2 cm in the fruit flesh, has been successfully used for determining the maturity at harvest of nectarines in order to predict their softening rate and so to choose their marketing destinations.

The aim of this work was to evaluate the usefulness of the absorption coefficient measured at 630 nm (μa_{630}) by TRS to assess apple quality at harvest and after storage. Jonagored apples were picked on 30 August and 13 September 2002. 150 fruits/pick were ranked by decreasing μa_{630} (from less to more mature) and divided into three classes of different maturity. At harvest, at the end of six months' storage at 1°C in normal or Controlled Atmosphere (1% O₂, 2% CO₂) and after 7 days of shelf-life at 20°C, apples were analysed for fruit mass, skin colour, firmness, soluble solids (SS) and titratable acidity (TA).

At the end of shelf-life less and more mature fruits were assessed by sensory analyses and for % juice. μa_{630} was significantly higher in first harvest apples. Apples with higher μa_{630} had lower fruit mass, lower % blush both at harvest and after storage. Fruits classified as more mature by TRS had less TA at harvest and more SS after storage; at sensory analyses these fruits were significantly sweeter, more aromatic and pleasant. By using TRS, fruit of different maturity and quality were separated within the same batch. It can be concluded that TRS can be used to select apples according to maturity and so to separate fruits of different quality within the same batch.

S12-24

A STATISTICAL APPROACH FOR THE ANALYSIS OF PROTON TRANSFER REACTION MASS SPECTROMETRY (PTR-MS) DATA AIMED AT A QUALIFICATION OF FRUITS BASED ON VOC EMISSIONS.

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The high degree of sensitivity and the large amounts of data typical of Proton Transfer Reaction Mass Spectrometry strongly requires an appropriate method of data handling, analysis and interpretation to optimize the amount of information that such data could give. The experiments that we have carried out and the available data from literature clearly show a quite strong dependence of the VOC emissions from a large number of parameters that characterize a fruit. Weight, degree of ripening, skin properties (such as colour, aroma and brightness) as well as post-harvest treatments and preservation, all of them affect quite significantly the pattern of emitted VOC. A correct statistical approach should then take into account several (possibly all) the relevant variables that contribute to the modifications in VOC emissions so that no information is lost.

We have developed an approach based on a model of the type causal network with respect to sets of parameters prior, intervening and consequent respectively. As a test case we have studied the preservation of Red Delicious under ILOS treatment and we have considered as co-variant parameters the weight, skin attributes such as dye, aroma and brightness. Through the statistical analysis of the VOCs emission measured by PTR-MS we have identified the masses of the VOC that best correlate to the different properties of the apples over the whole period of storage and for shelf life of about two weeks. It is very interesting to notice that such an analysis followed by a relative principal component treatment (RPCA) allows a very nice discrimination of the apples and of the effects of the treatments on preservation and shelf life. This communication discuss the great potential of this method to identify specific VOC sets that could be used as true markers for different apples attributes and treatments.

S12-23

PRESERVATION OF FRUITS: A STUDY BASED ON MONITORING VOCs BY THE NOVEL PROTON TRANSFER MASS SPECTROMETRY METHOD (PTR-MS).

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Volatile Organic Compounds (VOCs) could be fruitfully used as a non destructive method to monitor the state and quality of fruits and vegetables. In particular, as we have previously shown (Postharvest Biology and Technology 17 (1999) 143) Proton Transfer Reaction Mass Spectrometry (PTR-MS) could be nicely used to qualify post-harvest preservation and quality. This is in fact a very sensitive and real time instrumentation that allows the monitoring of a large number of organic volatile organic compounds down to a few pptv sensitivity.

Using such an apparatus we have investigated the preservation under a variety of different conditions and treatments of Renette Canada, Red and Golden Delicious apples over the whole storage period. The experimental data show that the VOC are very sensitive to the different storing conditions and treatments. Slightly different controlled atmospheres (Renette Canada); internal low oxygen stress (ILOS) treatments (Red Delicious) and ethylene inhibition chemical treatments (Golden Delicious) produce very significant differences in the VOC emission spectra that keep being observed over the whole conservation period and during the shelf life. Studies on berry fruits, which are characterized by short preservation times, have also been carried out. In particular we have investigated different modified atmospheres aiming at optimizing the quality during preservation of blueberries. The effects on the VOC emission have been clearly observed and correlated to the final product state and quality.

The data have been analyzed using relative principal component statistical analysis that confirm the ability of PTR-MS as a reliable and very sensitive way to discriminate the different procedures and conservation receipts by detecting organic volatile compounds. The method is envisaged as being very promising to optimize fruit quality during the whole chain of storage and marketing.

S12-25

ADVANCE TECHNIQUE TO PREDICT EATING QUALITY OF RIPE-MANGO AT UNRIPE STAGE USING NEAR INFRARED SPECTROSCOPY.

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A technique to predict eating quality, Brix value, of ripe mango from its harvest quality, measured nondestructively by near infrared (NIR) spectroscopy, was successfully developed. The NIR spectra in the short wavelength region (700 to 1100 nm) of unripe mangoes were measured immediately after harvest. The calibration equations for harvest indices, dry matter (DM) and starch content, were developed (SEP: 0.41 %w w⁻¹ for DM, 1.71 %w w⁻¹ for starch).

From the NIR spectra measured and the calibration equation developed, the relationship between harvest quality and Brix value at ripe stage of the same mangoes was revealed. Ripe mangoes would have high Brix value if the fruit contained sufficient amounts of DM and starch at harvest date. Brix value of ripe mangoes could be precisely predicted from the DM and starch measured nondestructively with NIR at harvest. The standard error of prediction (SEP) for the Brix calibration equation was 0.55 Brix.

S12-26

VOLATILE PRODUCTION IN 'FUJI' APPLES STORED UNDER DIFFERENT ATMOSPHERES BY HEADSPACE/GAS CHROMATOGRAPHY AND ELECTRONIC NOSE.

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Volatile production, sensory acceptance and electronic nose responses were measured in 'Fuji' apples (*Malus x domestica* Borkh) to evaluate the effects of different storage conditions, storage periods and shelf-life days. Apples harvested at 185 days after full bloom were analysed after 5 and 7 months of cold-storage in normal atmosphere (AIR: 21% O₂+0.03% CO₂) and in two controlled atmospheres (CA: 1% O₂+2% CO₂ and 3% O₂+2% CO₂). During post-storage ripening, apples were kept at 20°C for 1, 5 and 10 days before analytical and sensory measurements were made. Volatile production was obtained involving headspace/gas chromatography methods; electronic nose measurements by a sensor array of semiconductor gas, and sensory acceptance by a semi-trained panel.

Sensor responses registered by 21 different sensors were used to classify the apples using Principal Component Analysis (PCA). This PCA model containing data from all fruits (at harvest and after storage) showed that it was possible to identify fruits from harvest or storage; it was also possible to differentiate between AIR-fruits and CA-fruits. Principal components 1 (PC1) and 2 (PC2) respectively accounted for 63 and 30% of the total variability. A PCA model containing only data of stored fruits revealed differences according to different storage periods; in this case PC1 and PC2 respectively accounted for 50 and 20% of the total variability. On the other hand, a PCA involving volatile production, sensory acceptance and sensor responses corresponding to all fruits allowed a better differentiation between fruits from 1% O₂+2% CO₂ and 3% O₂+2% CO₂ atmospheres, with an explained variance of 58 % (two first PCs).

S12-28

COLOR AS A HARVEST INDEX FOR CHERIMOYA.

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Traditionally cherimollas are harvested by size and colour for local and export market. As the first shipments for export had some quality and condition problems at the international market arrival, it was necessary to check the colour using an objective method in order to establish the right colour for harvest. The condition was mainly affected by an inhibition of the normal ripening, it means no softening and flavour development.

The objective of this investigation was to determinate the colour evolution (using a colorimeter) during growing, maturation and different harvest times to evaluate the postharvest behaviour of the fruit after a ripening period of 6 days at 18°C.

Fruits were market early in the season, between 4 and 5 months before potential harvest; size and colour were measured every month using a sizer and a Minolta colorimeter. At harvest firmness, soluble solids, pH and titratable acidity were measured as well. The cherimoyas were kept at 18°C for 6 days

S12-27

NON-DESTRUCTIVE NIRS-ASSESSMENT OF APPLE QUALITY AND RIPENING PARAMETERS, COMPARED TO CONVENTIONAL ANALYSIS BY AN APPROPRIATE STATISTICAL PROCEDURE.

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The suitability of NIR-spectroscopy for the non-destructive quality assessment of apple fruits was investigated in the past 2 years. The measuring system (Sacmi F5, Imola, Italy) is based on spectral analysis of NIR transmittance that is more accurate than the reflectance modulus. The equipment is a mechanical set-up for commercial sorting-lines. The entire fruit is illuminated by an intensive halogen light source. The spectral changes of transmitted light contain information about chemical and physical composition, ripening and internal disorders. The aim of the study was to compare this novel instrument with traditional destructive techniques. In order to optimise the reliability of the NIR-measurements, specific calibration patterns for each apple variety were created. The cultivars under study were 'Gala', 'Golden Delicious', 'Red Delicious', 'Jonagold',

'Braeburn', 'Granny Smith', 'Fuji' and 'Cripps Pink'. Samples were characterized by a wide range of maturity stages. The detection of following parameters was evaluated: i) ripening, in terms of starch-index, endogenous ethylene and Streif-index; ii) quality, in terms of firmness, total soluble solids and malic acid content; iii) internal disorders, like internal flesh browning, core flush and water core.

In order to compare the two different analytical methods, particular attention was given to develop an appropriate statistical procedure. Reliability and reproducibility were given by calculating intraclass correlation coefficients in addition to conventional values like correlation factor, SEC and SEP (standard error of calibration, prediction, resp.). Moreover, a graphic representation of the statistical comparison is given using the Bland-Altman (1999) plot.

S12-29

ACOUSTIC AND SENSORY MEASUREMENTS OF DIFFERENT RIPENESS OF APPLES : 2.

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In first works realised by Symoneaux et al (2002), correlations between acoustic measurements (stiffness coefficient) and sensory evaluation by a trained panel were researched, studying the impact of a harvest's date on apple quality. Relationships with other destructive measurements were also studied. Three different stages of ripeness were chosen. For each variety, apples were harvested one week before, on the optimal date itself (determined by an expert) and one week after. All of these apples were tested two weeks after harvesting. The later the apples were harvested, the lower the stiffness, touch resistance and crunchiness. On the contrary, sweetness and odour intensity increased. Significantly positive correlations were observed between stiffness and touch resistance and crunchiness.

In this experimentation, the same methodology were used, completed by the impact of the storage on apple quality. Acoustic, sensory and instrumental textural measurements were processed on each apple. Correlations were researched with all data and not only with averages by batch as last year. The high correlations between acoustic and textural measurements were confirmed. Stiffness seemed to be a good non-destructive parameter for measuring apple texture. The correlation's methodology between sensory and instrumental measurements were also studied comparing results with all data and not just averages.

SESSION 13 (S13)

POSTHARVEST IN DEVELOPING COUNTRIES



S13-01**INCREASING FOOD AVAILABILITY BY REDUCING POSTHARVEST LOSSES OF FRESH PRODUCE.**Kader A.A.^{1*}¹University of California, USA.

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Qualitative losses (such as loss of caloric and nutritive value, loss of acceptability by consumers, and loss of edibility) are more difficult to measure than quantitative losses of fresh fruits and vegetables. While reduction of quantitative losses is a higher priority than qualitative losses in developing countries, the opposite is true in developed countries where consumer dissatisfaction with produce quality results in a greater percentage of the total postharvest losses.

Providing consumers with fruits and vegetables that taste good can greatly increase their consumption of the recommended minimum of five servings per day for better health. Development of new cultivars with better flavor and nutritional quality plus adequate productivity should be given high priority in all countries. Strategies for reducing postharvest losses in developing countries include: (1) Application of current knowledge to improve the handling systems (especially packaging and cold chain maintenance) of horticultural perishables and assure their quality and safety; (2) Overcoming the socioeconomic constraints, such as inadequacies of infrastructure, poor marketing systems, and weak R&D capacity; and (3) Encouraging consolidation and vertical integration among producers and marketers of horticultural crops.

S13-03**THE INFLUENCE OF POST-HARVEST CONDITIONING AND STORAGE PROTOCOLS ON THE INCIDENCE OF ROTS IN WHITE YAMS (*Dioscorea rotundata* Poir) IN GHANA.**Bancroft R.D.^{1*}, Aboagye-Nuamah F.², Crentsil D.³, Panni J.Y.³, Krampa L.⁴¹Post-Harvest Assistance, UK; ²Dept. Crop. Sci. Univ. of Ghana, Legon, Ghana; ³Agricultural Engineering Services Directorate, Ministry of Food and Agriculture, Accra, Ghana; ⁴Ministry of Food and Agriculture, Sunyani, Ghana.

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The post-harvest conditioning of root and tuber crops (such as potatoes and cassava) by exposure to elevated temperature and humidity ('curing') has long been used to extend their storage life. The use of this strategy on yams is not, however, well documented and appears not to be practised with any consistent conviction in West Africa. During the period 2000 to 2003, a series of on-farm trials was conducted on 'White Yams' (*Dioscorea rotundata* Poir) in Ghana to assess whether 'curing' and other related protocols could be exploited. The factors investigated included the impact of yam variety, tuber maturity (immature 'milk' yams and physiologically mature 'ware' yams), different 'curing' environments (plastic bags, clamps or modified storage rooms) and subsequent storage in different structures (pits or barns).

Interactions were observed between the conditioning treatments and varieties, and the different storage structures had a significant impact on yam weight loss, sprouting and the incidence and prevalence of rots. Overall 'milk' yams were more prone to deterioration than 'ware' yams and, irrespective of the possible benefits of 'curing', were much better conserved in traditional pits than in barns. Irrespective of treatment, rots were more often associated with the upper sections of the tubers, suggesting a link with pre-harvest insect damage and harvest cuts at the site of the vine. It was determined that the levels of relative humidity in pits, clamps and modified storage rooms could engender 'curing', whereas the humidity in plastic bags was excessive and simply brought about rapid rotting. Achieving the correct temperature for 'curing' was problematic. Ambient temperatures (high 20°C) proved sub-optimal whereas temperatures above 37°C were too high. These field trials suggest that the conditions necessary to 'cure' yams can be established in rural communities with limited resources.

S13-02**A LOOK AT POSTHARVEST IN IRAN.**Jowkar M.M.¹, Mohammadpour H.^{2*}¹Azad University, Tehran, Iran; ²Shiraz University, Shiraz, Iran.

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Being a developing country Iran is the 7th major horticultural producer. Official statistical reports state Saffron and cut flowers as having the least and the highest postharvest loss of about 0.006 and 33.0 percent respectively. They also report postharvest losses in Iran as being six more times than the world's mean, which is equal to the food needed for 20 million people. However, unofficial specialists report 35% as the minimum loss and in some cases they estimate it over 50% which is over 20 million tons Worth over 100 million dollars.

The major problem in controlling this great postharvest loss is that the Ministry of Agriculture is only responsible for the production of agricultural products; while on the other hand the postharvest losses are under the authority of other ministries and organizations. In this article factors effecting postharvest losses in Iran, recent developments and approaches in reducing them, and finally the rate of production, qualitative and quantitative loss and reduction, export-import, and postharvest losses per capita for most of the horticultural products are given.

S13-04**ASSESSMENT OF POST-HARVEST HANDLING SYSTEMS OF VEGETABLES IN THE EASTERN HILLS OF NEPAL.**Udas S.^{1*}, Rai B.K.¹, Khatriwada P.P.², Gurung M.³, Thapa R.³¹Central Campus of Technology; ²Pakhribas Agriculture Research Center, Pakhribas, Dhankuta; ³Sindhuwa Multipurpose Farmers Cooperative, Dhankuta; Nepal.

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The post harvest handling systems of four vegetables (cauliflower, cabbage, radish and tomato) in the vegetable growing areas of Eastern hills of Nepal was studied. Information was collected on: the time of harvest; harvesting methods, timing and availability of transport; grading; pre-cooling; packaging and storage. It was estimated that total post harvest losses of cauliflower, cabbage, radish and tomatoes due to spoilage and insect damage were 6%, 9%, 6% and 3% at collection center respectively, losses of cauliflower and cabbage (due to spoilage, bruise and trimmings) were 41%, 34%, radish (breakage) 4.5% and tomato (due to rupturing and spoilage) was 7%. The commodity loss due to spoilage and trimmings are then sold at 2 NRs kg⁻¹ for animal feeding by the retailers. The factors responsible for post harvest losses were a lack of proper packaging, transportation and grading systems.

An attempt was made to bring awareness about the post harvest handling systems by training farmers and the vegetable traders in the Eastern hills of Nepal. There is a great need for more research and training to overcome post harvest losses of vegetables in developing countries by adopting low cost technologies appropriate and affordable to the farmers, traders and processors as well.

FARMERS' USE OF PHI FACILITIES FOR FRUITS AND VEGETABLES IN INDIA: PRESENT PROBLEMS AND FUTURE STRATEGIES.

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India is the second largest producer of fruits and vegetables in the world. However, this is not matched with the availability of postharvest infrastructure (PHI) leading to enormous losses valued at more than 30 billions of rupees annually. In order to promote and establish PHI, reduce post-harvest losses and facilitate domestic and overseas trade in horticultural products, the National Horticulture Board (NHB) had initiated the Soft Loan Schemes in 1993-94. Under these schemes NHB provided soft loan assistance up to rupees 10 millions with 4 percent service charge to various organizations to set up the PHI projects in many states of India. These newly created PHI facilities with large investments were expected to provide immense opportunities to farmers to increase their incomes. However, farmers encountered several problems in using these facilities. The study seeks to critically examine the extent of these problems faced by farmers and suggest policy measures for its alleviation. The study is based on primary data collected from four major states (Maharashtra, Karnataka, Madhya Pradesh and Punjab) of India covering 444 sample farmers comprising of 219 member farmers of PHI units and 225 non-member farmers from the same area.

The study finds that farmers faced tremendous problems in using PHI facilities such as harvesting, pre-cooling, cold storage, grading, packing, transportation, and marketing. It has critically examined the magnitude of problems faced by member and non-member farmers while using each of these facilities in their area. The resentment of problem was more among the non-member farmers as compared to member farmers. The study concludes by suggesting strategies to overcome the problems. Sensitivity towards resolving these problems on priority basis will have implications for future PHI development in India and the availability of sufficient fruits and vegetables for domestic consumption and exports.

S13-07

STANDARDIZATION OF MATURITY INDICES OF 'KEW' PINEAPPLE.

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The Northeastern region of India produces more than 40 per cent of the total pineapple of the country and almost 90-95 per cent are organic. The Kew is the most promising cultivar in this region having good quality attributes. A considerable quantity of the produce is lost during handling and transportation due to lack of knowledge of the producer about the proper stage of harvesting. Moreover, appropriate maturity indices are not known for this variety. Therefore, standardization of maturity indices of this variety is very much required to reduce the post harvest losses as well as to maintain quality of the harvested produce.

Experimental findings revealed that the fruits harvested during 146-150 days after flowering (1/2 Color Development Stage) was found to be the right stage of harvesting pineapple. However, the fruits may also be harvested during 141-145 days after flowering (1/4 Color Development Stage). Days after flowering (146-150), Specific gravity (0.93-0.98), Respiration rate (7-10 mg Kg⁻¹ h⁻¹), TSS (18-19 °Brix), Acidity (0.77-0.83 %) and TSS: acid ratio (23-25) etc. might be considered as suggested indices for harvesting pineapple (Kew variety) at right stage for local as well as distant markets during November-December.

PHYSIOLOGICAL CHANGES IN AMAZONIC HOT PEPPER ACCESSIONS DURING GROWTH, RIPENING AND STORAGE.

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This work describes physiological behaviour in four accessions of hot pepper species (*Capsicum annuum*, and *Capsicum chinense*) coming from the amazonic pepper germplasm bank collection from the Amazonic Institute of Scientific Research SINCHI. Fruits from all accessions were harvested weekly from set to ripening stage in orchards from Leticia in the Colombian Amazonic region. Fruits exhibited no climacteric pattern with respiration rate lower than 100 mg CO₂ kg⁻¹ h⁻¹ and ethylene production below 0.01 µL C₂H₄ kg⁻¹ h⁻¹. In accession CS 049 (*C. chinense*), colour change from pale green to red was evident only at full ripening stage. In accessions CS-219 and CS-376, colour measured by

Hue angle or H* changed from green (H*=104°) to yellow (H*=79°) or orange (H*=37°), respectively, and was useful as maturity index. CS 032 accession remains purple (H*=29°) during development. Maximum colour turning was concomitant with accumulation of citric and ascorbic acid, capsaicin and dihydrocapsaicin, and relatively little changes in pH, soluble solids and acidity. The accessions were susceptible to chilling injury (pitting) at 5°C. Commercial shelf-life periods (as evaluated by shriveling at 12°C and 95% R.H.) were two weeks in CS-49 and CS-376, above 3 weeks for CS-219, and below 1 week for accession CS-032.

S13-10

SUSCEPTIBILITY OF FIVE APPLE CULTIVARS TO BROWNING.

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Phenolic compounds and polyphenol oxidase (PPO) activity in five apple cultivars were assessed in relation to browning susceptibility.

The degree of browning was determined by measuring brown pigments in homogenised pulp. The analysis variance of the browning rate, polyphenol content and PPO activity showed that only the effect of cultivar was significant while the interaction of location and cultivar were not significant. Comparison of means (Duncan) classified the cultivars in view of browning rate in three groups (P<0.01): strong (Red Delicious), weak (Arangeh and Granny Smith), and mid (Golden Delicious). Arangeh was the superior variety due to its highest total soluble solids and lowest browning rate.

POSTHARVEST BEHAVIOR OF ARAZÁ FRUIT TREATED WITH 1-MCP AND STORED AT TWO TEMPERATURES.

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Arazá fruit harvested at green mature stage in Caquetá (Colombia) were treated with 0 (control in air) or 1000 ppb 1-MCP for 1 hour at 20 °C and packed in macroperforated bags (liners) commonly required by UK supermarkets. Then fruit quality was inspected after 1 week at 7 °C and 95% or at 12 °C and 95% RH, with or without an additional shelf life period (3 days at 20 °C and 70% RH). The goal of this project is to determine critical points associated to this treatment during postharvest handling from harvest to consumers in Colombia. 1-MCP delayed respiration rate, ethylene production and decrease in Hue angle colour parameter (around 8°) in green mature fruit compared with control fruit at 7 °C or 12 °C. The treatment also decreased fluctuations in respiration peaks usually detected at 7 °C. Shrivelling and chilling injury in the form of skin scald were delayed by 1-MCP. Anthracnose development after the shelf-life period, was also delayed in treated fruits at both temperatures.

This short 1 MCP treatment was an useful coadjutant to extend shelf-life of green-mature arazá fruit even when stored at suboptimum temperatures.

POSTHARVEST USE OF 1-MCP TO EXTEND STORAGE LIFE OF MELONS IN BRAZIL – CURRENT RESEARCH STATUS.

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Efficiency of 1-MCP on postharvest life of whole Cantaloupe, Galia and Charentais melons and fresh-cut Cantaloupe was evaluated. In order to define the best concentration of 1-MCP, melons were treated with doses varying from 0 to 900 ppb. Three experiments were carried out under refrigeration: 1)'Hy-Mark' melons treated and stored at 5 °C; 2)'Hy-Mark' melons treated under regular and modified atmosphere and stored at 5 °C; 3)'Solar King' treated under regular and modified atmosphere and stored at 7 °C. Charentais melons were stored for 15 days at ambient temperature. For the experiments with fresh-cut melons, 'Hy-Mark' melons were treated with 1-MCP at 10 °C, sanitized, hand cut and stored at 5 °C. Pulp softening was the main characteristic affected in all experiments. Increasing delay in pulp softening according to the dose was noticed, although differences between doses above 300 ppb were not significant. Respiration and ethylene evolution rates were reduced and both CO₂ and ethylene peaks were delayed in trials with whole melons. 1-MCP doubled postharvest life of Cantaloupe melons at ambient temperature (from 1 to 2 weeks), treated 'Hy-Mark' melons were acceptable for 27 days whereas control fruits could be stored for not more than 7 days. When 1-MCP was associated to modified atmosphere, storage life was 3 days longer at ambient temperature. Treated Galia melons were kept firmer than the controls for up to 30 days despite the storage atmosphere, and all fruits were acceptable for up to 27 days, the best being those treated with 1-MCP and modified atmosphere. Although shelf life of fresh-cut melons as defined by firmness and appearance was of about 20 days for all treatments, food safety aspects limited it to 12 days.

PHYSIO-MORPHOLOGICAL BEHAVIOUR OF INDIGENOUS POTATO VARIETIES UNDER NATURAL STORAGE CONDITION.

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Physiological behaviour of tuber of three different sizes (large, medium and small) of ten indigenous potato varieties were studied under natural storage condition for 180 days (March 3 to September 3, 1999). Weight loss of tubers increased gradually with storage period and at 180 days of storing minimum weight loss was recorded in Shilbilati (9.63%) and maximum in Lalpakri (19.53%). It was found to be inversely proportional to the tuber sizes. Soft rot and dry rot identified as the causes of rotting of tubers in the storage and the incidence of dry rot (4.80%) was higher than soft rot (1.46%). The maximum was in Lalpakri (10.66%) and minimum in Shilbilati (2.66%). Hagrai showed the longest dormancy (required 115 days to sprout) and Lalmadda had the shortest (76 days). At 180 days of storing maximum sprouts was produced by Lalshil (9.63/tuber) and minimum by Shilbilati (2.06/tuber). Days to sprouting was inversely proportional to the tuber sizes but number and weight of sprouts per tuber were directly proportional to the same.

EFFECT OF 1-MCP ON MEMBRANE CHARACTERISTICS, ANTIOXIDANT DEFENSE SYSTEM AND POST HARVEST STORAGE IN INDIAN SWEET RED APPLE.

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This work was undertaken to study the role of anti oxidant and cell wall degrading enzymes such as Superoxide dismutase (SOD), Peroxidase (POD), Catalase (CAT), Ascorbate peroxidase (APX), cellulase and lipid peroxidase during post harvest storage of Indian apples using 1-MCP. 1-MCP is a newly introduced ethylene blocker and is now well -known to increase the shelf life of flowers and fruits.

Fruits of apple cultivar Sweet Red (resembling Gala apples of Washington State USA) widely grown in Himachal Pradesh were selected for this study. Due to inadequate postharvest storage technologies, high cost of transportation and short shelf life much of this bumper crop goes waste every year causing loss of millions of rupees.

One set of 50 fruits of uniform size was kept as control while two other sets were treated with 0.5 and 1.0 mg L⁻¹ of 1-MCP for 24h and stored at room temperature subsequently. The enzyme activities and their isoenzyme patterns were determined periodically. The degradation of flavonoids, anthocyanins and ascorbate was also determined.

The results have shown that 1 ppm MCP treated fruits had an increased shelf life of 10 days at room temperature as compared to 2-3 days in control. The treated fruits retained their colour and firmness for a longer time. The activities of SOD and CAT were higher while POD and APX activity were lower in treated fruits. There were some marked differences in the isoenzyme patterns. The degradation of anthocyanin and ascorbic acid was also slower in the treated fruits. The activity of cell wall degrading enzymes was also inhibited.

WORKSHOP A (WA)
GENOMICS AND PROTEOMICS
OF FRUIT QUALITY



WA-01**DEVELOPMENT OF GENOMICS AND INFORMATICS TOOLS FOR TOMATO: UTILIZATION TO ASSESS FRUIT DEVELOPMENT AND RIPENING.**Giovannoni J.^{1*}, Fei Z.²¹USDA-ARS and Boyce Thompson Institute for Plant Research, ²Boyce Thompson Institute for Plant Research, USA.

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A large tomato expressed sequence tag (EST) dataset (152,635 total) was analyzed to gain insights into differential gene expression among diverse plant tissues representing a range of developmental programs and biological responses. These ESTs were clustered and assembled to a total of 31,012 unique gene sequences. To better understand tomato gene expression at a global level and to identify differentially expressed and tissue specific genes, we developed and implemented a digital expression analysis protocol. By clustering genes according to their relative abundance in the various EST libraries, expression patterns of genes across various tissues were generated and genes with similar patterns were grouped. In addition, tissues themselves were clustered for relatedness based on relative gene expression as a means of validating the integrity of the EST data as representative of relative gene expression. Arabidopsis EST collections were also characterized to facilitate cross-species comparisons where possible.

Statistical analysis of EST prevalence in tomato fruit libraries resulted in 333 genes being classified as fruit ripening-induced and 185 as fruit ripening-repressed ($P < 0.05$). Tomato fruit digital expression data was also compared to publicly available grape EST data to gain insight into molecular manifestation of ripening processes

WA-03**METABOLIC ENGINEERING OF TOMATO FRUIT CAROTENOIDS.**Giuliano G.^{1*}, Diretto G.¹, Giliberto L.¹, Rosati C.², Pallara P.², Camara B.³¹Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA), Biotechnology Unit, Casaccia Research Centre, Roma, Italy; ²Trisaia Research Centre, Rondella (MT), Italy; ³CNRS, Plant Molecular Biology Institute, Strasbourg Cedex, France.

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Plant carotenoids are 40-carbon isoprenoid compounds involved in many physiological and biochemical functions, such as light harvesting and photo-protection from excess light energy; additionally, they colour many flowers and fruits, probably to attract animals and to protect reproductive structures from high light intensity. Carotenoids play a crucial role in human health as dietary antioxidants and as vitamin A precursors. We have begun a metabolic engineering approach on tomato (*Lycopersicon esculentum* L.) fruits, through overexpression of structural and regulatory genes. The general conclusions from our work, and from that of other laboratories, are the following:

- Fruit-specific overexpression/silencing of structural carotenoid genes often result in the expected phenotype. However, some structural genes give unexpected metabolic alterations.
- Overexpression of regulatory genes (photosensory receptors) result in broad metabolic alterations.

WA-02**A CUSTOMIZED CITRUS MICROARRAY AND ITS USE IN POSTHARVEST.**Pons C.¹, Royo C.¹, Forment J.¹, Gadea J.¹, Lluch Y.², Kanellis A.K.³, Zaccarias L.⁴, Lafuente M.T.⁴, Granell A.^{1*}¹IBMCP, Spain, ²IBMCP, Spain, ³Aristotle University, Greece, ⁴IATA, Spain

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The molecular mechanisms underlying the way fruit responds to the environment are not well understood, and this is especially true for those responses affecting fruit quality during storage. The development of high throughput molecular technologies such as transcriptomics can be very useful in defining the processes which affect quality during postharvest. We are applying microarray technology to Citrus varieties such as Fortune mandarin that develops peel alterations during extended cold storage with the idea the results can contribute to design better managing and storage procedures.

Although there are ongoing genomic programs in Citrus aim at cloning and identifying Citrus ESTs, these are not yet available. Furthermore large scale ESTs projects use random selection of ESTs from a range of different libraries which obviously cannot include plant material under all possible conditions; thus the coverage of the array can not be complete what may be particularly relevant when the number of ESTs is not large as it is the case so for Citrus. In order to cover this gap we have constructed a cDNA microarray from Fortune mandarin fruits. The array includes random cDNAs, high/low oxygen response genes, but is enriched with cDNAs from a subtracted library that contains cold induced genes. Bioinformatics analyses of the results obtained with this array reveals a host of new genes associated to the response of Fortune fruit to low temperatures. Some of the genes identified as cold responsive genes are tissue specific and are being classified by their pattern of expression and nature of the predicted gene product. The use of the array to study fruit response, in varieties differing on chilling response, in fruits exposed to different temperatures and time of storage, etc., will help us to get a more defined picture of the way storage conditions affect Citrus fruit quality.

WA-04**NEW INSIGHTS INTO FRUIT RIPENING THROUGH PROTEOMICS.**Rose J.K.C.^{1*}¹Department of Plant Biology, Cornell University, Ithaca, NY, USA

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Fruit development can be divided into several distinct stages, the last of which involves a coordinated series of changes in colour, texture, aroma and nutritional status, which are collectively referred to as ripening. The biochemical pathways that underlie these events are highly complex and in most cases poorly understood at the molecular level. As a complement to essential biochemistry, physiology and genetics, the application of genome-scale gene expression studies, typically referred to as transcriptomics and proteomics, provides a valuable means to elucidate ripening-related metabolism.

We have been developing a multi-tiered proteomics program to provide insight into the qualitative and quantitative complexity of protein populations in ripening fruit, focusing on tomato, which is now a well-established model experimental system. Moreover, the availability of various ripening impaired tomato mutants, such as ripening-inhibitor (*rin*), provides an excellent opportunity to examine key regulatory mechanisms that control the numerous ripening-related metabolic pathways. Comparative studies are also in progress in other fruits, such as pepper.

In addition to profiling the whole fruit proteome, we are investigating the sub-proteome of the cell wall, or apoplast, since the constituent proteins profoundly influence a number of fruit quality traits and postharvest characteristics, such as fruit texture and resistance to postharvest disease. A combination of experimental techniques coupled with in silico analyses are being used to identify suites of cell wall-related proteins/genes, many of which are previously unreported and that potentially contribute to horticulturally important extracellular processes. It is hoped that these diverse strategies will provide insights into the regulation of fruit development and ripening as well as suggesting approaches for enhancing fruit quality traits.

WA-05**GAIN AND LOSS OF FRUIT FLAVOR COMPOUNDS PRODUCED BY WILD AND CULTIVATED STRAWBERRY SPECIES.**

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The blend of flavor compounds produced by fruits serve as biological perfumes, used for the attraction of living creatures including human beings. These volatile mixtures include hundreds of metabolites and vary in their composition in different characteristic fruit flavors. The mechanism by which natural plant compounds such as flavors are gained and lost during evolution and domestication are largely unknown.

Here, we reveal a process for the evolution of diversity in strawberry fruit flavor components based on a change in enzyme localization and alteration in gene expression profile. Through a change in subcellular localization the enzymes encountered new substrates and produced novel metabolites characteristic of the polyploid strawberry cultivars of today. At the same time we discovered that an insertion mutation affected gene expression and caused the loss of other flavor compounds, typical of wild strawberries. Loss of a certain metabolite further influences the metabolite profile of the same plant species by initiating a metabolic chain reaction, in which substrates are no more available for the production of downstream compounds.

The findings uncover molecular evolutionary mechanisms used by plants to generate metabolic diversity, which may be specifically selected for in domesticated species.

WA-07**MOLECULAR AND GENETIC ASPECTS OF RIPENING AND QUALITATIVE TRAITS OF PEACH AND NECTARINE FRUITS.**

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During fruit ripening, several parameters most of them linked to quality traits undergo significant changes whose biological bases and mechanisms are only partially understood. A useful tool to elucidate molecular and genetic mechanisms regulating ripening is represented by mutants which, at least in tomato, show an altered perception and/or transduction pathway of ethylene. A selection of the nectarine cv Fantasia, characterized by a block of the ripening process apparently due to an altered synthesis of ethylene and/or an insensitivity to the hormone, has been isolated and used in the attempt of better understanding some peculiar aspects of the ripening physiology of this fruit species (e.g., the rapid evolution of the softening and melting processes resulting in a reduced shelf-life). The cDNA-AFLP technique has been used and the patterns of isolated bands compared in the selection and wild-type fruits throughout development and in correspondence of ethylene climacteric. At ripening, 73 polymorphic bands have been detected: 10 of these fragments showed high homology (> 70%) to Arabidopsis and rice genes and data on their expression patterns during ripening are presented.

Microarray technology allows to conduct systematic studies on gene expression on a large scale base. The application of this technology requires the construction of EST (expressed sequence tags) databases, sufficiently large and representative of the process under investigation. In cooperation with other research units and within a National Consortium aimed to study genomics and functional genomics in peach, an EST database has been created and oligonucleotide-microarray produced.

Results of microarrays hybridization with RNA extracted from the slr selection and the wild-type and peach or nectarine varieties characterized by different ripening patterns (e.g. melting vs non-melting), organoleptic traits (e.g., high aroma vs low aroma) and/or postharvest behaviour are presented.

WA-06**FUNCTIONAL GENOMICS AND BIOTECHNOLOGY OF PAPAYA MATURATION AND RIPENING ASSOCIATED GENES.**

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Papaya, an important tropical economic crop, its growth, development, and fruit ripening are all regulated by ethylene. From the orchard to market, the senescence and quality loss of papaya fruits are rapid. Subtractive hybridization method was used to clone 426 cDNAs (CpMRGs, papaya maturation and ripening associated genes) which are upregulated during papaya fruit ripening. These include genes involved in cell wall degradation, carbohydrate metabolism, protein and amino acid metabolism, nucleic acid metabolism, lipid metabolism, signal transduction, environmental and oxidative stress, light sensing, and many other unknown functional genes. The unknown functional cDNAs including 59 genes similar to Arabidopsis unknown proteins, 6 genes similar to *Zea mays* proteins, and 272 genes without similarity to the genes deposited in data bank. Several papaya genes have been cloned, expressed and characterized. These include 2 ACC oxidases, 3 ACC synthases, an anti-fungal protein, a chitinase and two tubby-like proteins. Antisense ACO gene has been successfully transferred into papaya and the fruit ripening of transgenic papaya was delayed for several days.

The 402 unique CpMRGs-based microarray was used to study the fruit-ripening associated genes. Forty two fruit specific and upregulated genes, including Cp-ACS2, glutathione S-transferase, invertase and several unknown functional genes, and 4 genes, including heat shock protein 82, chitinase, 23-2 phospholipase, and HSC71.0 were up-regulated not only during fruit ripening but also during leaf and flower senescence.

WA-08**GENOMIC APPROACHES TO POSTHARVEST BIOTIC AND ABIOTIC STRESSES OF CITRUS FRUIT.**

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Citrus fruit are subjected to both biotic and abiotic stresses during postharvest handling and storage that influence their marketability. The major biotic stress is caused by phytopathogenic fungi of the genus *Penicillium*, being *P. digitatum* the most important pathogen. Among the abiotic stresses, we are particularly interested in the heat-induced chilling tolerance of chilling-sensitive citrus cultivars.

To gain a deeper knowledge on the mechanisms underlying the defence response of citrus fruit to pathogen attack and on the heat-induced tolerance to chilling injury, we are undertaking two complementary approaches. In the framework of an Spanish "Citrus Functional Genomic Project, CFGP" we have generated one cDNA library for each condition that will allow us to get a general picture of the genes being transcribed. A more directed approach is the utilization of the Suppression Subtractive Hybridization technique to generate subtracted cDNAs libraries enriched in those genes preferentially expressed under a particular condition. After a differential hybridization screening of the SSH libraries a group of clones were selected for further characterization.

We will present the results of both approaches, with special emphasis on the common responses found between the two different stresses, and within each stress on the comparison between non-selected ESTs versus subtracted libraries. All clones, together with those generated in the CFGP will form part of a microarray that will allow us a more detailed analysis of the citrus fruit responses to stress.

WA-09

DIFFERENTIAL GENE EXPRESSION ANALYSIS OF TWO STRAWBERRY CULTIVARS WITH A DIFFERENT METABOLIC RESPONSE TO STORAGE IN ELEVATED CONCENTRATION OF CO₂ USING A TOMATO cDNA MICROARRAY.

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Some strawberry cultivars accumulate acetaldehyde, ethanol and ethyl acetate in response to high concentrations of CO₂ (20%) during storage, while in others the presence of these volatiles is not detectable. Our objective is to identify metabolic pathways other than fermentative that may be affected when cultivars of the two response types are exposed to high CO₂ concentrations. Microarray technology is a powerful tool that allows analysis of the expression of thousands of genes in a single experiment. However, generation of a species-specific microarray requires the construction of cDNA libraries, selection of expressed sequence tags (ESTs), sequencing, PCR and expensive equipment for spotting and processing.

With this in mind, we have utilized a publicly available tomato cDNA microarray with the knowledge that, although certain genes may be absent from the analysis, plants, and especially fruit, share many common biochemical pathways. The tomato microarray was hybridized with strawberry RNA extracted from two cultivars with different metabolic response to storage in CO₂. A set of 81 genes showed differential expression between the two cultivars when they were stored in an atmosphere containing 20% CO₂ for 48hrs. Genes with homology to enzymes involved in cell wall metabolism, protein synthesis and stress were identified. An analysis of gene expression over time during storage will be presented from a subset of the genes identified from the microarray experiment.

WA-10

PROTEOMIC APPROACH TO ANALYSE ORGANOLEPTIC QUALITY IN TOMATO FRUIT.

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The organoleptic quality of tomato fruits is a complex characteristic involving different components like flavour, aroma or texture. A recombinant inbred line (RIL) population was created from a cherry tomato line (Cervil) with a good overall taste and a common tomato line (Levovil) to study the genetic bases of these traits.

Molecular markers were used to map a total of 131 QTL for 38 traits which were distributed in different regions on chromosomes 2, 3, 4, 8, 9 and 12. For a particular region of chromosome 2 fine mapping was undertaken to separate four linked QTL one for fruit weight, one for locule number and two for sugar content. Near isogenic lines (NILs) for this special region were obtained. Three NILs as well as the two parental lines were compared during fruit development. Main variations were pointed out and compared with proteomes of other tomato tissues like roots, stems and leaves to detect fruit specific variations. To analyse the proteome, total protein extracts of the tomato pericarp were separated by two dimensional gel electrophoresis (IEF/SDS-PAGE). Proteins of interest were analysed by MALDI TOF or ESI-MS/MS and introduced into a protein database especially constructed for tomato fruit.

Proteomic analyses of parental lines and NILs were performed during different fruit developmental stages and candidate genes for the above mentioned characteristics were obtained. Some of these genes are well known to be linked to fruit development processes, the function of the others has to be further investigated.

WA-11

PROTEOMICS OF GENETIC DIVERSITY IN RELATION TO TOMATO FRUIT QUALITY.

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Improvement of tomato fruit quality for fresh market is based upon accurate evaluation of the genetic variation easily accessible to tomato breeders. The quality of tomato fruit is a complex characteristic involving a set of components such as fruit size, flavor, aroma, texture. We here illustrate part of a research project aiming at comparing genetic diversity available by means of neutral molecular markers, transposable elements and expressed proteins within the *Lycopersicon* genus. *Lycopersicon esculentum* exhibits low molecular polymorphism but high phenotypic variability, especially at the fruit size level. We collected 20 accessions of esculentum varieties representing the overall existing fruit size variation (from few grams to 500g) and one accession of each wild species.

To analyse the proteome, total protein extracts of the tomato pericarp were separated by two dimensional gel electrophoresis (IEF/SDS-PAGE) at two different stages of development. Image analysis was performed with Melanie IV and main qualitative and quantitative variations were detected. Research of the co-regulated proteins was done by clustering analysis in relation to classes of fruit. Varying proteins were analysed by MALDI TOF or ESI-MS/MS and introduced into our tomato fruit protein database after comparison with proteins expressed in other tissues.

WA-12

MICROARRAY AND REAL TIME PCR ANALYSIS OF FRUIT TRANSCRIPTOME IN STRAWBERRY ELITE GENOTYPES AND CORRELATION WITH PTR-MS SPECTRA OF VOLATILE COMPOUNDS.

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We have been studying the transcriptome of the octoploid strawberry (*Fragaria x ananassa*) in a number of Italian elite varieties, to assess fruit quality and correlate gene expression data with those from biochemical analyses and panel tests.

More than 3000 expressed sequence tags (ESTs) obtained from a fruit cDNA library were analyzed. The 50 largest contigs related to plant genes with assigned functions comprised 725 ESTs (23.7% of total), including genes not only associated with ripening (cell wall metabolism, sugar and acid synthesis, pigment formation, vitamin synthesis and allergenic properties), but also with plant-pathogen interactions, abiotic stresses and housekeeping functions. Over 1800 selected ESTs were used to produce a cDNA microarray, together with ripening-related candidate genes and checks. Comparative profiling experiments revealed a limited number of genes with variations in expression levels among different genotypes. Nevertheless, such differentially expressed genes were related to important quality and post-harvest traits as fruit firmness and aroma profile, and data from microarray experiments were confirmed by results of Real Time PCR analyses.

Proton transfer reaction mass spectrometry (PTR-MS) analysis of head space volatile compounds of fruits of studied genotypes suggested a correlation between the presence in the fruit of some esterified metabolites and the expression of genes putatively involved in their synthesis. New results from ongoing molecular and biochemical analyses and correlation with data from panel tests will point out the genes and compounds most correlated to fruit quality and post-harvest traits, as well as overall consumers' preferences.

WORKSHOP B (WB)
NEW STRATEGIES FOR TRANSPORT
OF ORNAMENTALS
AND OTHER HORTICULTURAL PRODUCTS

WB-01**ARE RECOMMENDED POSTHARVEST TREATMENTS REALLY REQUIRED?**van Doorn W.G.^{1*}, van den Boogaard G.J.¹, Boerrigter H.A.¹¹Agrotechnology and Food Innovations (A&F), Wageningen University and Research Centre, Wageningen, The Netherlands.*Presenter (wouter.vandoorn@wur.nl)

Some post-harvest treatments may not generally result in better quality. Other treatments may have some effect but are not cost-effective in terms of quality. A few examples will be given, using results from recent experiments with cut flowers and fruits. The quality of gerbera flowers, for example, is little affected by post-harvest treatments, but mainly determined by the cultivar and the grower, thus by the quality at harvest. This means that some precautions that are now advised in the gerbera trade seem superfluous. Even though treatments such as rapid cooling may not be cost-effective in terms of quality, they may well be required for other reasons. In addition, it would be unwise to generalise the findings as there are many products that do need extensive post-harvest care.

WB-03**WHY DO WE TREAT FLOWERS IN THE WAY WE DO?**Van Meeteren, U.^{1*}¹Wageningen University, The Netherlands*Presenter (Uulke.vanmeeteren@wur.nl)

Cut flowers are now transported over very far distances, for example from developing countries towards more industrialised nations. The long distance transport poses problems for quality maintenance. Therefore, more and more, the concept of a 'chain approach' is introduced in post harvest quality management and becomes more and more implemented in distribution chains of cut flowers. However, this approach is mostly applied to logistic aspects and information flow. A scan of the complete chain, to find the real critical steps for cut flower quality, is rare. In some cases, a quality simulation model is part of the system, which predicts the decline of quality during the post harvest phase. However, when all handling and conditions are the same during the post harvest phase, quality still varies. Information how the pre-harvest history influences quality aspects is scarce; knowledge about interactions between pre-harvest history and post harvest factors is totally missing. In production systems of human food, it is a good practice (obliged in many countries or demanded by the client) to use a system of Hazard Analysis and Critical Control Point (HACCP), a systematic chain analysis originally developed by NASA, to ensure food safety. To ensure a known quality level for cut flowers, and to prevent expensive investments without a positive return, we should know the critical control points for quality in the complete production chain. Due to the complexity of quality, mechanistic simulation models will be the ideal tools to identify the critical points. In this way, we can start to develop a HACCP system for cut flower quality.

WB-02**NEW STRATEGIES FOR TRANSPORTATION OF FLORICULTURAL CROPS.**Reid M.S.^{1*}¹University of California, Davis.*Presenter (msreid@ucdavis.edu)

In the past century, the centers of production and consumption of ornamentals increasingly have become widely separated. A cut flower bouquet purchased today in a Verona florist could easily combine Italian foliage with flowers grown in Kenya, Colombia, Holland and Thailand. The extended transportation infrastructure and delays between harvest and consumption implicit in this separation can easily result in significant reduction in quality and vase life. Geography plays an important role in selection of transportation mode, and most 'long distance' flowers still are transported by air. Air transport typically results in quality loss due to poor temperature control, accelerated water loss, and airport delays and interventions. The high Q_{10} for respiration in cut flowers (as much as 7!) implies a substantial premium for careful temperature control during transportation. Innovative systems for temperature control could be important tools for maintaining freshness during air transport. The primacy of postharvest temperature control has driven the continued search for ways to use surface transportation – sea containers and trucks are an important tool in this effort. The lack of response of cut flowers to controlled atmospheres (apart from ethylene-sensitive flowers) has meant that this technology has not been adopted with cut flowers. Careful temperature control and monitoring of container temperatures and the use of faster ships has resulted in successful out-turn of flowers transported from Central America to North America. Temperature control also frustrates efforts to direct-market flowers using the Internet. Innovative packaging concepts will be essential to success in this field.

WB-04**PRE-SHIPMENT AND SHIPBOARD FACTORS INFLUENCING THE OUT-TURN CONDITION OF FRUIT AND VEGETABLE CONSIGNMENTS IN INTERNATIONAL TRADE.**Snowdon A.L.^{1*}¹Wolfson College, Cambridge, UK*Presenter (anna.snowdon@cwcom.net)

Information is obtained during out-turn surveys at destination (on behalf of cargo receivers, underwriters, ship-owners or charterers) or during the study of claims documentation submitted by lawyers acting for one or other of the above parties. There may also be occasion to visit the producer country. Pre-shipment factors influencing cargo quality and out-turn condition include the health status of seed or planting material, weather during the growing season, crop husbandry, harvesting and handling techniques, post-harvest treatments, pre-cooling, packaging, and carriage instructions written by the shipper/exporter. Shipboard factors include design and function of the equipment, method of stowage, interpretation of carriage instructions, and duration of loading, voyage and discharge. For container shipments, which now account for more than 50% of the total tonnage of transported perishables, it is the shipper's responsibility to "stuff" the container in an appropriate manner; the container operator accepts the closed box and undertakes to supply refrigeration and/or ventilation in accordance with the shipper's instructions. Case-studies include Argentine pears to Italy, New Zealand onions to UK, Chinese garlic to the Netherlands, Egyptian potatoes to Germany, Chilean kiwifruit to the US and northern Europe, Costa Rican and Jamaican bananas to UK, and Ecuadorian bananas to Ukraine. Such cases demonstrate that serious deterioration is usually the result of a combination of adverse factors. Examples are inadequate pre-cooling, inappropriate carriage instructions, and failure to appreciate that stowage of palletised cargo is more critical than stowage of individual boxes, requiring careful attention if short-circuiting of air is to be avoided. There is now more awareness of the risk of interaction between cargoes (e.g. ethylene-sensitive kiwifruit affected by emanations from apples), but a lack of understanding of the folly of excessive fresh air intake into refrigerated space.

WB-05

TEMPERATURE AND THE POSTHARVEST PERFORMANCE OF ROSE (*Rosa hybrida* L. 'FIRST RED') AND GYPSOPHILA (*Gypsophila paniculata* L. 'BRISTOL FAIRY') FLOWERS.

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The respiration of cut flowers of rose (*Rosa hybrida* L. 'First Red') and gypsophila (*Gypsophila paniculata* L. 'Bristol Fairy') increased exponentially with increasing respiration. Q_{10} value between 0 and 10 °C was 3 for both flowers. The vase life of the flowers was negatively affected by simulated transport at higher temperatures whereas dry storage for 5 days at 0 °C resulted in a vase life that was not distinguishable from that of the initial controls. When 'First Red' flowers were held in wet storage, the effects of temperature on vase life were quite similar, with slightly longer vase life for wet-stored flowers from 12.5 and 15 °C. We found a highly significant linear relationship between respiration during storage and vase life after storage for these important commercial crops, indicating the importance of maintaining temperatures close to the freezing point during commercial handling and transport in contrast to common belief in the industry.

WB-07

KEEPING PLANT QUALITY DURING INDOOR LIFE OF WEEPING FIG IN RELATION TO PREVIOUS GROWING CONDITIONS.

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Growing conditions of weeping fig (*Ficus benjamina*) under reduced light levels is very important to get good quality plants and to shorten production period. However, climatic conditions during production of weeping fig also affect acclimation and therefore plant characteristics under indoor conditions. This study was conducted to investigate the effect of radiation levels, during production, on subsequent response of weeping fig in simulated interior environment. Plants were exposed to 50, 66 and 86% radiation exclusion during growing and then held for eight weeks in interior environment. During this period the net photosynthesis was higher on plants grown under lower light availability, beside a significant reduction of leaf starch content was observed. Regardless to the growing conditions plants showed a significant leaf drop, which was the more evident the lower the radiation exclusion during production period was. This result allows us to conclude that the plants produced under higher light exclusion percentage keep better their qualitative characteristics under simulated indoor conditions.

WB-06

PASSIVE REFRIGERATION (PRSTM) FOR STORAGE AND TRANSPORTATION OF HORTICULTURAL PRODUCTS.

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Passive RefrigerationTM containers for transport of perishable products have thermal accumulators which enables to keep the produce cool for a period of up to 30 days. The thermal accumulators contain cold brine, and are frozen prior to their use in the container. During transportation there is no requirement for electric power for cooling. High RH (typically > 90%) and air circulation avoid desiccation of the produce. The transport system is a reefer unit that can be shipped from the farm to the point of consumer sales, without cold chain interruption. We expect further improvement by integration of modified atmosphere technology. PRSTM units have no moving parts, therefore they have a high reliability and can be used in fully unattended operation. The unit can be shipped as dry cargo, thus at the relatively low cost of dry cargo. This results in door-to-door shipping at a cost that is about one third of that using conventional methods.

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