Controlled Atmosphere (CA) / Modified Atmosphere (MA) Conference Report – Trani, Italy 3 – 7 June 2013. Richard Hurndall (Hortgro Science) / Kobus van der Merwe (ARC) / Anton Gouws (Kromco)

Introduction

The conference was held in the historical town of Trani on the Adriatic coastline in the Apulia region of Southern Italy. The Apulia region contributes one fifth of the national horticultural production. Seventy percent of table grapes and cherries, and more than 30% of tomatoes, cauliflowers and artichokes are produced here. Olives also featured prominently. There were 220 delegates at the conference from 40 countries. The conference included the following themes and topics:

Impact of CA/MA on product physiology and quality

The physiological basis of modified atmospheres
Biochemical and molecular mechanisms underlying CA/MA effects
Effects on quality of fresh and fresh-cut produce
Respiration rate and its interaction with CA/MA
CA/MA related disorders
Fruit physiology in hypoxic conditions
Effect of CA/MA on flavour development
Mathematical modelling of physiological processes

Co-treatments and CA/MA

Modified atmosphere packaging (MAP) in combination with other pre-treatments for fresh-cut processing
Use of 1-methylcyclopropene (1-MCP) and other ethylene inhibitors alone or combined with CA/MA
Ethylene absorbers and scrubbers

Recent developments in CA/MA technology

Integration of CA/MA into the storage, distribution and retail handling system
Use of CA/MA to control postharvest diseases
Coating and waxing for atmospheric modification
Uses of innovative gases to substitute nitrogen in CA/MA
Application of atmosphere modification for processed vegetal products

MA packaging

Packaging technology and machinery
Packaging design
Active and intelligent packaging: environmental sensors
Nanostructure packaging technologies: bio-sensors

Economics of CA/MA applications

CA/MA technology sustainability
Recyclable/compostable packaging materials
Life cycle analyses (LCA) for packaging materials
Return on investment for CA/MA applications

Food Safety

Microbial growth
Other food safety considerations
Risk mitigation strategies

CA/MA in developing countries

Prof Yahia (FAO) opened the conference with a presentation on the status of modified and controlled atmosphere applications in the developing countries. Of interest was the fact that the highest fruit and vegetable losses occurred in developing countries (40%) whilst food waste was highest in the developed countries. Developing countries produce the most fruit, especially tropical and sub-tropical fruit, which is then destined for the developed world. Developing countries have the highest populations, which results in food insecurity due to availability of food.

Dr Jim Mattheis (USDA) discussed apple volatile compound dynamics during storage inducing low O_2 or high CO_2 injury. Low O_2 and high CO_2 delays the dissipation of water core. CA storage conditions prolonged storage life, and reduced ethylene production, disorder incidents, and losses in firmness, TSS and titrateable acids. Volatiles production differed quantitatively for each cultivar depending on O_2 or CO_2 concentration and storage duration.

M Buccheri (Food Technology Research Unit, Milan) discussed long-term air and CA storage effects on antioxidant properties and sensory quality of new Gala-type cultivars. The new scab-resistant cultivars RenoirCIV, Gemini and Gaia were compared to Galaxy. These new varieties have good storage and eating quality, and higher phenolic content. The anti-oxidant activity, which is cultivar dependent, increased during storage. The apple peel has higher anti-oxidant activity than the rest of the apple. The best storage regime for these cultivars was 1 °C and 1,2 % O_2 and 1% CO_2 for a 6-month storage period.

BE Verlinden (Flaanders Centre of Postharvest Technology, Belgium) discussed modelling biological variation in the skin background colour of Jonagold apples during CA storage. The model predicted colour change during storage and shelf-life. It was found that, to reduce energy costs, fruit could be stored at 4 °C for 125 days with the same result as storage at 1 °C for 170 days.

Zanella (Laimburg, Italy) described the paradigm shift from empirical control of conventional CA to dynamic CA (DCA) which responds to the fruits needs. This means that CA can be dynamically adjusted to each cultivar's specific requirements as well as seasonal variations. The chlorophyll fluorescence technique was described as an accurate measure of the fruit's stress response. The measurement of the large area of the fruit's skin was described as an advantage over other systems which measure the average gas concentration of the cold room. He further noted that fruit of different batches of the same cultivar gave the same fluorescence spiking response. Apart from the quality benefits and scald control, DCA prevents internal browning. A trend these days is to combine 1-MCP treatments with DCA for long-stored fruit.

Prange (Dalhousie University, Canada) noted that the deregistering of DAP and ethoxyquin in the EU requires the use of alternatives such as DCA and 1-MCP. The use of DCA has sky-rocketed and currently there are 2000 DCA rooms worldwide. The most recent development is a combination of DCA with anti-ethylene compounds such as 1-MCP and aminoethoxyvinylglycine (AVG - Retain), to add extra scald prevention during shelf-life for superficial scald-prone cultivars.

Van Schaik (Food and Biobased Research, Holland) introduced the concept of dynamic control of respiration (DCR) which is based on respiratory quotient (RQ) measurements backed up by laboratory ethanol-based determinations. An increase in the RQ precedes ethanol production in the cold room atmosphere. Ethanol is absorbed by the scrubbers and fruit tissue itself. The cold room must be switched off for 4 −5 hours to allow the RQ measurement to be taken. Advantages of the system include: measures the whole room's atmosphere, it compensates for leeks by maintaining a positive pressure, it controls scald, and energy reductions can be accomplished by storing at higher temperatures. This method does not require special sensors, does not suffer from interaction of different gas compounds, is not position specific and requires only limited modifications to existing CA systems. The system is expected to be available commercially in 2014.

Erkan (Akdeniz Universiy, Turkey) discussed the effects of modified atmospheres of the Palliflex system on postharvest quality of cherries. Turkey is the world's largest producer and exporter of cherries. The desired atmosphere is created in individual pallets. An advantage of this system is that it can accommodate different commodities in the same cold room. The use of this system reduced weight loss, controlled fruit pitting and stem browning. Furthermore, storage duration was increased from 10 to 60 days.

Bertolini (University of Bologna, Italy) reported that Abate Fetel is prone to soft scald, which can worsen during shelf-life. It is influenced by orchard conditions as well as CA conditions, such as O_2 and high CO_2. It is not influenced by storage temperature. Abate Fetel is also prone to superficial scald, which can be controlled by ultra low oxygen (ULO) and DCA. He stored pears at 0,4–0,7 O_2, 1% CO_2 at −1 °C for 6 months. DCA could however not prevent soft scald. Ethylene production during storage for different harvest periods was in the following descending order: RA > CA > ULO > DCA. The reverse applies for flesh firmness and green skin colour. DCA was the best treatment for the control of fungal growth. Under regular CA conditions, a close relationship was detected between the increase of conjugated trienols and superficial scald, while a significantly lower content was found under ULO and DCA. All fruit lots, except those held under RA, developed soft scald.

B. Nicolai (University of Leuven, Belgium) discussed gas transport inside the fruit. Fruit with a higher respiration rate is more susceptible to internal browning (IB). Larger fruit are generally more prone to IB development. Larger fruit have a larger area within the fruit which is exposed to low O_2 levels. Damage occurs when fruit is exposed to low O_2 concentrations while the fruit is still at high temperatures. Jonagold is not prone to IB, whilst Kanzi is sensitive and Braeburn very sensitive. The density of the fruit determines the permeability of gases through the fruit tissue, which in turn can give rise to IB. Oxygen moves through the inter-cellular cavities, which vary in size between cultivars, and not through cells. Responding to a question, Honeycrisp apparently has a low diffusivity potential and therefor high IB potential. Future research will focus on other aspects such as ethanol and ethylene, the molecular biology of browning, linking IB with metabolic networks, gas transport inside the cell, and the development of an oxygen sensor.

Verboven (BIOSYST-MeBioS, Belgium) investigated 3D imaging, a non-destructive method to detect internal disorders by means of X-ray and CT scans. These methods detect browning disorder, cavities, water-soaked tissues and dehydration. It is however currently too costly and time-consuming to be of practical value.

Rizzolo (CRA-IAA, Italy) noted three types of scald on Conference pear: brown, black and speckled scald. 1-MCP-treated fruit developed black scald in RA and initial low oxygen storage (ILOS), and brown scald in CA, ILOS and repeated ILOS, but to a lower extent than on untreated pears. Double (repeated) ILOS showed the highest percentage of healthy fruits, irrespective of 1-MCP treatment. Scald development was not prevented by 1-MCP treatment or by ILOS. However double ILOS gave the best control of scald.

Sanhueza (University Andres Bello, Chile) said that chilling injury (mealiness and browning) in nectarines can be reduced by using the following CA storage conditions: 5% O_2 and 15% CO_2 or RA at 4 °C for 21 days plus shelf-life at 20 °C. CA fruit were juicier than RA fruit.

Contreras (Michigan State University, USA) discussed preconditioning treatments of Honeycrisp apples to reduce physiological disorders. Honeycrisp apples were found to be sensitive to a previously undescribed injury (CA injury) comprising irregularly-edged brown patches in the cortex. CA injury severity declined when the preconditioning temperature was increased to 20 °C for 5 days: this almost completely eliminated the disorder. DPA treatment provided nearly complete control of CA injury. Injury severity increased as O_2 declined and CO_2 increased, and was evident within the first month of storage. The data suggest that earlier harvests have a greater potential to develop CA injury. 1-MCP controlled CA injury in RA.

The session on biochemical and molecular responses to CA conditions highlighted that biomarkers can be identified to predict internal disorders, identify the development of disorders during storage, and diagnose defects.

Watkins (Cornell University, USA) discussed the interactions between 1-MCP and CA storage on quality and storage disorders of fruits and vegetables. 1-MCP prevents ethylene production and reduces core flush and senescence. It however increases CO_2 disorders and flesh browning. The combination of 1-MCP and CA enhanced CO_2 injury and flesh browning. 1-MCP and CA reduced chilling injury in Japanese plums. Pre-harvest factors such as the use of Retain and Harvista can influence the development of postharvest CO_2 injury. DPA controls CO_2 injury. 1-MCP increases internal CO_2 injury in Honeycrisp apples and external CO_2 injury in Empire apples.

DeEll (MAF, Ontario, Canada) discussed the effects of 1-MCP and CA storage on the quality of Honeycrisp apples. Defects include loss of flavour, bitter pit, soft scald, soggy breakdown, senescence, greasiness, storage and lenticel decay. It is prone to CO_2 injury under CA conditions. CA storage at 2,5 − 3% O_2 and 1,5 − 2% CO_2 at 3 °C for 4 − 8 months reduced greasiness and soft scald. 1-MCP reduced greasiness and the internal ethylene concentration, and fruit had generally higher soluble solids and malic acid, compared to fruit without 1-MCP. Greasiness and soft scald were also reduced by CA storage. Internal CO_2 injury was aggravated by 1-MCP and/or CA; bitter pit was exacerbated by 1-MCP, and senescent browning was reduced by 1MCP in CA storage. Dr Jim Mattheis noted that Honeycrisp maintains its firmness very well in storage and further noted that acid at > 0,5% was the best harvest indicator. Van Schaik added that lower relative humidity storage conditions reduced internal browning.

<u>Meeting with Robert Prange and Angelo Zanella</u>

A meeting was arranged to discuss K van der Merwe's DCA project findings and possible adjustments. They approved the layout of the trials and were interested in the findings because of the built in shipping periods which they do not experience because of their close proximity to the markets. They were particularly interested in the project to determine the minimum DCA storage period to control scald as this was unknown to them. They confirmed that the results were in accord with their own findings. Zanella suggested that ethanol measurements be included if possible.

Prange noted that the Harvest Watch DCA software has a function to switch the sensors from pulsing to permanently on for 5 minutes, whereafter it is reversed to double check for unobserved anaerobic fermentation. This will be manifested by a gradual increase in the graph line. Zanella added that the sensors could be checked by switching on the cold room light for 5 minutes to see if the sensors react to the change in lighting conditions.

They were comfortable with the industry protocol for attaining DCA conditions in South Africa but added that the CO_2 level in the first oxygen pull-down phase should be adjusted to 3% O_2 plus 1% CO_2, instead of 1,5% CO_2. They further recommended that the research findings be published and presented without delay.

Posters

A list of posters is available, upon request.

Technical tour

The focus of this tour was on the Giuliano Puglia Fruit (www.giulianopugliafruit.it) packing facility focussing on cherries, grapes, peaches, apricots and artichokes, and most of the production is exported to other EU countries. The packhouse handles 150 −160 tons of cherries per day. The company is committed to R&D, carrying out experimental projects with the objective of improving product quality and processing. It is noteworthy that the extensive vehicle parking areas were covered by solar panels.

The tour was concluded with a visit to the world heritage site of Alberobella, a city of drystone dwellings.

Recommendations

Technology innovation in South Africa

International experts in DCA and DCR technologies should be brought to South Africa to inform industry of these technologies in the light of the recent banning of DPA in the EU. Given the volumes of SA fruit destined for the EU, packhouses need to make the mind shift of moving away from the use of DPA due to cross-contamination issues.

Identification of possible new projects

Adjust the current Abate Fetel CA storage project to include determination of the best O_2 level for CA storage.

Abate Fetel to be treated with SmartFresh^{SM}, including later picked fruit, and stored in RA.

Investigate the effect of 1-MCP application to DCA-stored fruit after storage, prior to shipment.

Test the DCR technique on apples and pears under SA conditions.

Determine the minimum DCA storage period, including intermittent storage periods, to control superficial scald on Packham's Triumph.

Presentation of DCA project results at next CA/MA conference

It is recommended that the findings of the DCA projects be presented at the next CA/MA conference.

Succession plan for next generation

Given the amount of information gained, it was a pity that there were not more members of our industry present. It was apparent how the younger member of our group could feed off the contacts and relationships made with international experts over the years. In this respect it is necessary for the younger generation to use the next CA/MA conference in four years' time to be introduced to the respective international experts by the older generation.