Postharvest management of broccoli

(and broccolini)

Not just sticking it in a box

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What is broccoli?

- An inflorescence (corymb)
- Growing, photosynthesizing, transpiring, respiring, flowering, making seeds….

Photosynthesis

Sunlight (energy) + CO_2 + H_2O ➔ Sugars + O_2

Respiration

Carbohydrates + O_2 ➔ CO_2 + H_2O + Energy

Respiration rate = Metabolic activity ≈ life

Is there a problem with broccoli quality?

Broccoli has an aura of health, looks great and tastes good, so why don't people buy more of it?

- Consumer research suggested that barriers to purchase include:
  - poor and inconsistent quality
  - short storage life
- 'Audits' conducted of randomly selected retailers in Sydney, Melbourne, Brisbane and Perth
  - What quality is the broccoli on display?
- Samples purchased for assessment of storage life
  - Does broccoli have the 7 days 'fridge life' that consumers expect?

The Good

The Bad

The Ugly

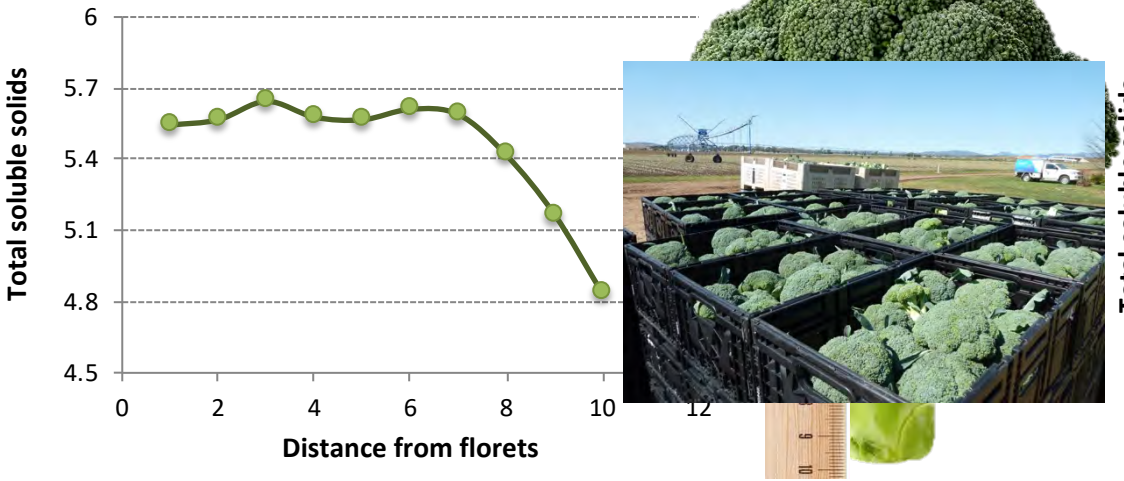
Yes, there is a problem with broccoli quality

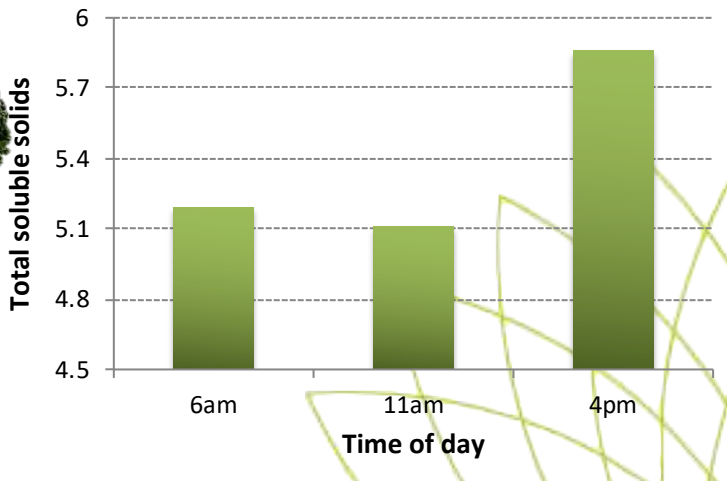
- **22.8%** of samples were only graded “OK” or worse
- **23.2%** of purchased samples failed to meet consumer storage life expectations
- There was no relationship between price and either initial quality *OR* storage life

YES, it’s TRUE, retail quality of broccoli **IS** inconsistent and lacking in freshness

Harvest

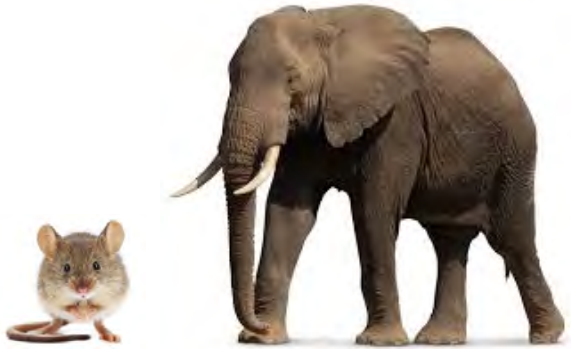
- Cut off from water, nutrients and sunshine

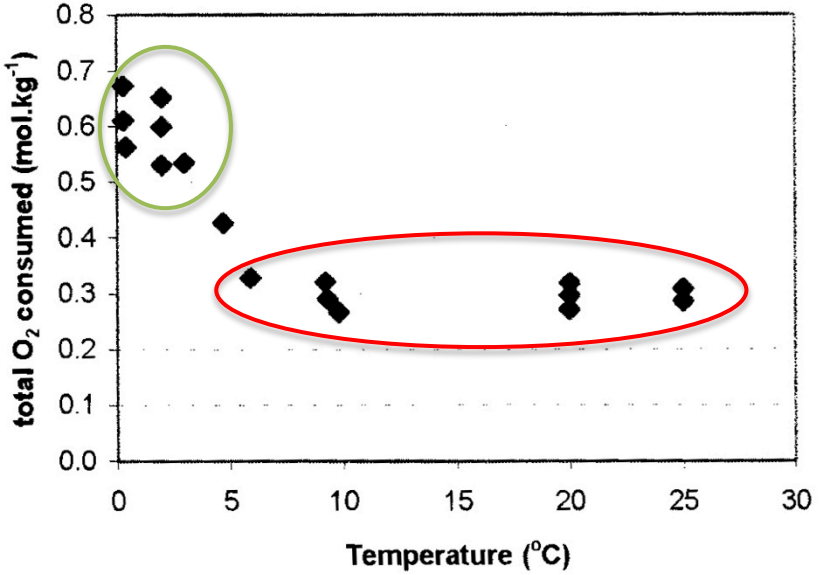




Harvest

- Broccoli has limited storage reserves
  - The faster it uses them up, the sooner it dies
- Respiration “life”
  - Respiration = metabolic activity = life





Harvest

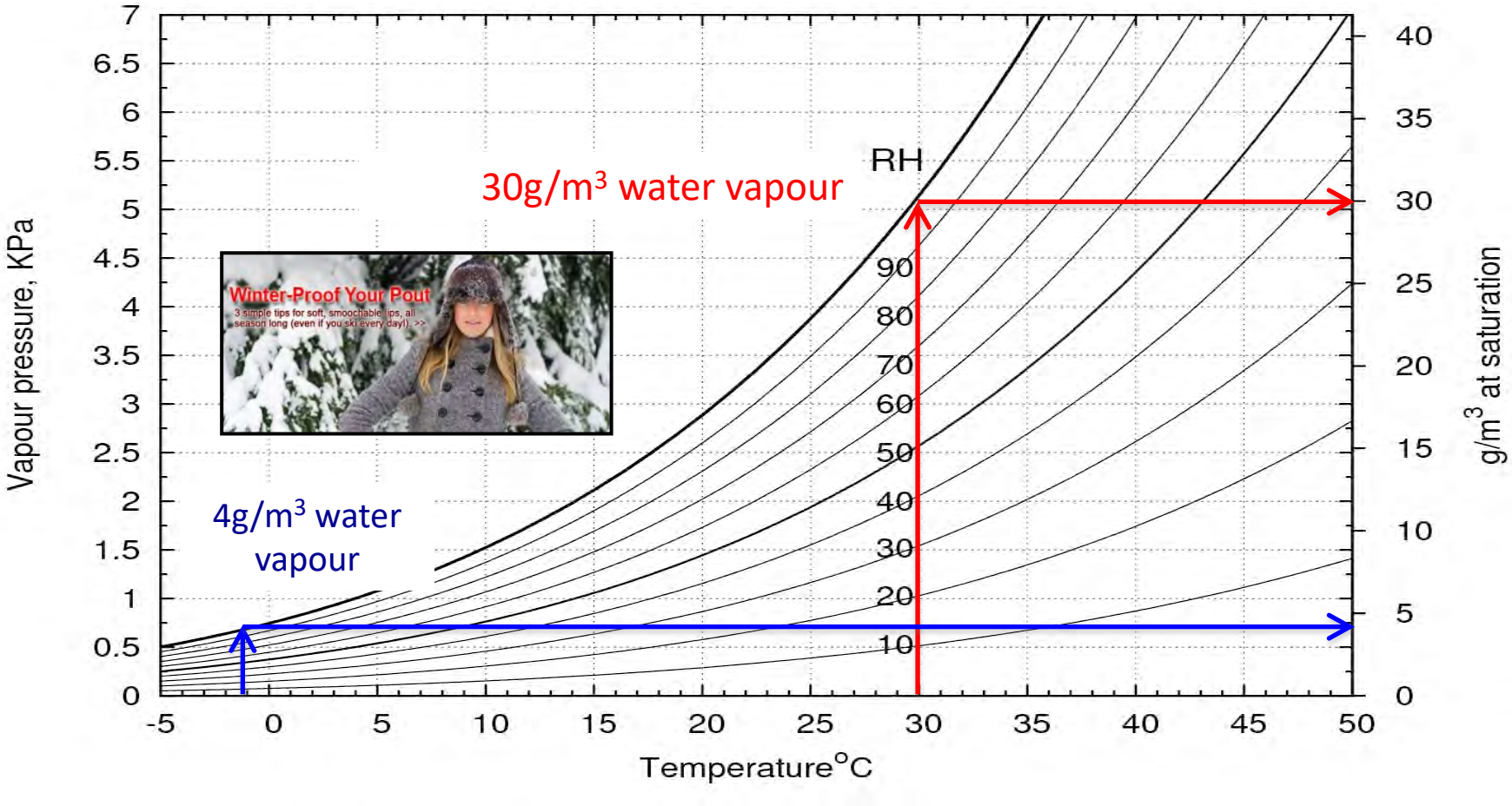
- Handle like a cut flower not a football
- Transfer to the packing shed **ASAP**
  - Can lose 6% moisture sitting in the field postharvest



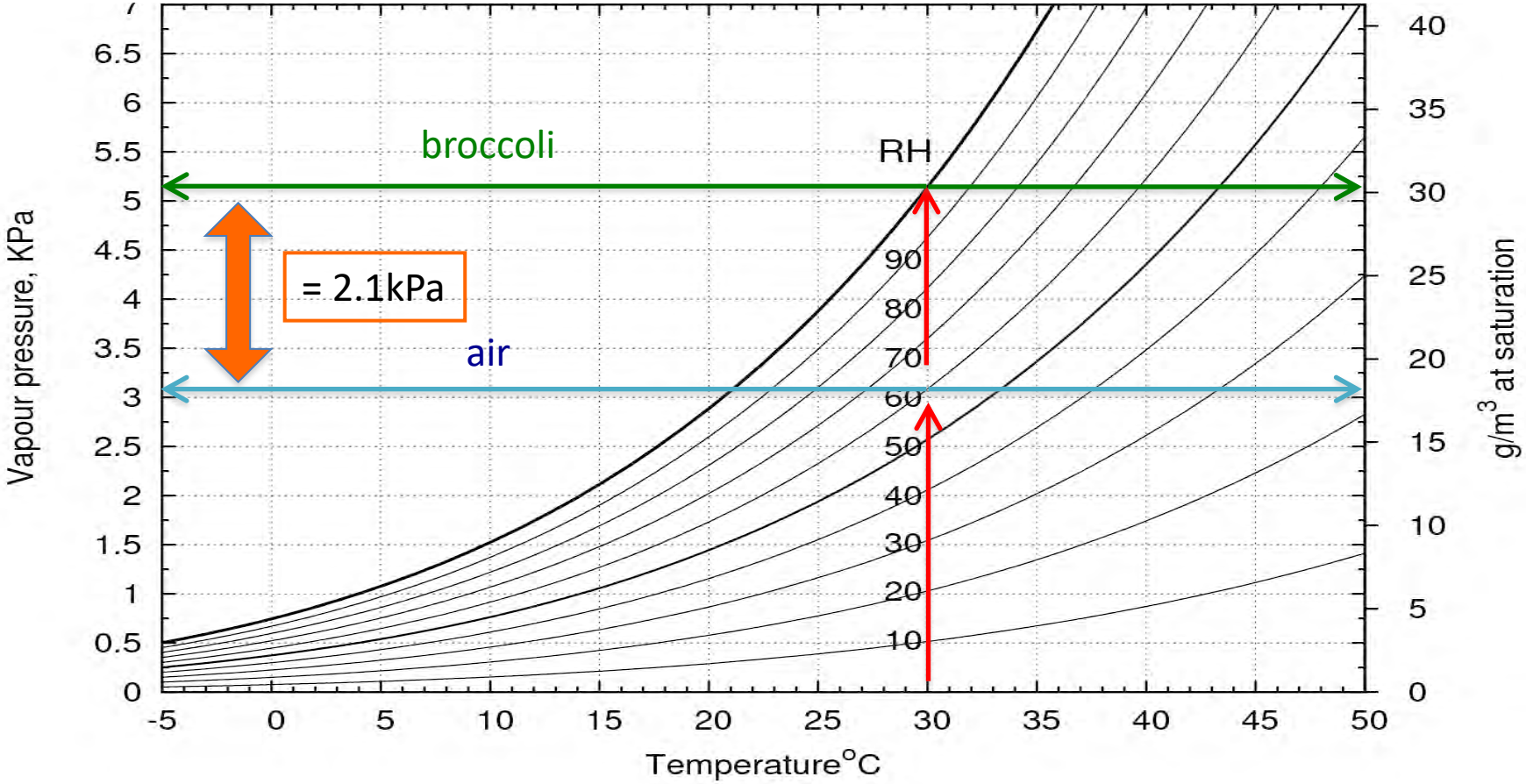

Cooling after harvest

- Temperature is the most important factor determining storage life and quality of broccoli
- While broccoli is warm it is
  - Burning up its storage reserves
  - Losing moisture
  - Producing ethylene
  - Responding to ethylene

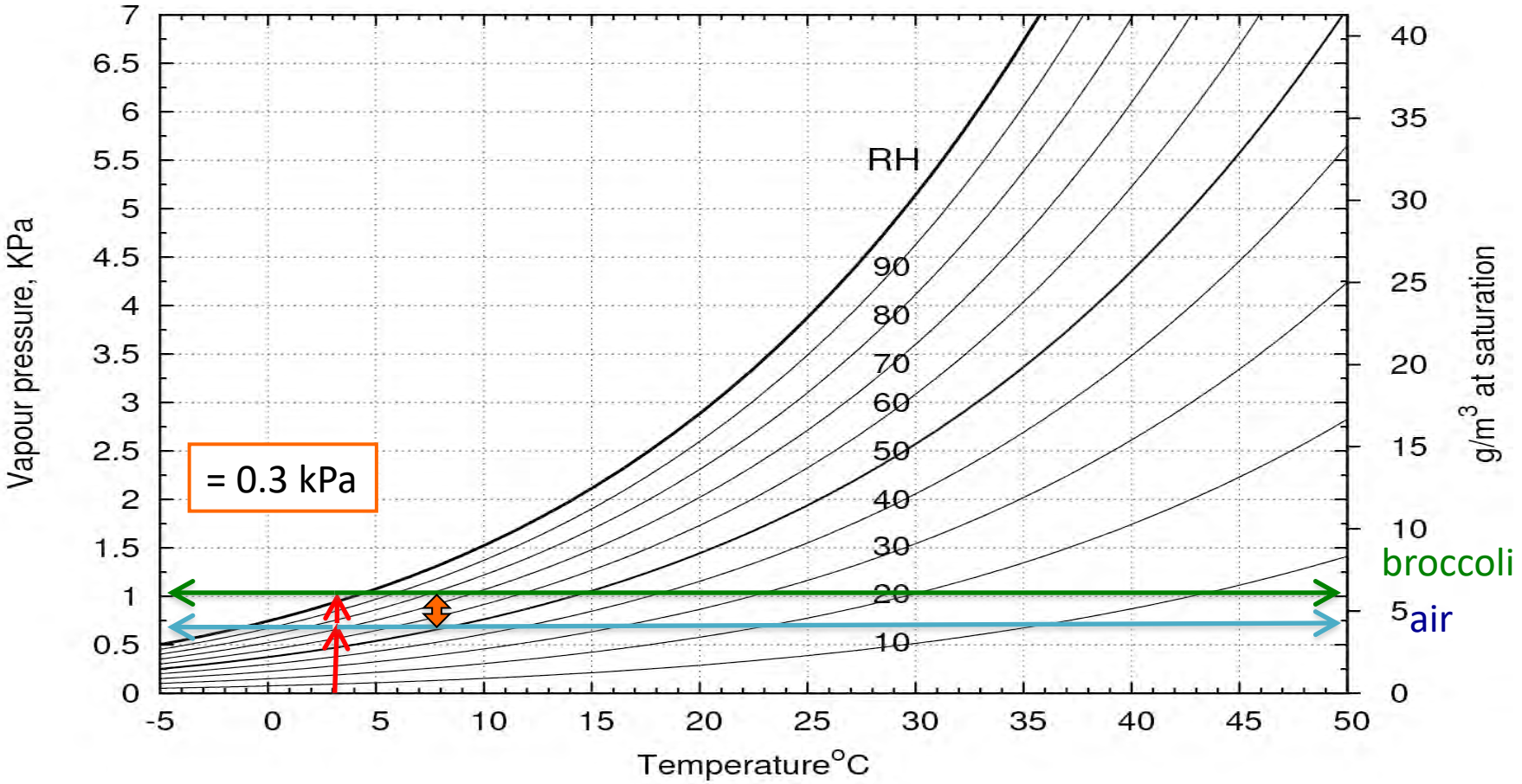
Vapour pressure deficit – the psychrometric chart



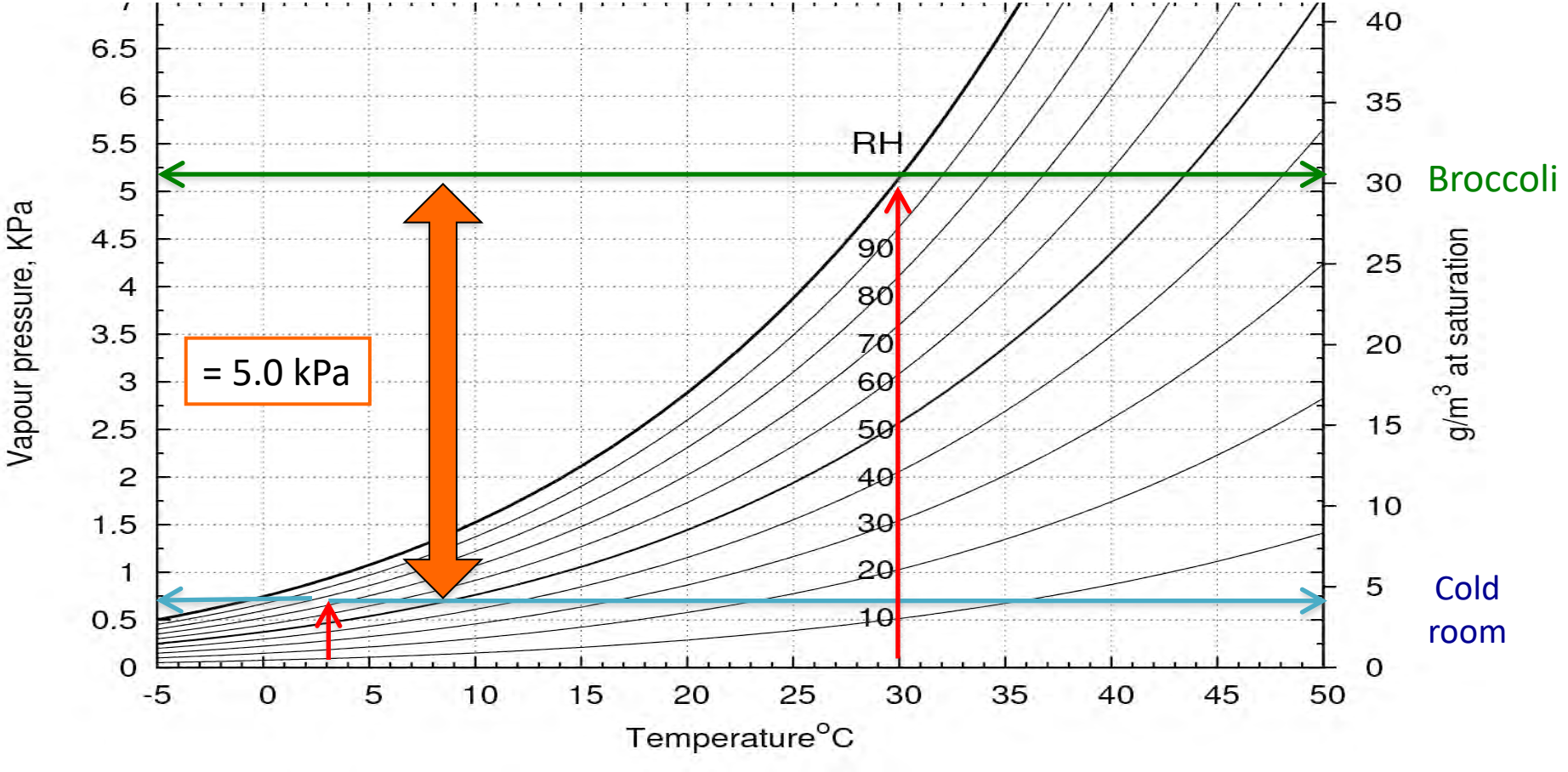
Harvest on a warm, dry day in Gatton (30°C + 60% RH)



In storage (4°C + 70% RH)

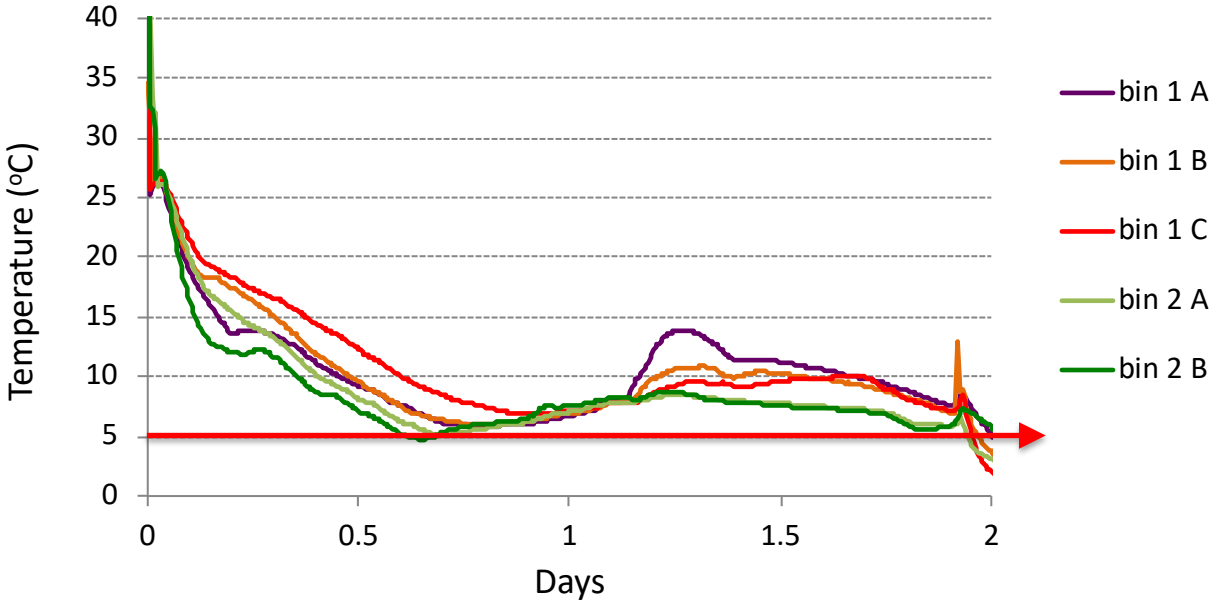


After harvest, no pre-cooling (warm broccoli into cold room)



Room cooling can be slow

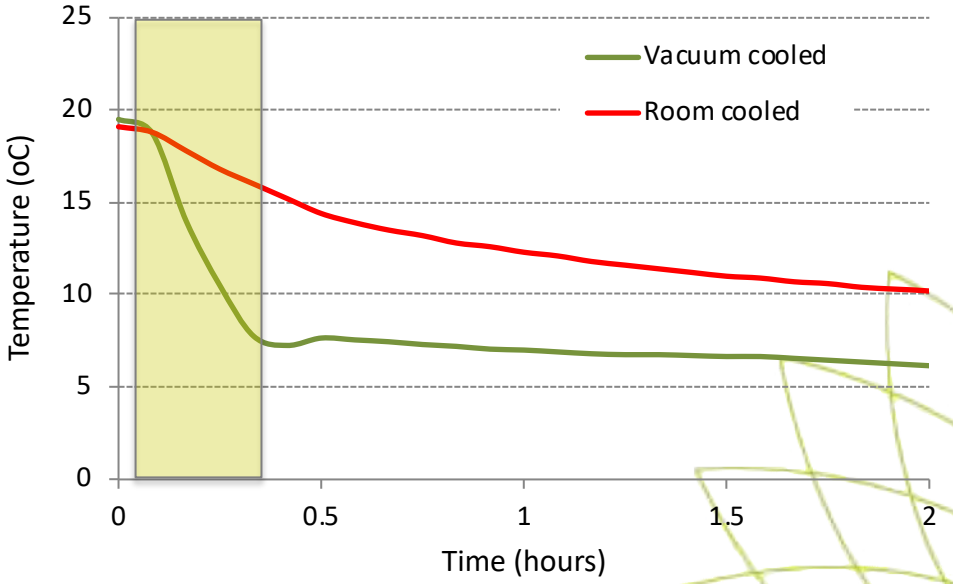
- A hot day in Gatton….



Vacuum cooling is fast

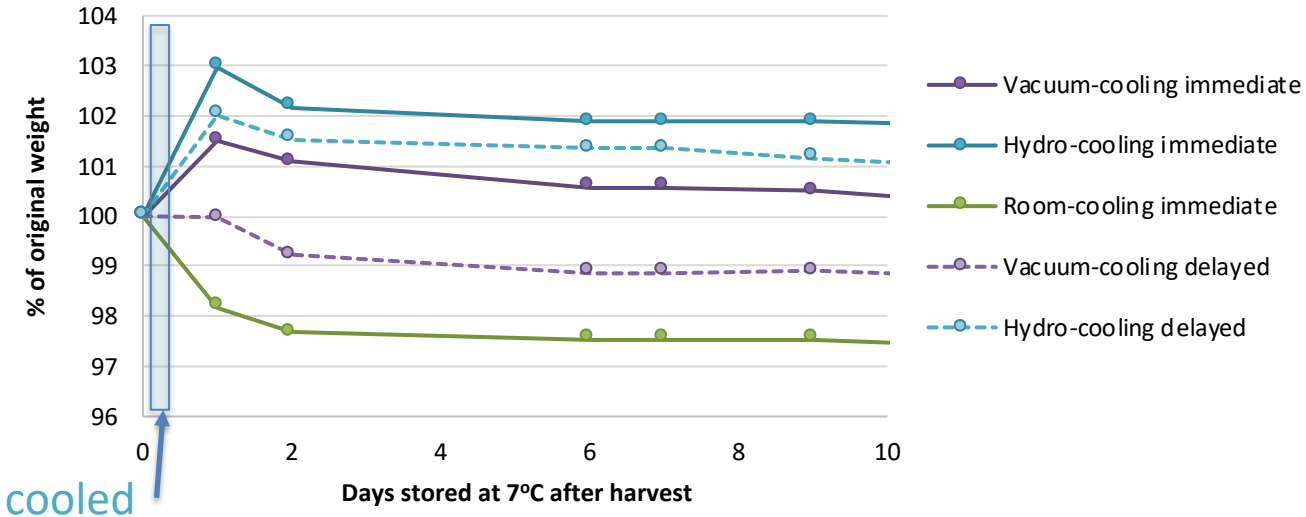
Vacuum cooling is fast

- Broccoli can cool by 11°C in 15 minutes
- More efficient use of cold room space



Hydro-vacuum (and hydrocooling) can add moisture

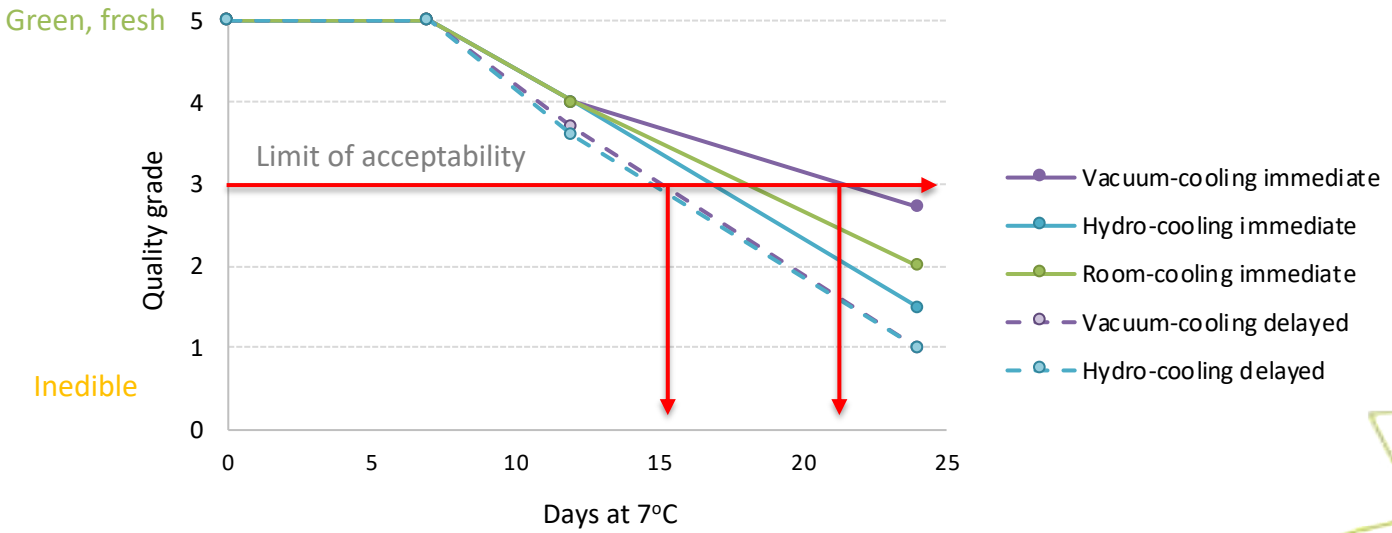
- Broccoli can **lose** up to 6% weight between the field and the packing shed
- But it can **regain** some weight during cooling!



Weight gained during cooling is retained during storage

Benefits from rapid cooling continue during storage

- Broccoli that was vacuum cooled immediately had the best storage life



Packing – to ice or not to ice

ICE is good

- Expected by some customers
- Protects against temperature fluctuations = cheap insurance
- Looks good in the box
- Keeps broccoli hydrated
- Styrofoam boxes are strong

ICE is bad

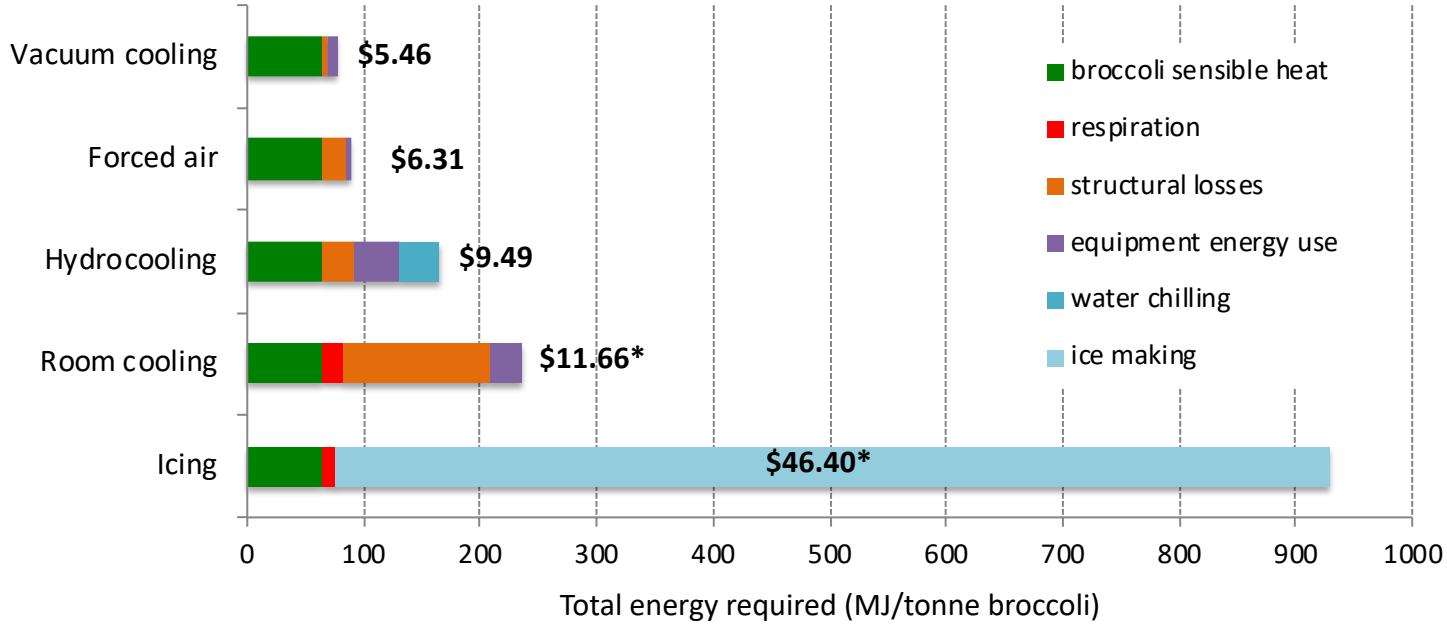
- Only cools if it is melting
- Broccoli sitting in water rots, splits and discolours
- Ice is below 0°C (~-20°C) so can cause freezing damage to florets
- Producing ice uses energy + potable water
- Transport costs increase
- Styrofoam boxes will outlive the human race

Packing broccoli in ice

- To cool 1t of broccoli from 25^{o}C t 5^{o}C would require approximately;
  a. 20kg of ice
  b. 50kg of ice
  c. 100kg of ice
  d. 300 kg of ice

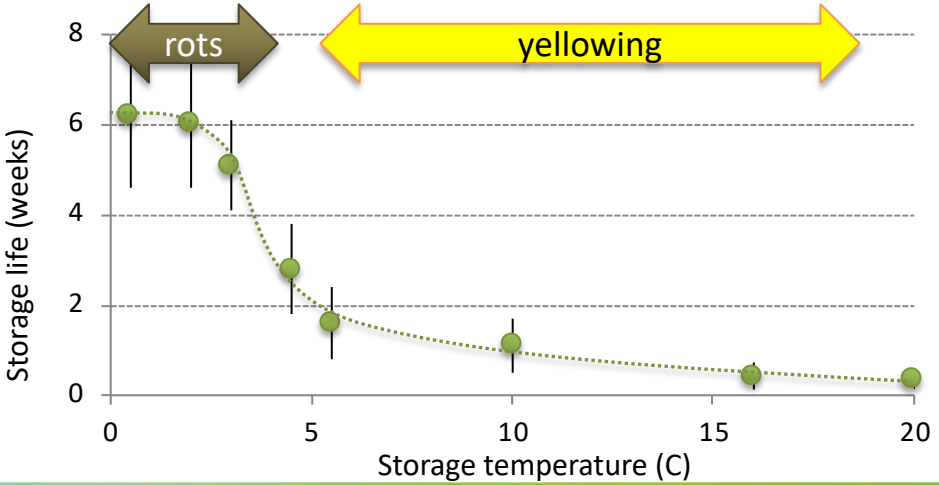
Ice is an inefficient way to cool things

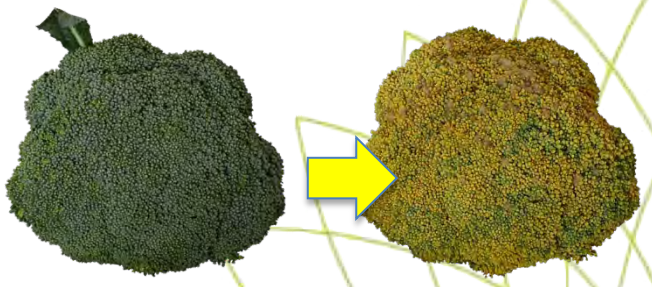
Cooling costs



Storage – what temperature?

- Storage life is maximized at 0°C ***BUT***
  - Holding at 0°C is expensive and can potentially freeze the product
  - So long as temperature is <5°C, broccoli can remain in good condition for several weeks



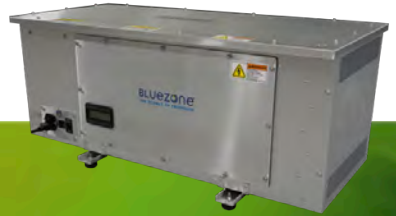


Managing ethylene

- Ethylene sources include some vegetables (corn, carrots), fruit, rotting materials and…. warm broccoli
- Only 1ppm ethylene (0.0001%) can increase yellowing, stimulate rots, reduce quality
- BUT effects of ethylene on broccoli are reduced **below 5°C**
  - Limited benefits from minimising ethylene in rooms running at 2-4°C

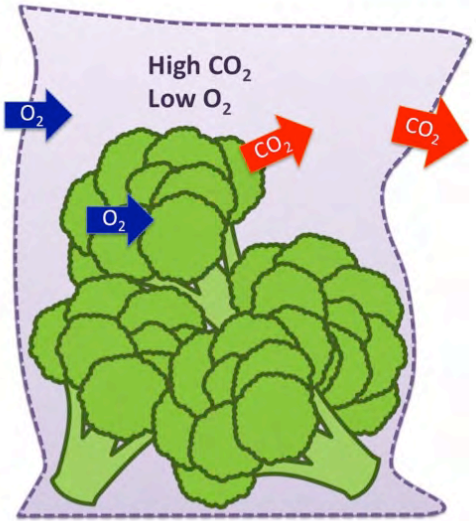
Managing ethylene

- If you **do** need to reduce ethylene in storage rooms
  - Scrub with potassium permanganate
  - React with ozone (but be ***very*** careful)
    - Reacts with ALL organic molecules
    - Limit of **0.1ppm** for human health in workplaces
    - Need to either trap the ozone *OR* use overnight then vent it *OR* use very low levels and monitor in real time
  - React with UV-C light
    - UV-C light may be generating ozone too



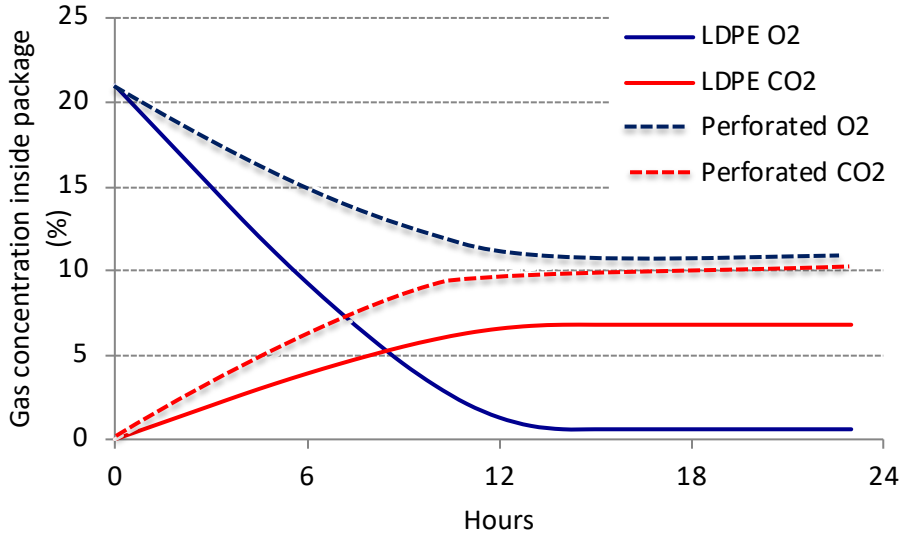
Protecting from ethylene – MAP

- Modified atmosphere packaging uses respiration by the product to change the atmosphere inside a package
- Key is elevated CO_2
  - Inhibits ethylene action
  - Delays breakdown of chlorophyll (yellowing)
  - Reduces respiration rate (maybe… a tiny bit)
- Important not to accumulate too much CO_2 as it gets a bit stinky

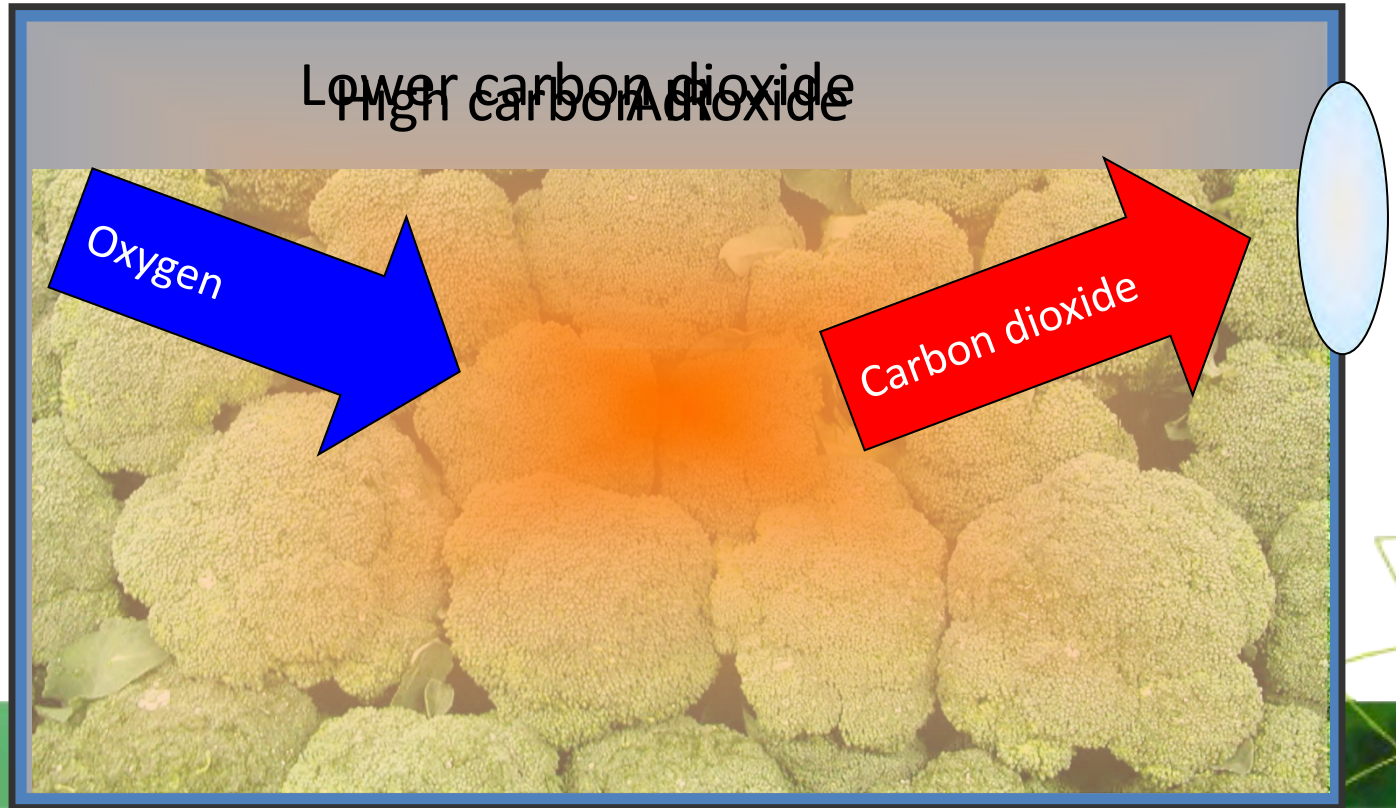


Modified atmosphere packaging

- Broccoli colour is preserved by 7 to 10% CO_2
- Atmosphere depends on film type
  - Most films more permeable to CO_2 than O_2
  - Perforated films equally permeable to both
- Temperature affects respiration rate
  - ↑ temperature = anaerobic
  - ↓ temperature = package ineffective
- Broccoli under MAP can get a bit smelly if the atmosphere is not maintained



Modified atmospheres for export



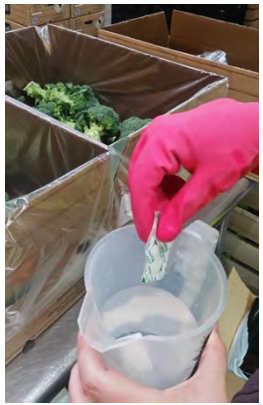
Protecting from ethylene – **1-MCP**

- 1-methycyclopropene or “SmartFresh” makes products insensitive to ethylene
- Applied as a gas at low concentrations (1ppm)
  - Undetectable after treatment
  - No human health effects
- Widely used to delay ripening of fruit, especially apples
- Registered for fumigation of broccoli
  - BUT fumigation is hard to fit into normal supply chains ….
- Trials – new “InBox” system

Fumigation

SmartFresh trials – InBox

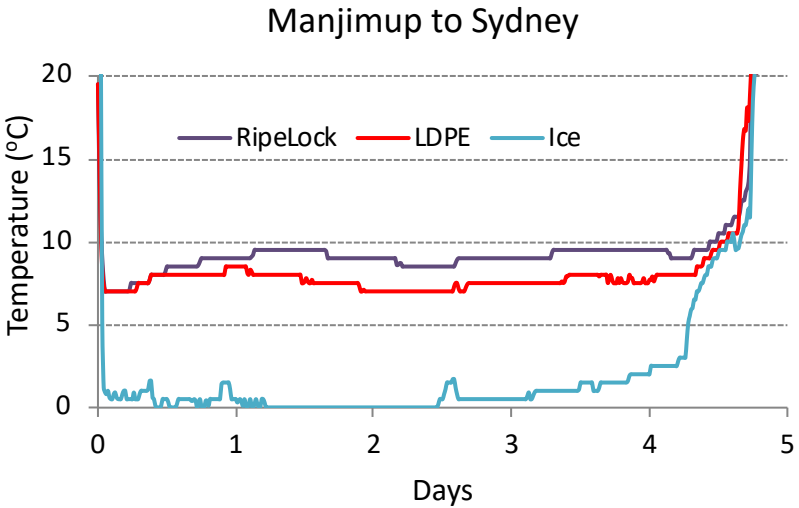
- InBox sachets can easily be added while packing pre-cooled broccoli
- Used in combination with RipeLock liner

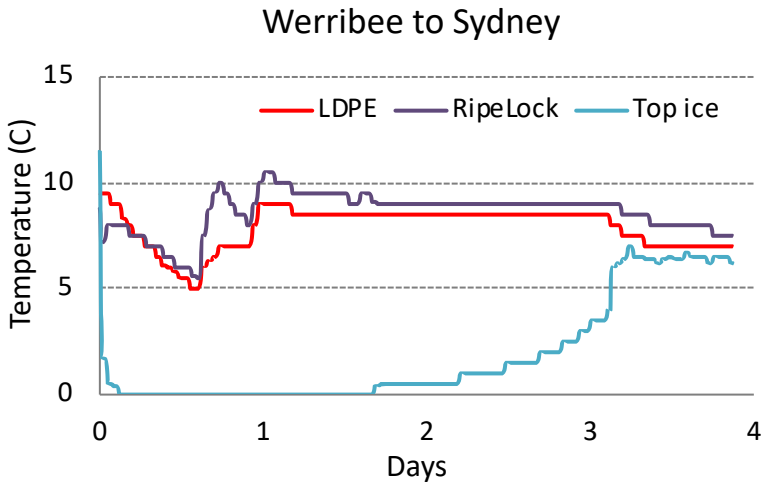


Trial locations

Results - temperature

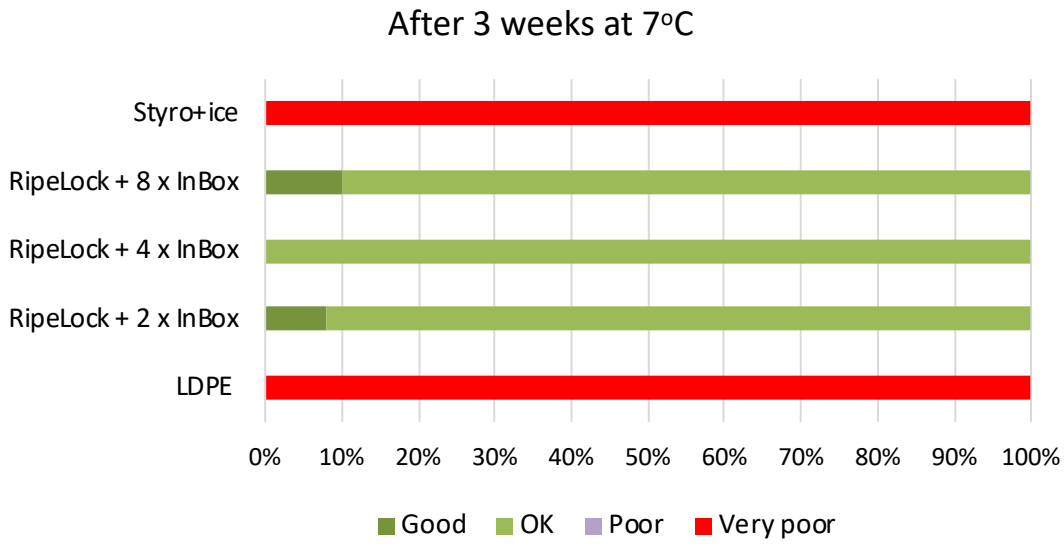
- Temperature management was terrible!
  - But the iced broccoli were protected!! No wonder packers still use it……..





Results

- SmartFresh protected broccoli from temperature abuse



Manjimup

Werribee broccoli, after 2 weeks at 7°C

Top ice

Ripelock +
4 x InBox

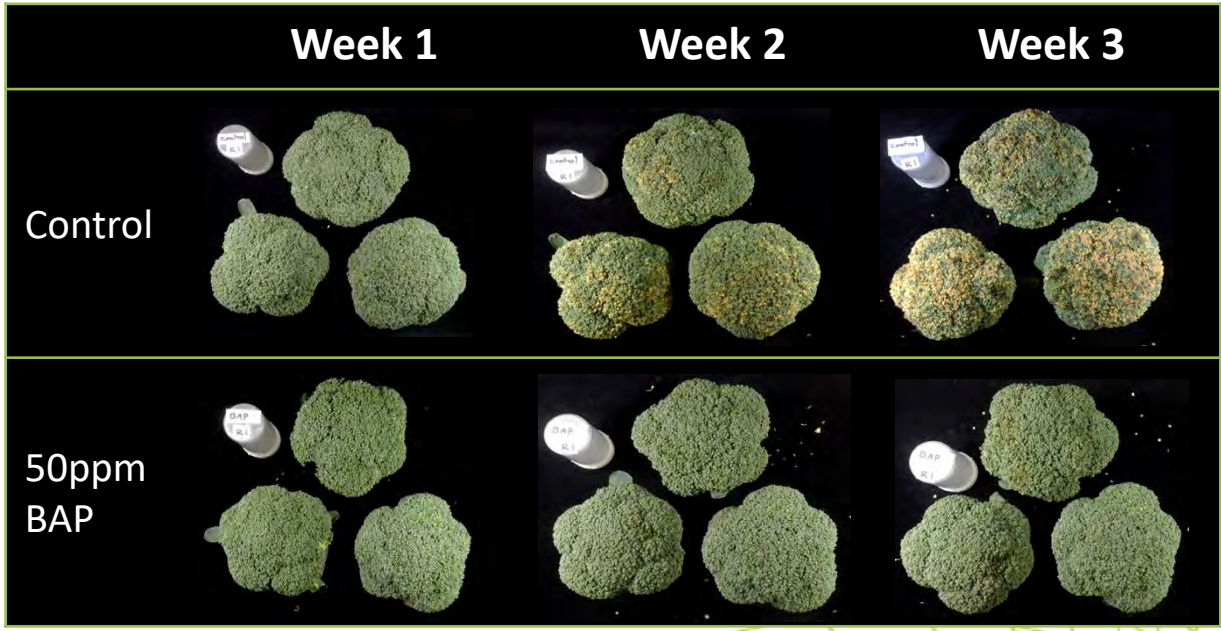
Ripelock +
8 x InBox

LDPE

Registration of InBox is currently with the APVMA
Approval is expected by April next year
Broccoli will **definitely** be on the label!

Another option…

- Benzyladenine purine or "BAP"
- Analogue of a natural plant hormones, so *may be* "generally recognised as safe" (GRAS)
- Increases cell division
- Not registered



Conclusions

Improving the quality of broccoli at retail can increase sales

- **Best practice;**
  - Harvest carefully
  - Cool as soon and as fast as possible
  - Store at 2 to 4°C
  - **If** temperatures during storage / transport cannot be kept below 5°C
    - Consider top-icing
    - Control / reduce ethylene
- **For export or storage >3weeks**
  - **Control temperature @ 0°C**
  - Consider using controlled / modified atmosphere packaging
  - Fumigate with 1-MCP or use “InBox” when this technology becomes available
    (if registered in destination market)

Thankyou!