

# Broccoli

*Brassica oleracea var. italica*



## Best practice

Broccoli is a flower bud or, more technically, an immature, swollen inflorescence. Although the florets do not open after harvest, they have a fast respiration rate, respond strongly to ethylene and yellow rapidly under ambient conditions.

Harvest maturity is based on the head diameter required by the market. Several picks are often needed to ensure each harvest lot has even maturity and size. Overmature heads are characterised by loose, open florets and have reduced shelf life.

Broccoli should be cooled below 5°C as soon as possible, especially if it has been harvested under warm conditions. Below 5°C ethylene sensitivity is reduced, whereas above 5°C heads yellow far more quickly.

Hydro-vacuum cooling is the best cooling method in terms of outturn quality and energy consumption. If using hydrocooling, it is important to allow enough time for the core to thoroughly cool. Forced air cooling can also be effective. Room cooling in bins is not recommended.

Broccoli should not be stored wet as this increases stem rots and discolouration of the cut leaf bases. It should also be handled gently, as the delicate florets are easily bruised and broken.

Cooled broccoli is still commonly packed in styrofoam cartons with top icing. This keeps the product cool, hydrated and protected during storage and transport, and is expected by some customers. However, this practice has significant cost disadvantages (carton cost, ice making and transport), potentially increases rots and is environmentally unsustainable.

Increasingly, broccoli is being field packed. Reducing handling decreases costs as well as potential damage to the heads. Packed cartons can be effectively hydro-vacuum or forced air cooled. As long as the cold chain is maintained, broccoli packed this way should have superior quality to broccoli packed in styrofoam with ice.

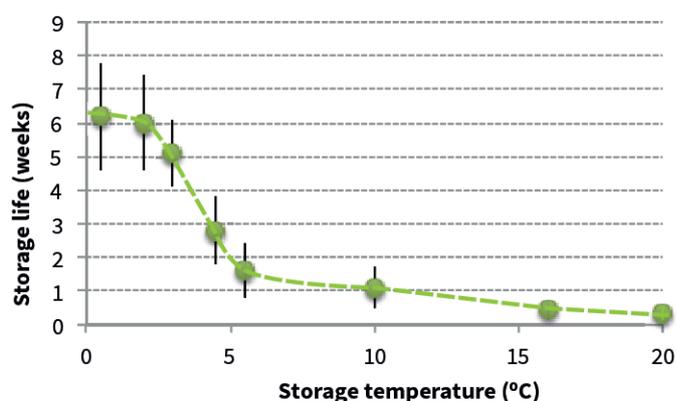


Broccoli can be field packed directly into crates, reducing cost and potential damage from re-handling

## Storage life

Storage life is maximised at 0°C combined with high relative humidity. Storage life is relatively unaffected between 0 and 2°C, broccoli usually remaining in excellent condition for at least 3–5 weeks at this temperature.

Below 5°C storage life is usually ended by the onset of rots. Above 5°C, floret yellowing (due to ethylene) and general deterioration end storage life.



Storage life of broccoli at different temperatures, bars indicate the likely range around each mean value

## Key points

- ▶ Broccoli is an immature flowering head. It has a fast respiration rate and is very perishable.
- ▶ Broccoli should be handled carefully to avoid damaging the delicate florets.
- ▶ Cooling below 5°C as soon as possible after harvest is essential to retain quality. Hydro-vacuum cooling is the best way to cool broccoli.
- ▶ Storage life is maximised at 0°C, but broccoli will remain in excellent condition for up to 6 weeks at 1–3°C.
- ▶ Exposure to ethylene accelerates yellowing of the florets, especially at temperatures over 5°C.
- ▶ Top icing keeps product cool and is expected by some customers. However, this practice increases costs. If the ice melts then rots and stem splits are increased.
- ▶ Modified atmospheres can benefit broccoli if storage times are longer than 3 weeks.

# Broccoli

Broccoli responds well to modified atmospheres (MA) if stored for an extended period (>3 weeks). Atmospheres containing 7–10% CO<sub>2</sub> are usually recommended. Oxygen concentration is less important, but should generally be 2–10%.

MA storage can slow the onset of rots and retain green colour. Off-odours may occur, but these normally dissipate after a few hours in normal air. A more serious issue is that broccoli may appear in excellent condition on removal from MA storage but deteriorate rapidly during retail.

Treatment with SmartFresh (1-methylcyclopropene) has been demonstrated to delay yellowing of broccoli by reducing sensitivity to ethylene. The effects of treatment are retained during storage, resulting in improved quality during and after retail display.



Hydro-vacuum cooler loaded with broccoli bins

## Weight loss

- ▶ Broccoli can gain up to 5% weight during hydrocooling or hydro-vacuum cooling.
- ▶ Broccoli can lose up to 6% weight and still remain marketable.
- ▶ Broccoli that has lost >7% of its initial weight will be soft and unacceptable.

Weight loss during storage, transport and retail may be estimated using the data shown in the table below. Note that weight loss will be significantly slower for packed product and will vary according to carton and packaging type as well as ventilation rate.

*Average percent weight loss per day for unprotected broccoli at different temperatures and humidities, ± values represent 95% of the predicted range.*

Relative Humidity	Temperature				
	0°C	2°C	5°C	10°C	20°C
40%	3.0 ±1.4	3.5 ±1.4	4.3 ±1.5	5.5 ±1.5	10.2 ±1.6
60%	2.2 ±1.4	2.5 ±1.4	3.1 ±1.4	3.9 ±1.4	7.0 ±1.5
80%	1.4 ±1.4	1.5 ±1.4	1.8 ±1.4	2.2 ±1.4	3.8 ±1.4
90%	1.0 ±1.4	1.0 ±1.4	1.2 ±1.4	1.4 ±1.4	2.2 ±1.4
100%	0.0	0.1	0.2	0.5	1.4

## Summary

Storage conditions	Optimum temperature	0°C
	Optimum RH	95–100%
	Storage life (best)	6 weeks
	Storage life at 5°C	2–3 weeks
Cooling	Cooling method	Hydro-vacuum cooling is highly recommended. Hydrocooling or forced air systems are also suitable.
	Freezing point	-0.6°C
	Susceptibility to freezing	Moderate
	Chilling sensitive?	No
Physiology	Respiration rate	High
	Ethylene production	Low
	Ethylene sensitivity	High – results in yellowing of florets and increases disease.
Packing	Cleaning	Harvest clean and pack. If necessary wash with a sanitiser.
	Rate of water loss	Very high, can benefit from POS packaging but not generally used.
	Display	Can be displayed on ice, best displayed refrigerated.



Packing broccoli into styrofoam cartons, ready for top-icing, and the finished product on display at the markets

# Broccoli

## Diseases

### Alternaria spot – *Alternaria* spp.

Dark grey to black spreading spots appear, usually with distinct margins. Rarely found on heads, but can occur on stems, particularly broccolini.



### Bacterial head rot – *Erwinia* spp., *Pseudomonas* spp.

A common postharvest disease, especially in broccoli stored for an extended period. Infection often occurs in the field, but symptoms develop after harvest. Increased by prolonged wetness, as can occur if ice melts inside cartons.



### Bacterial soft rot – *Pectobacterium carotovorum*

A wet, slimy rot with an unpleasant smell. Most often found in the stem, but can also infect the head. Associated with prolonged wetness, as can occur if ice melts inside cartons.



### White blister – *Albugo candida*

White blister causes broccoli florets to enlarge, sometimes with white petals becoming visible. Heads are distorted. Anything greater than a mild infection makes heads unmarketable.



Photo: S Grigg

## Disorders

### Hollow stem

Hollow stem is caused by boron deficiency during growth. The stems are brittle and split, developing internal brown, corky lesions. Brownish lesions may also appear on florets.

Photo: NSW DPI



### Physical damage

Broccoli florets are easily crushed and broken, especially during harvest and packing. Careful handling is essential to prevent damage.



### Purpling

Broccoli grown under cold conditions can develop a purplish tone, especially on the tops of the florets. This disorder is highly variety dependant.



### Yellowing

Yellowing results from ethylene exposure and / or general senescence at over 5°C. Individual florets yellow first, but the effect soon spreads. At 20°C, yellowing can occur within 2–3 days of harvest.



## Grading



1



2



3



4



5

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