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Improving quality and extending shelf life of broccoli heads through ethylene management

In order to meet the fluctuating demand for broccoli by the retail sector and to ensure a year-round supply for UK consumers, broccoli needs to be stored for periods of up to two to three weeks.

Ethylene is a natural hormone produced by plant tissues, including broccoli heads, which speeds up the rate of deterioration. As well as being produced naturally, ethylene can also be introduced into the storage atmosphere through commercial activities such as the use of propane or diesel-powered forklift trucks. This factsheet outlines results obtained through AHDB Horticulture-funded project FV 395, and describes how the management of ethylene in the storage atmosphere and/or the use of chemicals that reduce the impact of ethylene can improve quality and extend shelf life of broccoli heads.



Figure 1. Stages of deterioration in broccoli

Action points

- Background ethylene concentrations in stores can be reduced through the use of electric-powered rather than internal combustion-powered forklift trucks in confined storage spaces. If this is combined with the use of ethylene scrubbers it can lead to improved storage and increased shelf life of broccoli.
- A split application of 1-Methylcyclopropene (1-MCP) at a rate of 312 parts per billion (ppb) applied at harvest, and a second application after three weeks of storage, has been shown to reduce the onset of senescence during shelf life (18°C).

Background

In order to meet fluctuating demand by the retail sector and to ensure a year-round supply for UK consumers, broccoli needs to be stored for periods of up to two to three weeks. Moreover, the year-round demand for broccoli in the UK necessitates the import of produce overland from Spain and other Mediterranean countries between December and May. Maintaining the quality of UK-stored product and that of imported broccoli requires intervention in the supply chain to ensure that broccoli maintains a fresh, green appearance with minimal water loss.

The loss of product quality due to the rapid onset of senescence is controlled by the interaction of a number of plant hormones including ethylene, which play a key role in senescence (death) of green tissues. As a gas, ethylene is one of the few hormones that can also stimulate responses in adjacent produce. The removal of ethylene from the environment during handling/storage of certain perishable produce is increasingly being recognised as an effective strategy to improve quality and extend shelf life.

The use of chemicals that can block the response to ethylene, or reduce its production within plant tissues, has also been investigated and is used commercially for a range of commodities. For example, in the UK, SmartFresh™ (1-MCP, which inhibits the response of plant tissues to ethylene) is used routinely on apples at the start of storage to delay the onset of ripening and ethylene-induced physiological disorders. An Extension of Authorisation for Minor Use (EAMU) exists for its use on broccoli after harvest. Some initial findings on the use of SmartFresh™ post-harvest application are presented here.

Management of ethylene in packhouses and storerooms

Ethylene in the atmosphere

Laboratory trials confirmed the effect of ethylene in the atmosphere on the rate of deterioration of broccoli heads. Concentrations as low as 250 ppb in the atmosphere accelerated the rate of deterioration significantly. This is illustrated by figure 2, which shows the results of a visual assessment of heads stored in 'clean' air (control), in 100 ppb, or 250 ppb ethylene. After two days at ambient temperature, (SL2) control broccoli heads kept in an ethylene scrubbed environment showed no senescence, but 28% of those stored in 250 ppb ethylene were showing senescence.

Measurement of ethylene within the atmosphere at commercial broccoli handling facilities gave an insight into the ethylene concentrations commonly found in the commercial situation. Concentrations in the field where there would be considerable ventilation, and in the packhouse, which is also well ventilated, were not at levels that we would expect to impact on broccoli quality. However, unventilated storerooms and enclosed areas accumulated the greatest amount of ethylene. The conclusion is that, in most facilities, the removal of ethylene through ethylene scrubbing machines would have beneficial effects on broccoli quality.

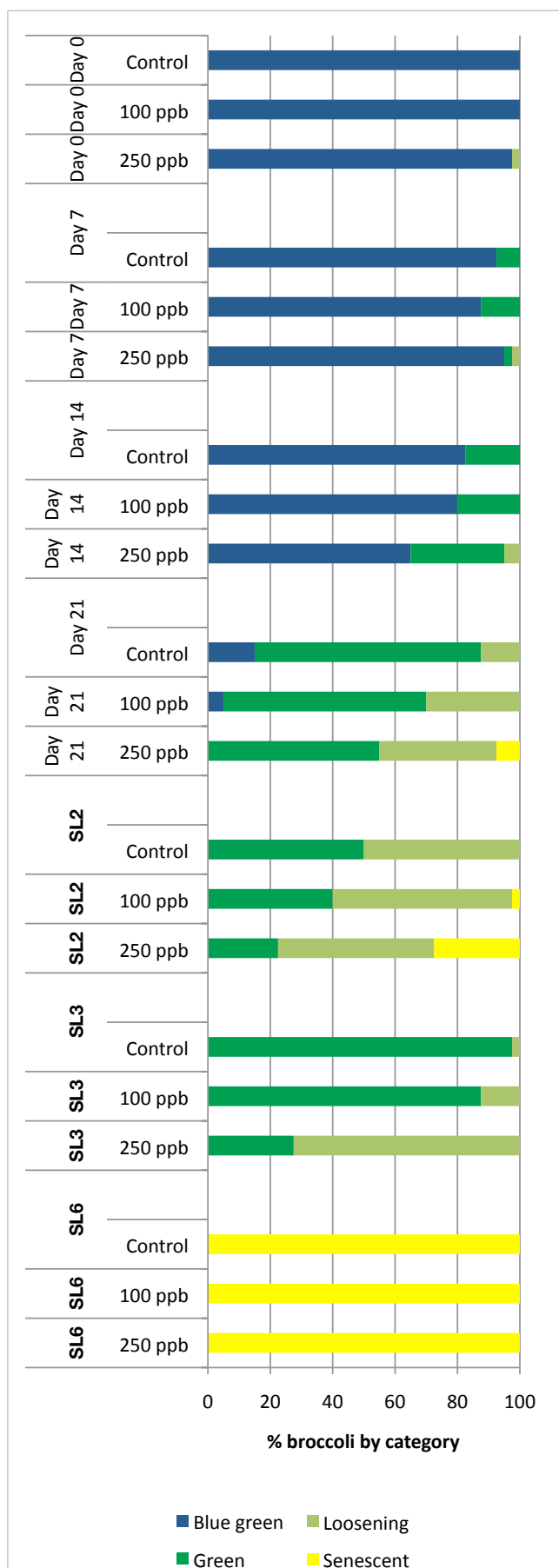


Figure 2. The state of broccoli heads cv. Ironman following three weeks storage at low temperature (1°C) in air or air contaminated with ethylene at 100 and 250 ppb respectively and then moved into ambient temperatures. SL2 indicates two days stored under shelf-life (ambient) conditions

Table 1: A summary of ethylene concentrations measured in air samples taken from a range of locations through the broccoli handling chain.

Location	Ethylene concentration in the atmosphere
Harvesting rig	0–3 ppb
Packhouse	10–50 ppb
Storeroom	7–>400 ppb

A range of suitable ethylene scrubbers is available on the market that work by many different mechanisms: UV photo catalyst, heated nickel or platinum catalyst, passive oxidation by potassium permanganate, or ozone scrubbers. Commercial tests on the effects of ethylene scrubbers were carried out. It was concluded that effective removal of ethylene from the atmosphere requires both the use of scrubbers and avoiding the use of machinery such as propane or diesel powered fork-lift trucks. With both strategies in place ethylene can be kept below 100 ppb, thereby preventing the acceleration of senescence by ethylene.

When testing the effectiveness of an ethylene scrubbing system in a commercial facility it is advisable to carry out air testing to confirm that the system chosen is working. It is difficult to find cheap ethylene monitors that are accurate at the low concentrations to which broccoli is sensitive. The best solution is to find a research organisation that has access to laboratory equipment such as gas chromatograph and make arrangements for testing to be conducted.

Chemical blocking of ethylene action

1-methylcyclopropene (1-MCP) is a chemical that blocks ethylene perception in plants and, therefore, reduces ethylene stimulated effects such as senescence of vegetables and ripening of fruit. This can be applied in a formulation (SmartFresh™) in which the gas is encapsulated in a spray-dried powder, such that addition of water releases the 1-MCP gas into a sealed environment. The standard application rate used for fruit is 625 ppb for 24 hours at storage temperature. During project FV 395, the most effective treatment for broccoli was found to be a split dose (312 ppb) at harvest and after 21 days storage. Figure 3 shows that this treatment has a very marked effect in reducing the rate of broccoli head yellowing.

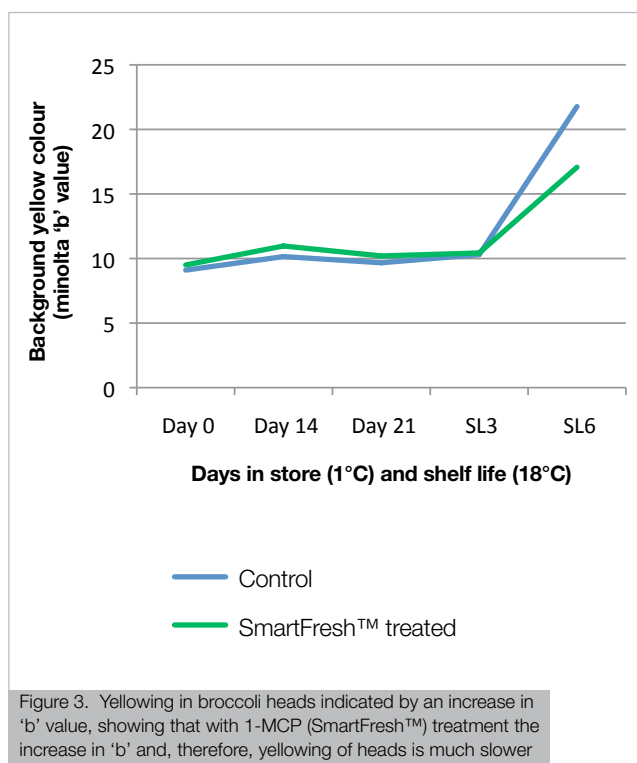


Figure 3. Yellowing in broccoli heads indicated by an increase in 'b' value, showing that with 1-MCP (SmartFresh™) treatment the increase in 'b' and, therefore, yellowing of heads is much slower

Further information

Useful AHDB project reports

AHDB Horticulture project FV 395 Ethylene management to improve quality and extend shelf life of broccoli.

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