Grower Summary

CP 079

Understanding the underlying mechanisms and the role that pre-harvest horticultural maturity, agronomic factors and growing conditions have on postharvest discolouration in celery

Annual 2014

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

Further information

If you would like a copy of this report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Industry Representative:	Dr Ed Moorhouse
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GROWER SUMMARY

Headlines

- Celery cut-browning and pithiness increase with crop maturity; browning also increases with storage time.
- The postharvest application of exogenous ethylene and 1-methylcyclopropene (1-MCP) did not significantly influence browning.

Background

Celery (*Apium graveolens* L.) is a foliage crop whose long and thick petioles are consumed . It is considered an important crop because it contains several bioactive molecules which have positive effects on human health (especially anti-cancer and anti-inflammatory) (Winston, 1999). Celery is quickly marketed after harvest in order to maintain its freshness and palatability so that it can be better appreciated by consumers. Yet, due to the fact that celery has a high water content, (about 95%) it is highly perishable, thus, susceptible to losing its quality during postharvest storage. One of the problems affecting celery is postharvest browning at cut surfaces (both the petiole and the butt end); this is a physiological disorder that commonly occurs in many fresh fruits and vegetables. Browning occurs on cut or damaged surfaces in most cut produce; the problem manifests itself as black/brown stains. The issue is serious for growers and the fresh produce industry as celery affected celery is perceived by consumers to be less fresh with its viewed as decaying and/or diseased. This leads to sales reductions and increased customer complaints. The importance of fresh appearance and bright green colour as main parameters of good quality celery has been reported by Gómes and Artés (2004).

According to previous scientific literature, postharvest browning is an enzymatic process which is mainly thought to be due to the synergistic activity of polyphenol oxidases (PPOs) and phenylalanine-ammonia-lyaise (PAL). PPOs is a class of enzymes which oxidise phenolic compounds to produce heterogeneous compounds, called melanins, which are responsible for the black/brown colour on cut surfaces of fresh products (Queiroza *et al*., 2008). PAL catalyses the first step in the phenylpropanoid metabolic pathway (the deamination of phenylalanine), producing, at the end, several phenolic compounds, which are the substrates for the browning reaction operated by PPOs (He and Luo, 2007). Also another enzyme: peroxidase (POD) is thought to play a role in the browning process, even though its contribution seems to be little significant (Subramanian *et al*., 1999).

Some studies to identify the postharvest factors influencing browning in celery and its relative enzymes have been conducted. Research carried out by Loaiza-Velarde *et al*.,

(2003) showed that the application of heat shock treatments significantly reduced browning potential and the wound-induced PAL activity in excised petioles. Gómes and Artés (2004) reported that celery stalks stored in controlled atmosphere (CA) with high CO_2 concentration maintained a greener colour than stalks stored at normal CO_2 levels without producing any undesirable off-odours and off-flavours. Another recent study conducted by Zhan *et al*., (2013) demonstrated that continuous light exposure (2000 lux) during storage significantly reduced the activity of PPO, POD and browning index in celery.

Despite the studies mentioned above, there is still a knowledge gap on the detailed physiological and biochemical mechanisms involved in postharvest browning in celery. In addition, the role that pre-harvest and agronomic factors have on this disorder still remains unknown. A study conducted by Guerra *et al*., (2010) on the self-whitening celery variety Golden Clause found that with delayed harvesting, the browning potential was reduced in all parts of the plant and quinone content was increased. Research on green celery varieties had not been done. However, there are studies in literature investigating cut-browning in other horticultural crops like fresh lettuce; a crop which is seriously affected by this disorder. For instance, deficit irrigation seems to significantly reduce cut-browning in Romaine lettuce despite the accumulation of phenolic compounds (Luna *et al*., 2013). In another study, the lettuce variety Grand Rapids developed less green leaf colour when 'over-mature' and it had less total quinone content (Chutichudet *et al*., 2011).

Regarding crop fertilization, there are no current studies on the influence of nutrients on browning in celery, yet, there is some evidence on lettuce. Literature regarding the latter crop is contradictory, especially as regards nitrogen applications. Hilton *et al*. (2009) revealed that calcium can decrease discolouration in lettuce at low K:N ratios. It has also been demonstrated that calcium application can reduce the caffeates at low K:N ratios (Wurr *et al*., 2003), even though its availability can be influenced by many factors like temperature, water content and crop development. It is important for growers to understand the pre-harvest factors that influence browning, as this will enable them to change or modify their production practices to reduce the incidence of browning in harvested produce. However, postharvest issues affecting browning are not fully understood.

In summary, a better understanding of the agronomic, physiological and biochemical factors involved in postharvest browning in celery will help growers to counteract the problem. It is expected that agronomic and commercial strategies will be set up in order to reduce browning level at both the cut petiole and butt ends. As a consequence customers will increase their confidence in the product and suppliers will be able to meet supermarket specifications.

Materials and Methods

The experiment was carried out in three different growing seasons, two in Spain (Murcia) and one in UK (Barway, Cambridgeshire). The two Spanish trials were conducted in the early and late growing season, while the English trial was conducted in the late season. In each trial, celery plants were harvested every week to obtain immature, mature and over-mature samples according to the optimum harvest date of celery. Once harvested, plants were vacuum-cooled to remove field heat and dispatched to the Plant Science Laboratory, Cranfield University. Samples were then divided into two batches in order to conduct two sub-experiments in parallel: the harvest maturity experiment (HM experiment) and the postharvest experiment (POSTH experiment). The HM experiment aimed at investigating the role of crop maturity on cut-browning, while the POSTH experiment focussed on evaluating the involvement of ethylene on cut-browning. All samples were subjected to visual and physiological analyses over storage at regular time intervals. Visual analyses were performed at both butt and cut petiole ends of the samples, and included subjective colour, objective colour, pithiness and bolting. Visual analyses were done by using comparative hedonic scales. Physiological analyses included ethylene production rate and respiration rate.

Results and Discussion

HM experiment

Results showed that cut-browning significantly increased with storage time, with the blackening developing sharply in the initial phase of storage (in the first 6 storage days). Cut-browning also evidently increased with crop maturity, with the plants from the latest maturity stage showing the highest browning level. Pithiness showed a very similar trend to browning. Plants bolted only in the early Spanish growing season. Ethylene production rate was not measured because of problems with the gas chromatograph resolution threshold, which was not appropriate for detecting the very low gas levels released by the celery plants.

POSTH experiment

Results demonstrated that continuous supplementation of 10 μl l^{-1} exogenous ethylene and treatment with 2 μl l^{-1} of 1-MCP did not significantly affect browning and pithiness at cut ends of celery. However, within each crop maturity stage, ethylene showed to stimulate respiration rate and 1-MCP to inhibit it.

Financial Benefits

Currently there are no direct financial benefits for growers.

Action Points

Results arising from this part of the project suggest that harvesting celery at an appropriate maturity stage can result in reduced postharvest browning and pithiness. This can result in reduced rejections by suppliers and less customers complains, which can consequently benefit growers.