Heat-Shock and Fresh Cut Lettuce

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Introduction

Browning of fresh fruits and vegetables reduces quality and is often the factor limiting shelflife and marketability (Bolin and Huxoll, 1991; Couture et al., 1993). This is especially true when these horticultural commodities are wounded by cutting, peeling, or abrading the surface. Enzymatic and non-enzymatic reactions with phenolic compounds produce brown pigments in plant tissue. Some tissues (e.g., artichokes) contain high levels of preformed phenolic compounds and rapidly brown in the air after wounding. Preventing browning in these tissues requires deactivation of the enzymes responsible for browning (e.g., polyphenoloxidase), exclusion of oxygen (e.g., oxygen levels below 1%), or application of chemical antioxidants (e.g., ascorbic acid). In other tissue, (e.g., lettuce) the quantity of phenolic compounds in uninjured tissue is low and browning follows the enhanced synthesis and accumulation of phenolic compounds (Tomás-Barberán et al., 1997).

Wounding (e.g., cutting, cracking or breaking of lettuce) produces a signal that migrates through the tissue and induces the synthesis of enzymes in the metabolic pathway responsible for increased production of phenolic compounds (Ke and Saltveit, 1989; Peiser et al., 1998). The first enzyme in the phenylpropanoid pathway is phenylalanine ammonia-lyase (PAL). Induced synthesis of this enzyme after wounding is rapidly followed by the accumulation of phenolic compounds like chlorogenic, isochlorogenic and dicaffeoyl tartaric acid, compounds that are associated with browning in lettuce (Tomás-Barberán et al., 1997.).

Heat-Shock

Every living organism responds to a heat-shock by producing unique proteins called heat-shock proteins. Heat-shock proteins not only protect the plant from further heat stress, but they also confer protection against other abiotic stress, such as chilling. In many organisms, the induction and synthesis of heat-shock proteins is accompanied by a reduction in the synthesis of other proteins. This turning off of protein synthesis may be as important in the heat-shock response as is the synthesis of the heat-shock proteins.

Some stresses are more important to the plant than others, and there appears to be a hierarchical response of tissue to different abiotic stresses (Saltveit, 1997). For example, normal protein synthesis is redirected by wounding, and both normal and wound-induced protein syntheses are redirected by heat-shock. The ability of a heat-shock to “turn-off” the synthesis of proteins other than heat-shock proteins could be used to redirect protein synthesis in wounded lettuce tissue and prevent browning if the production of heat-shock proteins superceded the production of PAL.

Method

We have recently shown that browning can be prevented in iceberg lettuce by a short thermal stress (Loaiza-Velarde et al., 1997). A heat-shock of 50 °C (122°F) for 90 seconds effectively prevents the synthesis of PAL by wounded lettuce leaf tissue and its subsequent browning (Fig. 1).

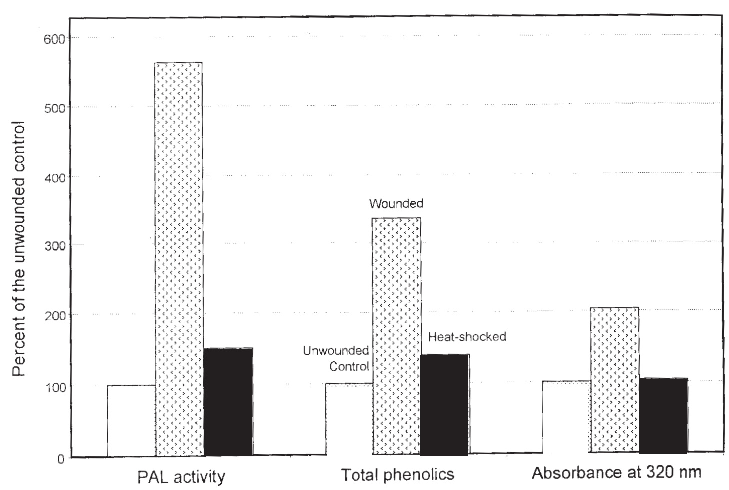

Figure 1. *The effect of wounding and heat-shocking [50 °C (122°F) for 90 sec] on the development of phenylalanine ammonia-lyase (PAL) activity (µmol cinnamic acid produced/g•h), concentration of total phenolic compounds (µg/g), and absorbance at 320 nm (a measure of browning) in iceberg lettuce tissue after 24 h.*

This inhibition of PAL synthesis is probably accomplished by redirecting protein synthesis away from wound-induced proteins (e.g., PAL) to the synthesis of heat-shock proteins. The heat-shock does not act through interfering with the wound signal since it is effective when administered both 4 hours after and 4 hours before wounding (Fig. 2).

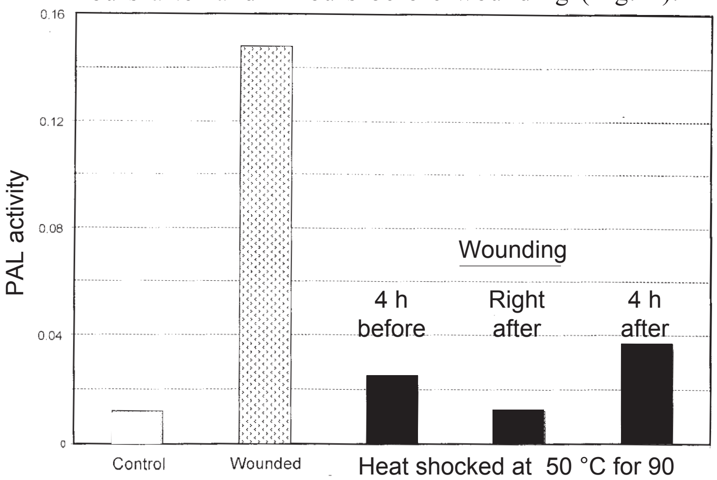

Figure 2. *The effect of wounding and the timing of the application of a heat-shock [50 °C (122°F) for 90 sec] to iceberg lettuce tissue on the development of phenylalanine ammonia-lyase (PAL) activity (µmol cinnamic acid produced/g•h) after 24 h. The heat-shocks were applied 4 h before wounding, at the time of wounding or 4 h after wounding.*

The heat-shock effect was so persistent that lettuce did not show any browning even after being held for 15 days in the air at 5 °C (41°F). This treatment could eliminate the need to store fresh-cut lettuce in low oxygen, and or high carbon dioxide modified atmospheres to prevent browning during marketing.

Commercial application

The ability of a heat-shock to control browning when administered either before or after the preparation of fresh-cut lettuce greatly expands the probability of it being incorporated into commercial processing lines. A short heat-shock produced by immersion in 50 °C (122°F) water for 90 sec could replace the washing step between the chopping step and the centrifugation step used to remove excess water. Being warmer than the usual 0 °C (32°F) of lettuce on most processing lines, water adhering to the heat-shocked lettuce would be less viscous and more easily removed by centrifugation.

Alternatively, excess water could be removed by vacuum cooling. This is not possible with 0°C (32°F) lettuce, since the heat needed to vaporize the water which produces the cooling would not be there, but heat-shocked lettuce would be warm enough to take advantage of vacuum cooling.

No chemicals used

Consumers do not want their fresh fruits and vegetables to contain additives or chemical residues. No chemicals are used in the heat-shock treatment, and the heat-shock proteins that are produced by the lettuce are natural compounds found in many fresh fruits and vegetables. The ease with which a heat-shock can be administered to lettuce and the lack of an offensive chemical residue makes this technique an attractive method to control browning in fresh-cut lettuce, and perhaps in other fresh fruits and vegetables as well.

References

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