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THE EFFECT OF HEAT SHOCK ON BROWNING-RELATED ENZYME ACTIVITY IN LETTUCE

Introduction

Problem:
The shelf life of minimally processed lettuce is limited due to brown discoloration. As appearance is an important quality parameter and strongly affects the consumer's decision to buy fresh produce, browning leads to economic loss for the producers and unnecessary food waste.

Cause:
Wounding of plant tissue, during handling and processing, increases the activity of browning-related enzymes: phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO) and peroxidase (POD), eventually leading to the production of brown pigments.

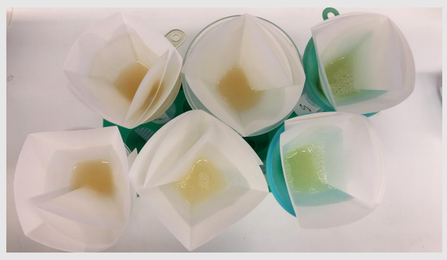
Minimally processing of lettuce = Harvest & transportation + Trimming & cutting + Washing & desinfection + Centrifugation + Packaging & cold storage

Proposed solution = a mild HEAT SHOCK:
- ⇨ Based on the hierarchal order in the response of plant cells to certain abiotic stresses: exposure to higher temperature leads to a shift in protein synthesis from the wound-induced production of browning-related enzymes to the production of heat shock proteins.
- ⇨ Interesting alternative for the use of chemical additives which can be easily applied as a washing step in the process chain.

Aim:
- Assessment of the effect of mild heat shock on lettuce browning and the evolution of the activity of PAL, PPO and POD during refrigerated storage.
- Identification of an efficient heat shock treatment for the inhibition of enzymatic browning in lettuce.

Experimental design

1. Excised midrib segments of Iceberg lettuce were cut into pieces.
2. Heat shock treatment (4 (control) / 30 / 40 / 45 / 50 °C – 60 sec)
3. Cooling (0 °C – 30 sec)
4. Centrifugation
5. Packaging (n = 2) and storage (up to 10 days at 7 °C)
6. On each day of analysis (day 0, 1, 2, 3, 7 and 10): extraction and spectrophotometrical analysis of browning potential (BP) and enzyme activities (PAL, POD and total & active PPO)



⇨ All experiments were carried out in double or triple.

Figure 1: results of heat shock 30/50 °C

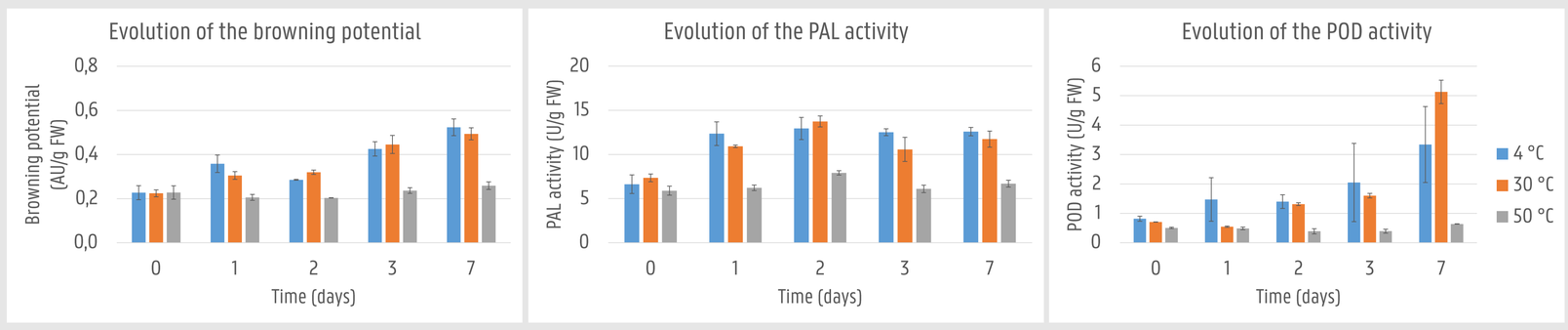


Figure 2: results of heat shock 40/45/50 °C

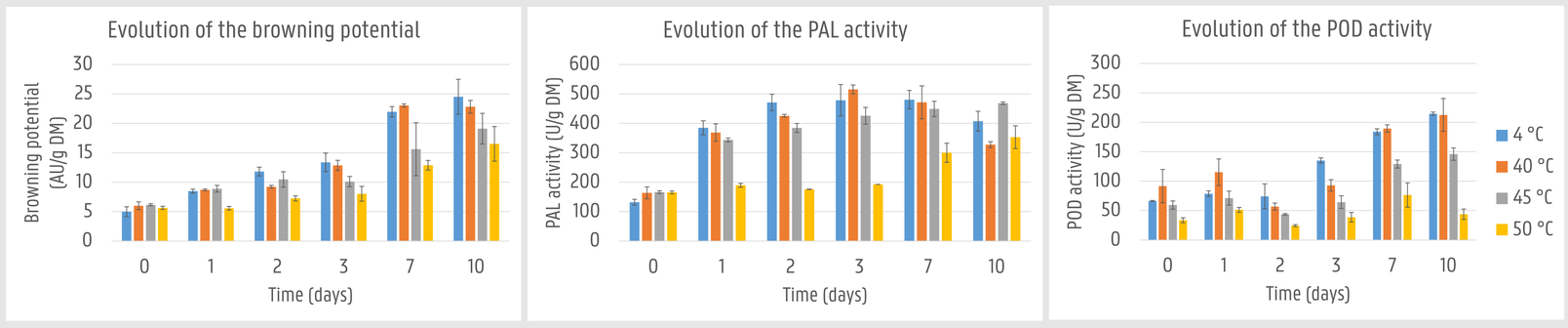
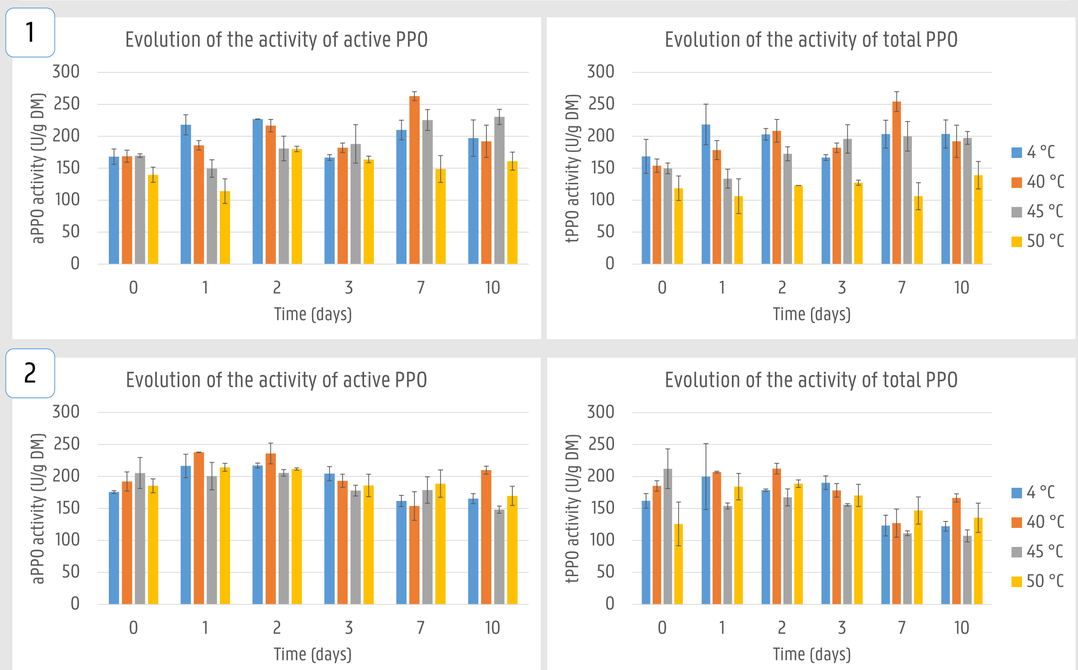


Figure 3: results of active and total PPO activity for both time series of heat shock 40/45/50 °C



Conclusion

Heat shock treatment at **50 °C for 60 seconds** is most effective in inhibiting enzymatic browning of minimally processed Iceberg lettuce:
- There is no increase in activity of both PAL and POD.
- Browning of the lettuce pieces was delayed with an average of 6 days compared to the control tissue (4 °C – 60 sec).

- Mild heat shock treatment seems promising, but remains an energy-consuming method.

Future perspectives

Research will focus on the identification of natural compounds with an equally effective anti-browning activity.

Results

Experiment 1: heat shock 30/50 °C (3 individual time series, *figure 1*):
- Control tissue (4 °C) and treatment at 30 °C (60 sec):
  - Increasing trend for BP (starting from day 1) and the activity of both PAL and POD (starting from day 2).
- Treatment at 50 °C (60 sec):
  - No increase in activity of both PAL and POD, up to 7 days after processing and heat treatment.
  - Browning of the lettuce pieces was completely inhibited.
  - Possible negative effect on texture (loss of crispness) was observed (in 2 / 3 individual time series).

Experiment 2: heat shock 40/45/50 °C (2 individual time series, *figure 2*):
- Heat treatment at 50 °C (60 sec) is most effective in inhibiting the increase in activity of PAL and POD, as well as the browning of lettuce pieces, up to 7 or even 10 days after processing and heat treatment.
- Exposure to 45 °C or lower had little or no effect on all measured parameters.

Total vs active PPO (*figure 3*):
- No clear increasing/decreasing trend for the PPO activity during storage, as well as almost no difference between the activity of active and total PPO.
- The effect of heat shock on the activity of PPO was not consistent (minor inhibition at 50 °C in the first time series, compared to no inhibitory effect in the second time series).
- Although the exact cause is unclear, these irregularities in PPO activity, as well as the dissimilarities observed between the individual time series, could be due to the difference in supplier for each batch of lettuce used for the different time series.

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