Thermal Treatments for Enhanced Shelf-Life of Minimally Processed Foods

Robert D. Hancock
Quality, Health and Nutrition, Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA.
Rob.Hancock@scri.ac.uk

Scottish Crop Research Institute

Food Processing Knowledge Transfer Network

The UK is currently the European leader with regard to minimally processed (fresh-cut) food sales with a market value in excess of €700 M in 2004[1]. Minimal processing of vegetable foods leads to the rapid induction of wound responses which ultimately result in deterioration of the product thus restricting shelf life (Fig. 1). Restricted shelf life represents difficulties for the industry due to the inability to schedule production according to supply, instead having to respond to demand which can fluctuate daily depending on unpredictable factors such as prevailing weather conditions.

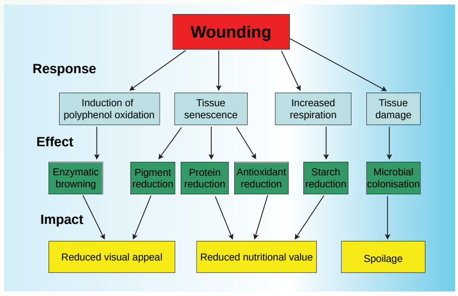

Figure 1 – Schematic of wound induced changes in fresh-cut products
Tissue damage during the preparation of fresh-cut products results in a series of physiological responses. The effects of these responses result in negative impacts regarding consumer acceptance of the product.

Treatment	Example	Target	Advantages	Disadvantages
Acidulants	Citric acid	Enzymatic browning	Cheap, available from 'natural' sources	Flavour taint
Antioxidants	Ascorbic acid	Enzymatic browning	Cheap	Flavour taint Fortification legislation
Preservatives	Sulphite	Enzymatic browning	Cheap, highly effective	Potential allergen Legislative issues
Antimicrobials	Hypochlorite	Microbial contamination	Cheap	Occupational exposure Consumer acceptance Nutritional deterioration
MAP	Low oxygen atmosphere	Enzymatic browning, Respiration, Microbial colonisation	Effective for prevention of deterioration resulting from several factors	Costly Potential impact on flavour High oxygen atmospheres explosive
UV-light	UV-C	Microbial contamination	Effective surface sterilisation	Costly May cause nutrient losses

Table 1 – Methods available for shelf-life extension of minimally processed products

Several methods are currently available for the extension of shelf life in minimally processed foods (Table 1) however, recent trends in consumer demand for 'natural' foods and the framing of food safety legislation within the paradigm of the precautionary principle are creating pressures to move away from chemical methods towards more environmentally benign techniques. Presented here are details of a research program for the development of methods for the extension of shelf life using mild thermal treatments.

Mild Thermal Treatments are Effective for Shelf-Life Extension

Mild thermal treatments are effective for the improvement of a number of parameters that result in shelf life deterioration (Fig. 2). Despite the relative ease of integration into current processing chains, the low cost and environmental sensitivity of thermal treatments, they have not been widely adopted. The most likely explanation is that conditions must be optimised for each material processed (species, cultivar, cut size etc). Here, research work is outlined that intends to overcome such problems by providing standardised protocols for the rapid determination of optimal thermal treatments.

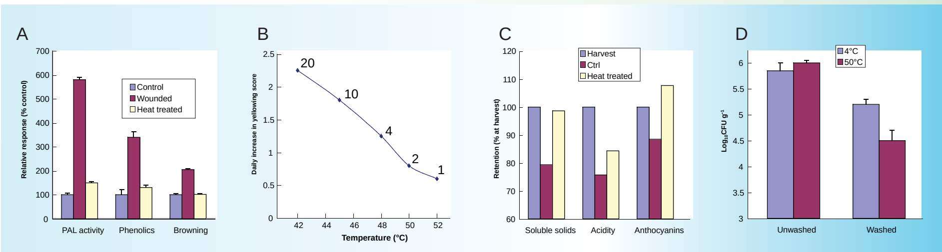

Figure 2 – Impact of thermal treatments on shelf life parameters.

A – Browning in cut lettuce. Cut lettuce was treated by immersion in water at 45°C for 90 s. After 24 h storage at 4°C phenylalanine ammonia lyase (PAL) activity, total phenolic content and degree of browning was determined. Control lettuce was stored whole and wounded lettuce was cut but not thermally treated.[2]

B – Yellowing of broccoli florets. Broccoli florets were prepared by cutting from the main stem and held in water at the defined temperature for the period of time shown (min). The daily increase in yellowing was determined by visual inspection and presented as an arbitrary scale. Untreated florets yellowed by 2.5 day^{-1}.[3]

C – Nutrient retention in strawberry. Strawberry fruit were harvested and air treated at 45°C for 60 min, nutrient retention was determined after 10 days storage at 3°C.[4]

D – Microbial contamination of cut lettuce. Lettuce was washed in water for 1 min at 4 or 50°C. Immediately after washing, samples were blended in peptone and serial dilutions spread onto plate count agar.[5]

Workpackage

The initial aim of the investigation will be the empirical determination of optimal thermal treatments in three distinct food types: prepared salad leaves, prepared potatoes and prepared brassicas (Fig. 3). Impact on both shelf life and quality parameters will be examined.

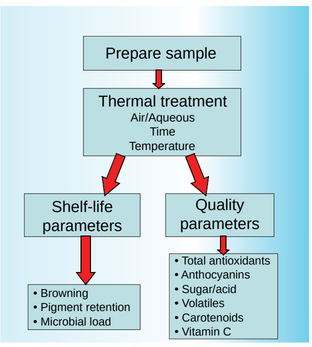

Figure 3 –
Empirical determination of optimal thermal treatments

The next stage of the investigation will determine the mechanism by which thermal treatments extend shelf life. Current evidence suggests that both heat shock proteins[2] and reactive oxygen species[6] are involved in mediating the beneficial effects of thermal treatments. Figure 4 shows a working hypothesis for how thermal treatments affect plant metabolism and the techniques that will be used to investigate the hypothesis.

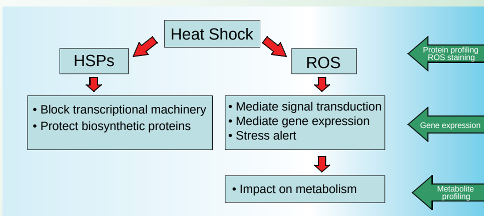

Figure 4
Potential mechanisms by which thermal treatments impact on plant metabolism
Thermal treatments (heat shock) are known to result in the synthesis of heat shock proteins (HSPs) and release of reactive oxygen species (ROS) within plant tissues. HSPs act as chaperones protecting other vital biosynthetic and regulatory proteins. In addition, as the capacity for plant tissues to synthesise proteins is limited, increased production of HSPs blocks the production of detrimental wound proteins such as those required for enzymatic browning. ROS are important signalling compounds produced within plant tissues to provide information regarding environmental stresses and it is likely that the transient increase in ROS caused by thermal treatments prepare the plant for subsequent wounding stress. The arrows to the right of the figure provide examples of techniques that will be used to investigate the hypothesis.

Deliverables

- Easily integrated method for the extension of shelf life in three specific foods
- Understanding of the signal transduction and biochemical processes resulting in extended shelf life
- Biochemical and molecular markers for the rational development of the methodology in other foods

References
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