Effects of high pressure processing on carrot tissue: a microstructure approach

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Abstract

High pressure processing (HPP) has the potential of extending the shelf life of fruits and vegetables whilst preserving nutrients and, importantly, many sensory attributes. Although there is a developing body of literature identifying the advantages of this technology for specific products under specific conditions, it is important to gain further understanding of why undesirable quality changes can also be enhanced by this process. For this reason, this work focused on the changes that HPP promotes within the microstructure of the product (carrots, *Daucus carota* L.) considering that macroscopic quality is determined at a cellular level.

This project was part of a government funded flagship programme at CSIRO Australia, where carrots were chosen as a model product of study. The effects of HPP on this commodity were studied for a range of pressures (100-600 MPa) applied for different holding times (2, 10 and 30 minutes) at ambient temperatures (20 °C). The effects were measured qualitatively and quantitatively by using several microscopy techniques, textural, physiological, biochemical and sensory analysis and through comparison with unprocessed (raw), frozen and heat processed (boiled, steamed and sous vide) carrots. The information collected provided understanding of how different pressure levels affected the physical and physiological responses of carrots based on cellular changes. It also allowed HPP to be positioned within the range of other preservation techniques and to identify relationships between quantitative and sensory quality attributes.

The key findings of the study can be divided into HPP effects below and above 200 MPa, as near this pressure a “tissue break point” was identified. Pressures below 200 MPa only slightly affected the cellular structure arrangement according to microscopy techniques, which explained small textural changes, but there was an interesting shift in the metabolic response from aerobic to anaerobic metabolism, presumably due to stress. Above 200 MPa, cell structures became less organized and more disrupted resulting in significant loss of textural characteristics such as hardness and cutting forces compared to raw carrots. This texture loss was related to cellular leakage and loss of turgidity. Considering that

texture is one of the most important quality attributes in carrots, this study searched for ways of ameliorating the impact of pressure by manipulating turgidity before and after the HPP process. One possibility was by weight loss prior to high pressure processing, but this approach did not help to overcome texture losses after HP treatments above 200 MPa, as structures were irreversibly damaged. Below 200 MPa, cells were still able to regain some turgor pressure (pressure of the cell content against the cell wall); however changes in cell permeability were evident. The addition of calcium chloride solutions in samples high pressure treated at above 200 MPa showed no quantitative texture improvements, confirming membrane damage as the principle mechanism and limited influence of biochemical reactions (pectin degradation by pectin methylesterase) affected cell walls at the conditions studied.

Sensory perception by a trained panel showed a positive response toward HPP carrots treated at 600 MPa for 2 minutes. It was interesting to observe no significant differences in many sensory attributes in comparison to raw and sous vide samples, while boiled carrots showed low acceptability due to loss of most volatiles, texture and colour attributes. Storage trials confirmed that high pressure treated samples retained higher quality after 14 days at 4°C by supporting a lower count of lactic acid bacteria and consequently having less ethanol and acetic acid production in the pack.

Overall, this research has provided a greater understanding of the application of high pressure on whole vegetable pieces by following microstructural changes. Based on this work, HPP can be considered equivalent to other 'lightly processed' technologies such as sous vide and may offer benefits as a complementary process to this or other similar preservation techniques. Future opportunities could be investigated taking advantage of the changes observed in cell permeability (< 200 MPa) for diffusion processes such as salting and candying. Health benefits arising from nutrients being more exposed and preserved after pressure treatments should be further studied by following nutrient availability and body absorption. Furthermore, studies on altering rates of compression or decompression and various pressure cycling effects could assist in optimisation of future commercial HPP applications.

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Thanks

The more I learn, the more I realise how little I know (Socrates).
I wish we had more time in our hands to just observe and take in
all the knowledge that is out there.

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