Water status and temperature effects on carrot and radish processing

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Introduction

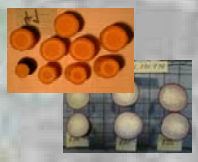
Optimised packaging and storage help to maintain quality of fresh ready-to-use salad mixture. However, product keeping quality is also influenced by processing. Slicing should be highly optimised because it inevitably damages tissue. The mechanical properties of a product affect the cutting resistance. Tissue toughness and stiffness are related to cell wall physical properties. They are also influenced by water status and temperature, and their interactions. Hence, these parameters also affect cutting.

Material

Carrots (*Daucus carota* L., cv. Nerac and Nanthya) were obtained from local growers and used fresh or stored at 0°C or 4°C in PE bags until experimentation. Radish plants (*Raphanus sativus* L. var. *sativus*; cv. Nevadar) were grown in a climate chamber and harvested just before each experiments.

Methods

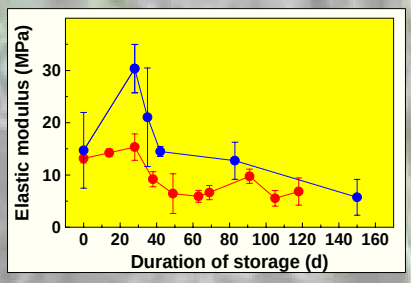
Water status Water potential of intact carrot roots and radish tubers were measured with a Scholander type pressure bomb (Plant Water Status Console 3000, Soilmoisture Inc., Santa Barbara, CA, USA).

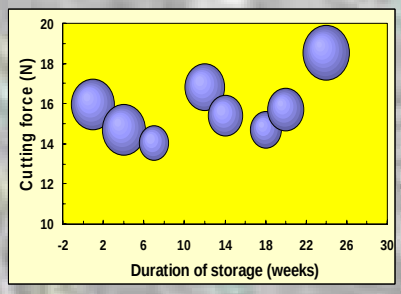


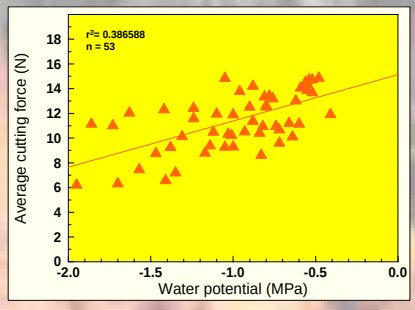
Cutting force Both carrot roots and radish tubers were sliced using a microtome blade adapted to an universal testing machine (Instron or Zwick) at a cutting speed of either 1016 or 600 mm min^{-1}, respectively.

Results

During cold storage mechanical tissue properties of carrots such as the maximum cutting force, i.e. *firmness* and the elastic modulus, i.e. *stiffness* change due to variations in product water status and cell wall chemical properties. Both may affect processing.

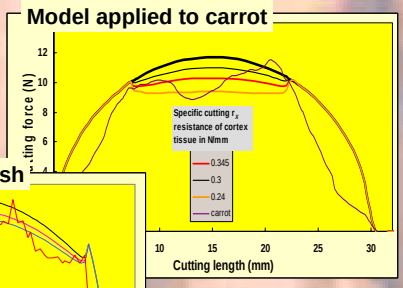


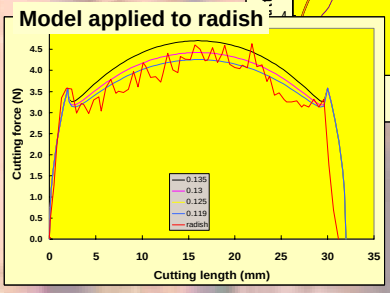




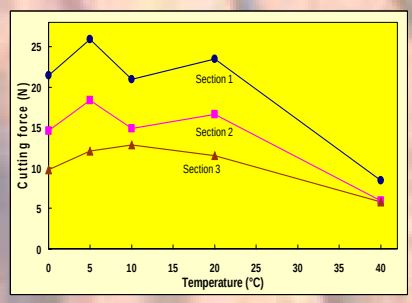
Water potential and mean product cutting force were positively correlated in fresh carrots and radish tubers (not shown). This indicates that the slicing process should be adapted to actual degree of freshness of a product to reduce the risk of unnecessary high damage during cutting.

Modelling of the overal tissue resistance (R_C) during cutting perpendicular to the length axis may help to optimize the understanding of the relevant physiological and physical processes thus enabling to reduce damage during cutting.





Cutting force varied with tissue temperature (in the range from 0°C to 45°C) reaching highest values at 5°C. Forces changed with the longitudinal cutting position and were always maximum in the middle section of the roots. It is not yet clear whether temperature affects water status and/or cell walls.



Model:

Parameters:

total diameter D; cortex diameter d; specific resistance of the cortex r_P
specific resistance of the inner tissue r_I; length of cut x

Calculations:

for $x = 0$ to $x = 1/2*(D - d)$ $\quad R_C = r_P*2(x*(D-x))^{1/2}$

for $x = 1/2*(D - d)$ to $x = D/2$ $\quad R_C = r_P*2((x*(D- x))^{1/2} - ((x -1/2(D-d)*(d-(x -1/2(D-d)))^{1/2}) + r_I*2((x -1/2(D-d))*(d-(x -1/2(D-d)))^{1/2}$

Conclusions

Variations in cell wall properties and water status influence the tissue resistance to cutting in fresh and stored carrots and radish tubers. This may affect the degree of damage during processing. Analysing the cutting process with a simple mechanistic model can help to improve this process finally yielding a better keeping quality.

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