Dynamic effects of temperature and water status on postharvest texture of radish and carrot tubers

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Introduction
Texture is a major determinant of fruit and vegetable quality. Consumers can easily feel this quality aspect by touching, it can also be measured objectively by destructive and non-destructive methods. Texture of fresh fruit and vegetables is determined by both product water status and cell wall mechanical properties. Both parameters can be either differentially or concomitantly influenced by various conditions during the entire postharvest chain. In this study, we focused on the basic effects of water status and temperature on the texture of intact carrots and radish tubers. Despite many efforts, the interactive effects of these parameters on texture are still not well understood, but better knowledge may help to improve the keeping quality and processing of fresh perishable products.

Material and Methods
Carrots (Daucus carota L., cv. Nerac and Naran) and radish tubers (Raphanus sativus L. var. sativus; cv. Nevadar) were grown in a climate chamber and harvested just before each experiment.

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).

Firmness (mean cutting force) of carrot and radish tubers was determined by slicing with a microtome blade adapted to an universal testing machine (Instron or Zwick) at maximum cutting speed (1016 or 600 mm min⁻¹, respectively).

Results
In carrot and radish tubers, water potential and pressure potential were related with firmness, as indicated by the cutting force, and tuber stiffness, i.e. the elastic modulus (Fig. 1, 2, 3). However, only stiffness showed a clear and significant correlation with water status in both produce (Fig. 3).

As expected from water relations theory, the mechanical component of water potential (i.e. pressure potential or turgor), largely determines the elastic modulus of both tubers and roots. Beyond wilting, the variation of firmness and stiffness with declining water potential was less pronounced indicating the prominent influence of turgor on produce texture.

In carrot taproots, firmness, stiffness and turgor were higher at low temperatures (ca 10°C) than at room temperature (ca 20°C), reaching highest values at 5°C (data not shown).

In radish tubers, temperature did not unequivocal affect firmness (Fig. 4). In young tubers, cutting force at high water potential was maximal at 5°C, declining to a steady value at higher temperatures. Firmness increased at a given water potential at tissue temperature above 10°C when the fast growing radish tuber developed beyond the early generative phase.

In long term cold-stored carrots, stiffness and firmness independently (Fig. 5) dynamically changed due to physiological acclimation processes, known as cold-acclimation, without variations in water potential (data not shown).

Conclusions
Water status, temperature and development interactively affect firmness and stiffness in fresh and stored carrot and radish tubers, however to a very different degree. Thus, variations in cell wall properties and water status influence the tissue strength. This potentially affects the degree of damage during handling and processing.

Presented at the 3rd International and Multidisciplinary Conference on Quality in Chains, an Integrated View on Fruit and Vegetable Quality; 6-9 July 2003, Wageningen, The Netherlands