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Real-time measurements of apple cubes enzymatic degradation by micromechanics: preliminary results

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Summary:

The diffusion of micronutrients from vegetables is mainly governed by the breakage of the structures at different scales: vacuole, cells, tissues or whole fruit. The aim of this preliminary work is to study the feasibility of micromechanics applications to characterize the breakage level of enzymatically degraded apple cubes.

Material and methods:

- Apple (Granny Smith) cubes ($7 \times 7 \times 6 \text{ mm}^3$) immersed one night in a 0,6 M mannitol solution (turgor pressure equalization)
- Miniature tensile stage (Deben Microtest DB-T200Petri) equipped with a 100 N load cell, *Figure 1*
- An apple cube is immersed in the mannitol & enzyme solutions during the compression cycles at room temperature
- Up to 30 compression & go back cycles, preload 3 N, strain 5% (0.35 mm), speed $0.2 \text{ mm} \cdot \text{min}^{-1}$
- Enzyme Pectofruits XL® (Spindal), concentrations: 0, 0.5, 1, 3, 5 ml /100 ml of 0.6 M mannitol solutions

Results:

Figure 2

Without enzyme:

- (i) Load vs deflection curves are straight lines \Rightarrow elastic behaviour, $E \approx 2 \text{ MPa}$,
- (ii) load amplitude dL remained almost constant during 1½ or 2 hours

With enzyme:

- (i) load amplitude dL decreased with time
- (ii) the higher the enzyme concentration, the lower load amplitude dL
- (iii) for high enzyme concentration the elastic behaviour disappeared
- (iv) for high enzyme concentration, the softening effect appeared sooner than for low enzyme concentrations

Figure 3

As the different tests were carried on with different apples, the results are normalized by plotting dL / dL_{max} vs time.

- (i) a lag phase (red arrow) for the lower enzyme concentrations
- (ii) the texture loss is higher for higher enzyme concentrations
- (iii) the measured texture loss kinetics were almost linear for low enzyme concentrations and exponential up to a minimum for higher ones.

Conclusion:

Compression cycles in a miniature tensile stage permitted to characterize the texture loss of enzymatically degraded apple cubes as a function of time. Other micromechanical tests (compression until rupture, micro-puncture) will be performed. Better experimental conditions (temperature control, stirring) are required for modeling the degradation kinetics of fruits and vegetables with micromechanics.

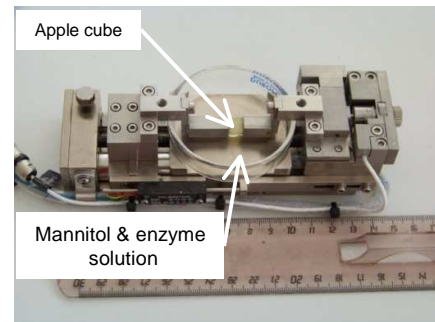


Figure 1: Miniature tensile stage (Deben Microtest).

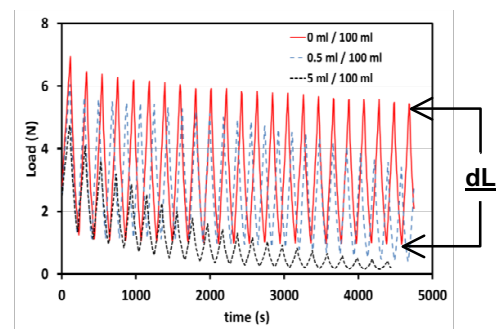


Figure 2: Representative Load vs time curves for different enzyme concentrations.

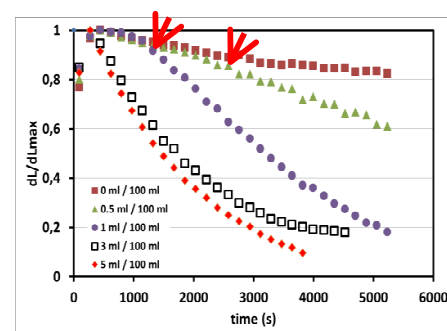


Figure 3: Representative evolution of dL / dL_{max} as a function of time for different enzyme concentrations.