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KINETIC STUDY ON MICROSTRUCTURAL CHANGES DURING CONVECTIVE AIR DRYING OF GRAPES

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OBJECTIVES

- Introduce a microstructural approach in convective drying of fruits.
- Monitor physical microstructural changes during air drying of grape quarters.
- Quantify cellular shrinkage.

INTRODUCTION

- Air drying leads to major changes in the fruit structure and texture, such as loss of fruit firmness (*Bolin and Huxsoll, 1987*). Physical properties of foods and texture in particular may be related to their microstructure (*Aguilera and Stanley, 1999*).
- Shrinkage of tissues was reported as a major physical change on fruit and vegetable microstructure during drying (*Reeve, 1943; Crafts, 1944*). Long neglected in the formulation of drying models, shrinkage has to be accounted for, since it affects the mass transport phenomena.
- Microscopy is a powerful tool for studying food microstructure, especially if complemented with techniques of image analysis (*Aguilera and Stanley, 1999*).

MATERIALS & METHODS

Samples:

- Ruby grapes (*Vitis vinifera*) quarters of 2.4 cm diameter
- water content in a vacuum oven at 70°C = 80.63% ± 0.14 (w/w)
- cellular walls stained with methylene-blue 0.034%, during 15 s

Drying Experiments:

- Control of temperature, relative air humidity: 20, 30, 40, 50, 60°C
- for approximately 2 hours
- air velocity = 1.6 ± 0.11 m/s

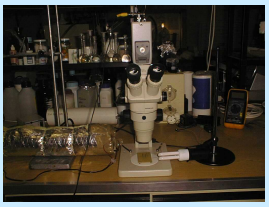

Fig. 1 - Stereo-microscope with video camera and air-drying tube.

Microstructure and Image Analysis:

- magnification of 25X
- 20 cells selected
- softwares Paint Shop Pro 4.12 and UTHSCA Image Tool 2.0
- parameters
  - dimensional: **area, perimeter, Feret diameter, major and minor axis length**
  - shape: **elongation, roundness and compactness**

RESULTS & DISCUSSION

- Disruption of cellular walls/ cellular collapse / surface progressively more brilliant with the gradual increase of liquid water.

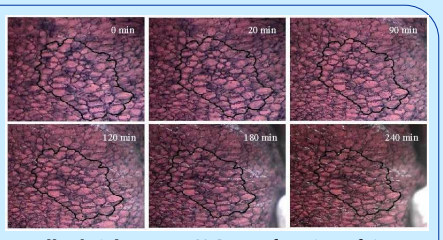

Fig. 2 - Images of grape cells shrinkage at 40°C as a function of time.

- Dimensional parameters showed an exponential decrease with drying time.
  → First order model $\frac{p}{p_o} = \exp(-k_T\, t)$
- Temperature accelerates the rate of change.
  → Arrhenius model
  $k = k_{ref}\ \exp\left[-\frac{Ea}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right]$
- One step non-linear regression of all data with STATA 3.0

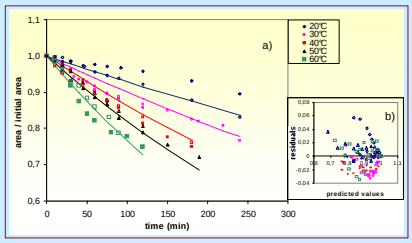

Fig. 3 - a) Experimental cellular area as a function of time and temperature. Continuous lines represent model predicted values. b) Model residuals as a function of predicted values.

Table 1 - Rate of change at 40°C and activation energy, for each cellular parameter related to dimensions.

Cellular parameters	$k_{40°C}$ x 10^{-3} (min^{-1})	Ea (kJ/mol)
Area	1.46 ± 0.05	3.1 ± 0.3
Perimeter	0.89 ± 0.05	3.1 ± 0.4
Major axis	0.88 ± 0.05	2.9 ± 0.3
Minor axis	0.95 ± 0.05	3.6 ± 0.7
FD	0.91 ± 0.04	3.3 ± 0.3

- Shape parameters did not show any tendency with drying time (two-way ANOVA for unbalanced data)

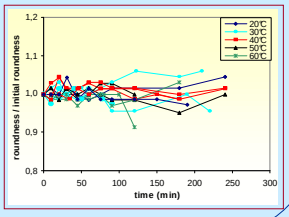

Fig. 4 - Experimental cellular roundness as a function of time and temperature.

CONCLUSIONS

- Stereo-microscopy is a useful non-invasive tool in studying drying.
- Cells dimensions suffered modifications during drying, but their shape remained unchanged.
- Area, perimeter, major and minor axis length and Feret diameter presented an exponential decrease with drying time and a first-order model was well fitted. Within the studied range, temperature increased the rate of cellular shrinkage and this effect followed an Arrhenius type behavior.
- There was no consistent trend of cellular elongation, roundness or compactness with time or temperature.
- The study of drying at microscopic level will certainly contribute to better understand its mechanisms.

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