

# KINETIC STUDY ON MICROSTRUCTURAL CHANGES DURING CONVECTIVE AIR DRYING OF GRAPES

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Inês N. Ramos<sup>1</sup>, Cristina L. M. Silva<sup>1</sup>, Alberto M. Sereno<sup>2</sup> and José M. Aguilera<sup>3</sup>

1. Escola Superior de Biotecnologia, Universidade Católica Portuguesa, Portugal. Email: crislui@esb.ucp.pt

2. Faculdade de Engenharia, Universidade do Porto, Portugal

3. Escuela de Ingeniería, Pontificia Universidad Católica de Chile, Chile



## 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.

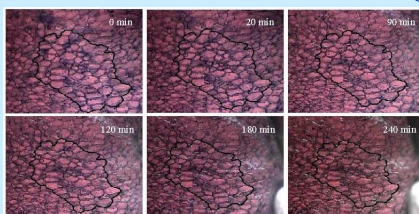


Fig. 2 - Images of grape cells shrinkage at 40°C as a function of time.

- Dimensional parameters showed an exponential decrease with drying time.

$$\rightarrow \text{First order model } \frac{P}{P_0} = \exp(-k_r t)$$

- Temperature accelerates the rate of change.

→ Arrhenius model

$$k = k_{ref} \exp\left[-\frac{E_a}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]$$

- One step non-linear regression of all data with STATA 3.0

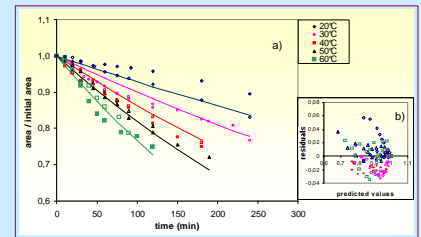


Fig. 3 - a) Experimental cellular area as a function of time and temperature. Continuous lines represent model predicted values. b) Model residuals as a function of predicted values.

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

Cellular parameters	$k_{40^\circ\text{C}} \times 10^{-3} \text{ (min}^{-1}\text{)}$	$E_a \text{ (kJ/mol)}$
Area	$1.46 \pm 0.05$	$3.1 \pm 0.3$
Perimeter	$0.89 \pm 0.05$	$3.1 \pm 0.4$
Major axis	$0.88 \pm 0.05$	$2.9 \pm 0.3$
Minor axis	$0.95 \pm 0.05$	$3.6 \pm 0.7$
FD	$0.91 \pm 0.04$	$3.3 \pm 0.3$

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

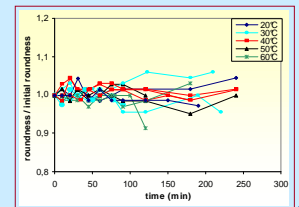


Fig. 4 - Experimental cellular roundness as a function of time and temperature.

## 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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