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A NEW METHODOLOGY FOR OPTIMIZING SOLAR DRYING OF FRUITS

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What is Solar Drying ?

- Sun-drying
- Solar-drying

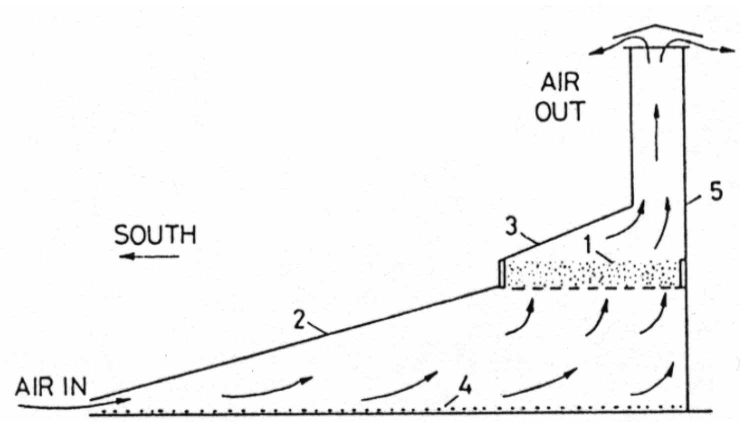
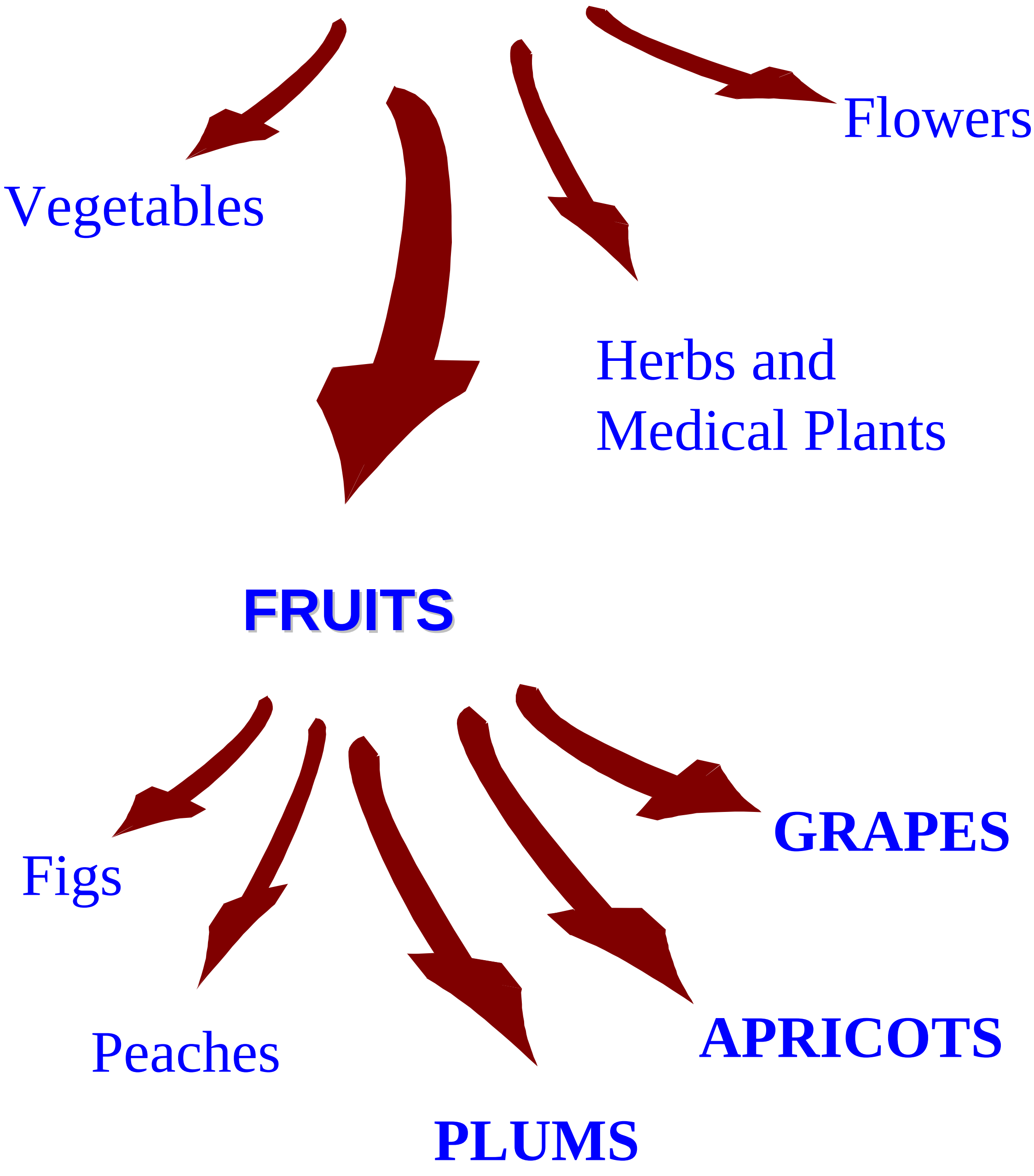


Fig 1 - Simple scheme of a solar drier.

DRIED PRODUCTS



Outline

1. Overview of Research

2. Methodology for Optimization

3. Research going on

1. Overview of Research

- One of the oldest food preservation methods

- Exponential model

(Newman et al., 1996)

$$\frac{M-Me}{Mo-Me}=\exp(-K\,t)$$

- Simplified forms of Fick's equation

$$\frac{M-Me}{Mo-Me}=\frac{6}{\pi^2}\exp(\frac{-\pi^2 D\,t}{r^2})$$

$$\frac{M}{Mo}=\frac{6}{\pi^2}\exp(\frac{-\pi^2 D\,t}{r^2})$$

- Two-compartment diffusion model

$$\frac{M-Me}{Mo-Me}=A_o\exp(-k_o t)+A_1\exp(-k_1 t)$$

(Glenn, 1978)

- The Page model

(Madamba et al., 1996) $$\frac{M - Me}{Mo - Me} = \exp(-K\,t^N)$$

- Most studied basic parameters:

< air Temperature
air Velocity

- Air temperature effect follows the Arrhenius law:

$$K = Ko\,\exp\left[-\frac{Ea}{R}\left(\frac{1}{T}-\frac{1}{To}\right)\right]$$

- Lack of research on the effect of air Humidity

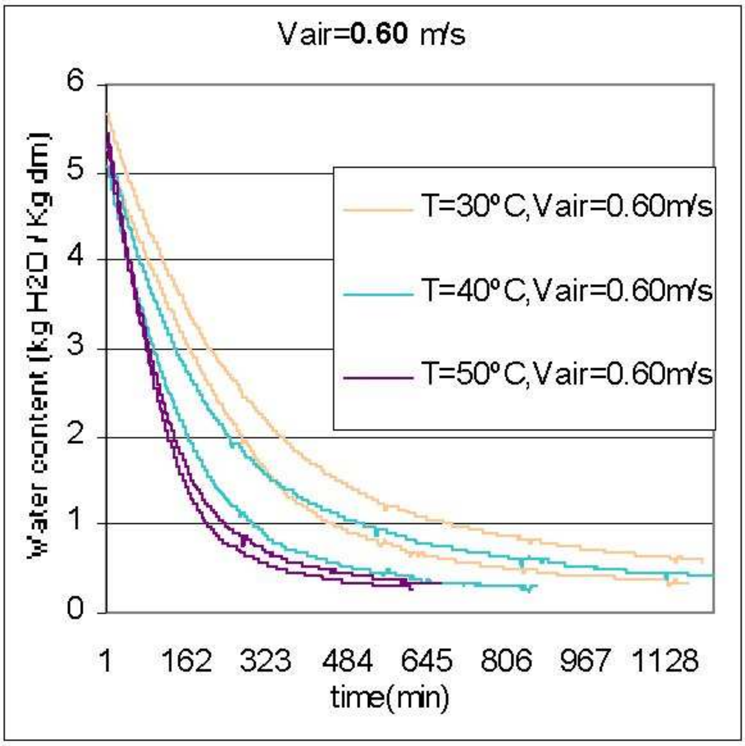
equilibrium moisture content

3. Research going on

3.1. Drying Kinetics at Pilot Scale

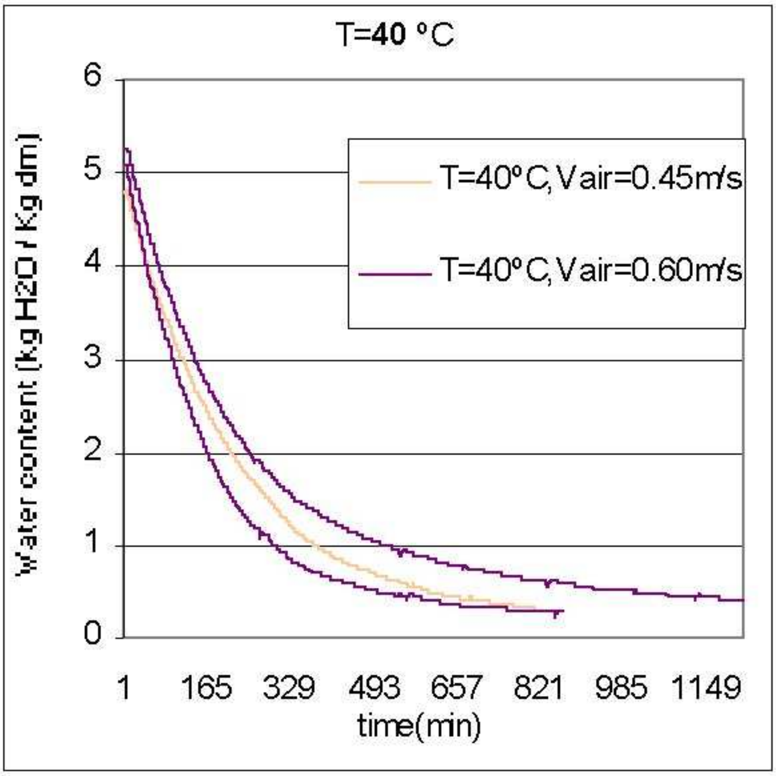
Fig 2 - Pilot plant tray drier.

Modeling Drying Kinetics of Dominga Grapes



- A single falling-rate behavior was observed.
- Air velocity, in the tested range, has no significant effect. ⟺ internal diffusion
- The air temperature effect follows the Arrhenius law:

$$K = Ko \exp\left[-\frac{Ea}{R}\left(\frac{1}{T}-\frac{1}{To}\right)\right]$$



A one-step non-linear regression was performed simultaneously to all the data:

Activation Energy = 31.8 ± 0.3 kJ/mol

Mean equilibrium moisture content = 0.338±0.007 kg water/kg dry mater

Air Relative Humidity Effect on Lambertin Apricots Drying Kinetics

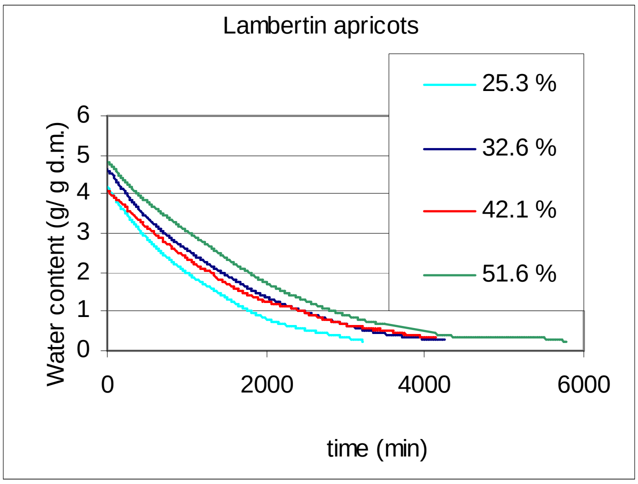
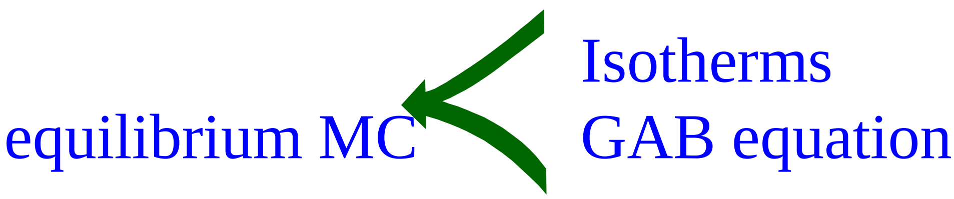
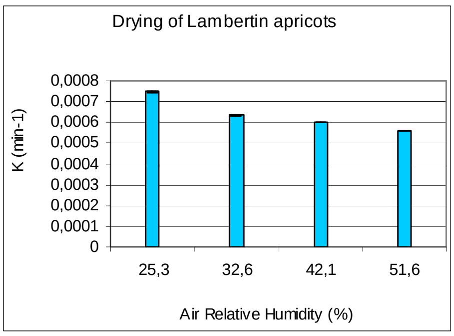


Fig 5 - Effect of air relative humidity.





- Exponential model

Air Relative Humidity ↑

Drying rate ↓

Total drying time ↑

Air RH / Temperature

- Smaller effect on drying rate
- Bigger effect on total drying time

3.2. Microstructure Studies

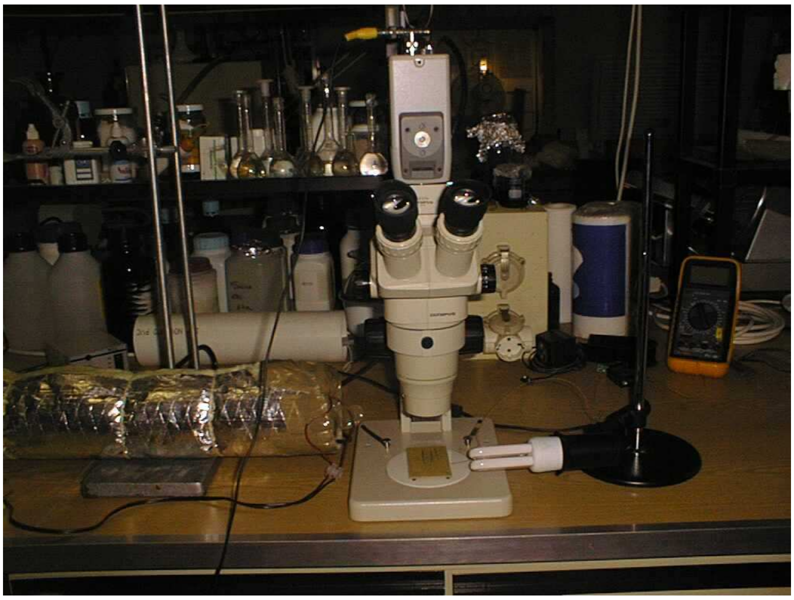


Fig 7 - Video-microscope and Drying apparatus

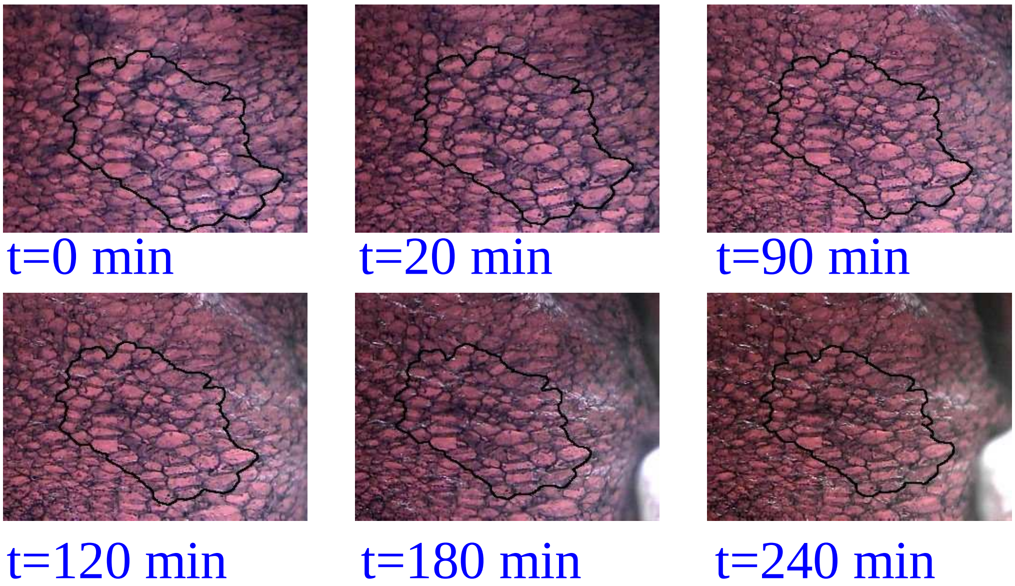


Fig 8 - Images of shrinkage of grape cells at 40ºC.

Parameters:

total area, perimeter
major axis lenght, minor axis lenght
elongation, roundness,
Feret diameter, compactness

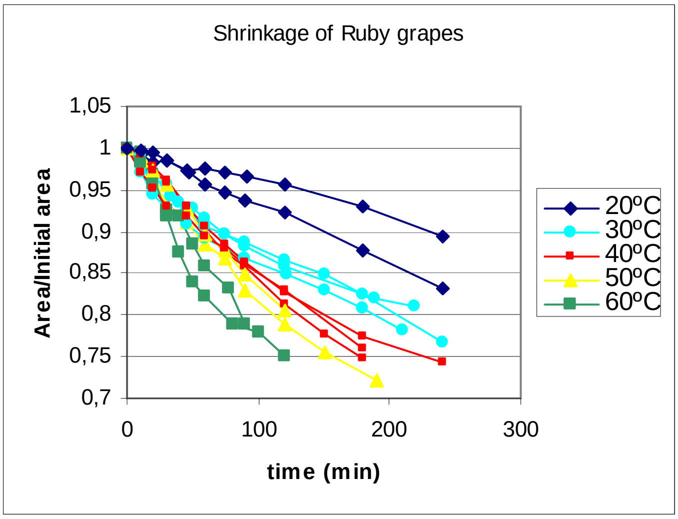
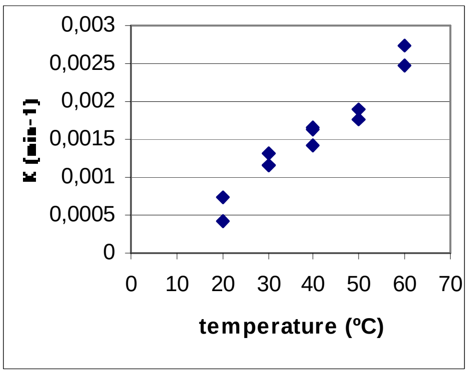


Fig 9 - Effect of air temperature on shrinkage of Ruby grapes.

- First order model



3.3. Dynamic Studies

Solar Drying

Fig 11 - Solar Drier in Trás-os-Montes.

Fig 12 - Preparative Techniques of
Monuca Red seedless grapes.

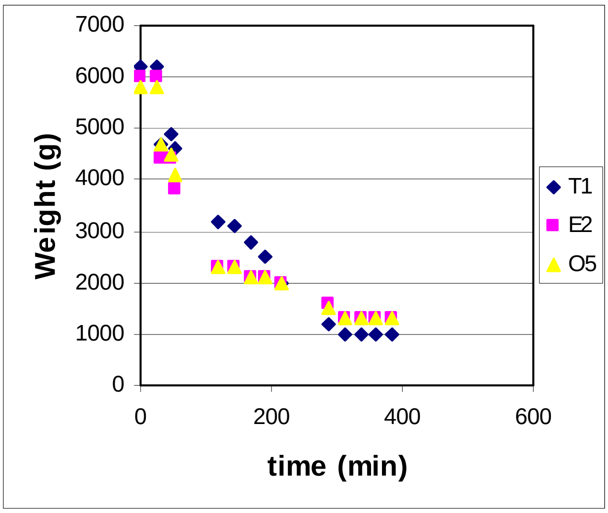


Fig 13 - Drying curves in the Solar drier.
Comparision between pre-treatments.

Blanched samples — hot water / edible oil 0.1%

faster drying rate

- Cyclic behaviour Solar drying → Dynamic studies Pilot scale drying

Pilot Scale

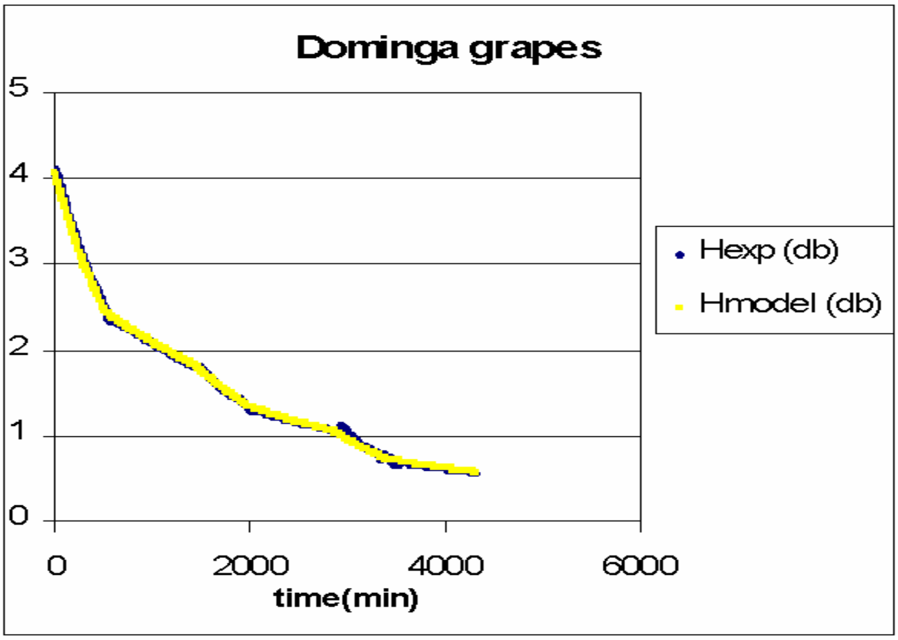


Fig 14 - Dynamic experiment at pilot scale and modeling.

•Smoother changes in equilibrium

Activation energy = 4.4 KJ/mol
Drying rate of reference at 40ºC
= 6.77×10^{-4} min^{-1}
Mean equilibrium moisture content
= 0.30 kg w/kg dm

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