A NEW METHODOLOGY FOR OPTIMIZING SOLAR DRYING OF FRUITS

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What is Solar Drying ?

- Sun-drying
- Solar-drying

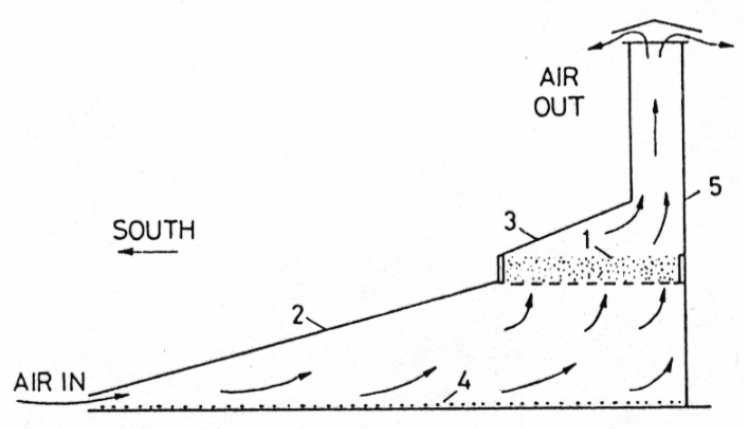
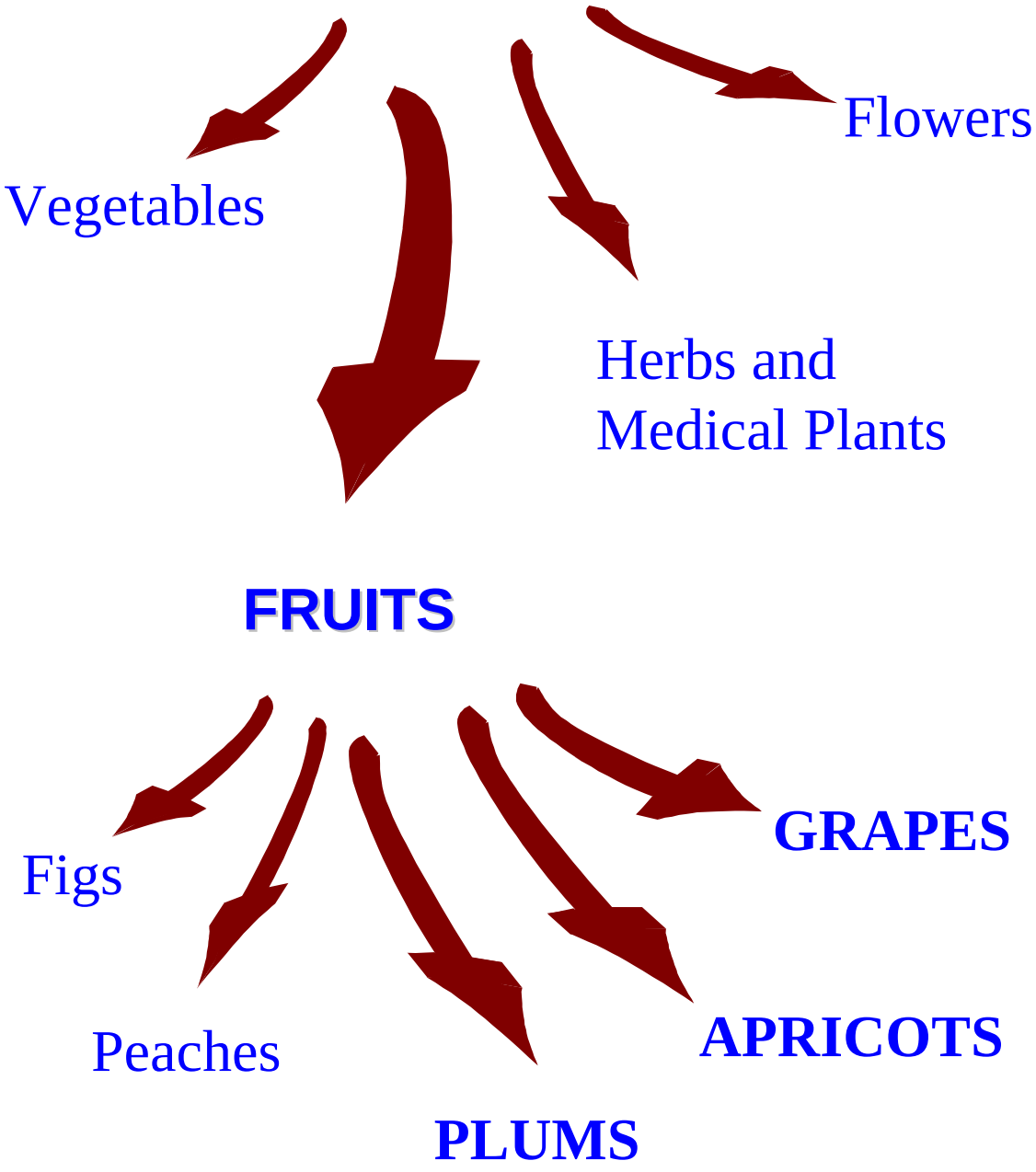


Fig 1 - Simple scheme of a solar drier.

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

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

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

- 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:

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

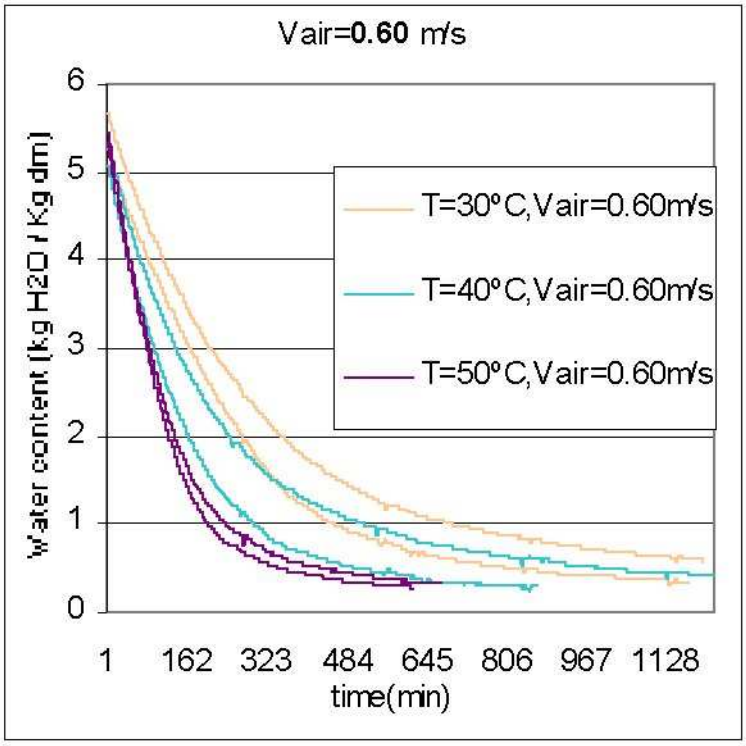
- Lack of research on the effect of
  air Humidity
  equilibrium moisture content

3. Research going on

3.1. Drying Kinetics at Pilot Scale

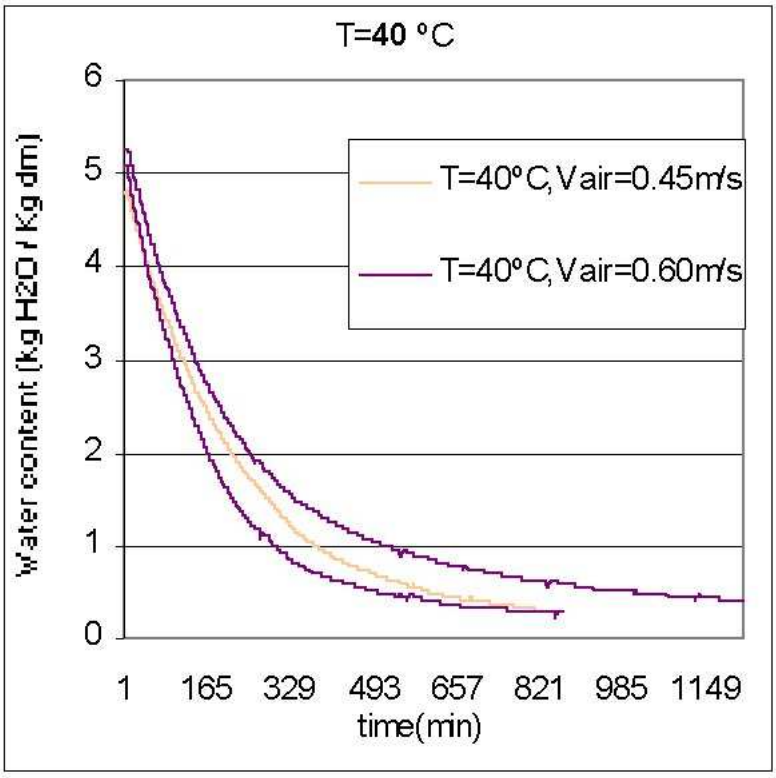
Fig 2 - Pilot plant tray drier.

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

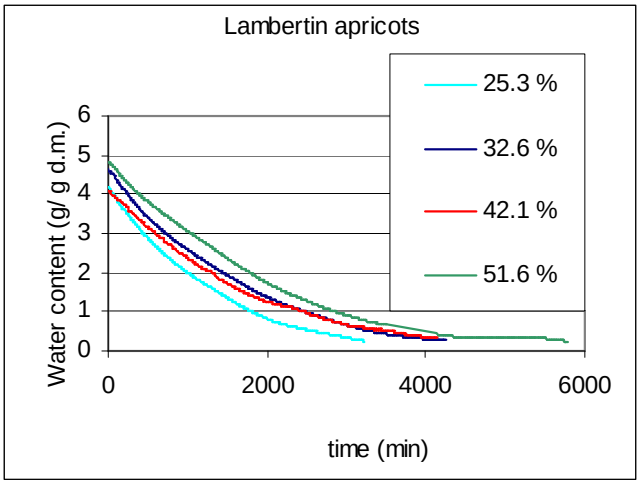
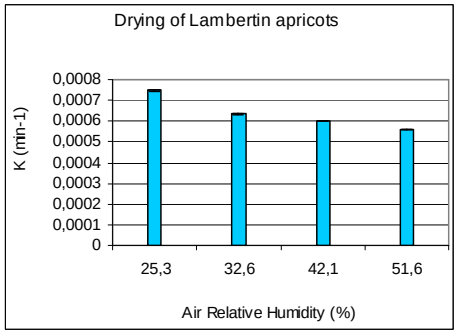


Fig 5 - Effect of air relative humidity.

equilibrium MC ← Isotherms GAB equation



- Exponential model

Air RH / Temperature

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

3.2. Microstructure Studies

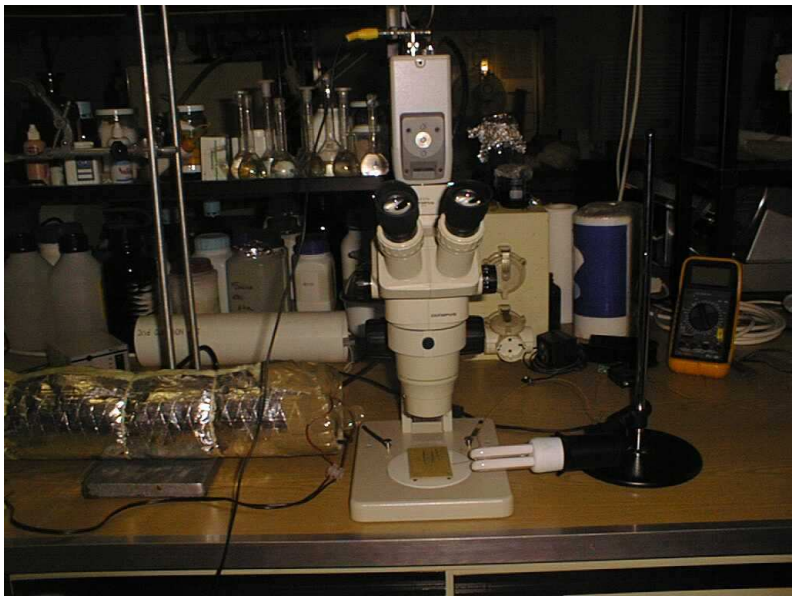


Fig 7 - Video-microscope and Drying apparatus

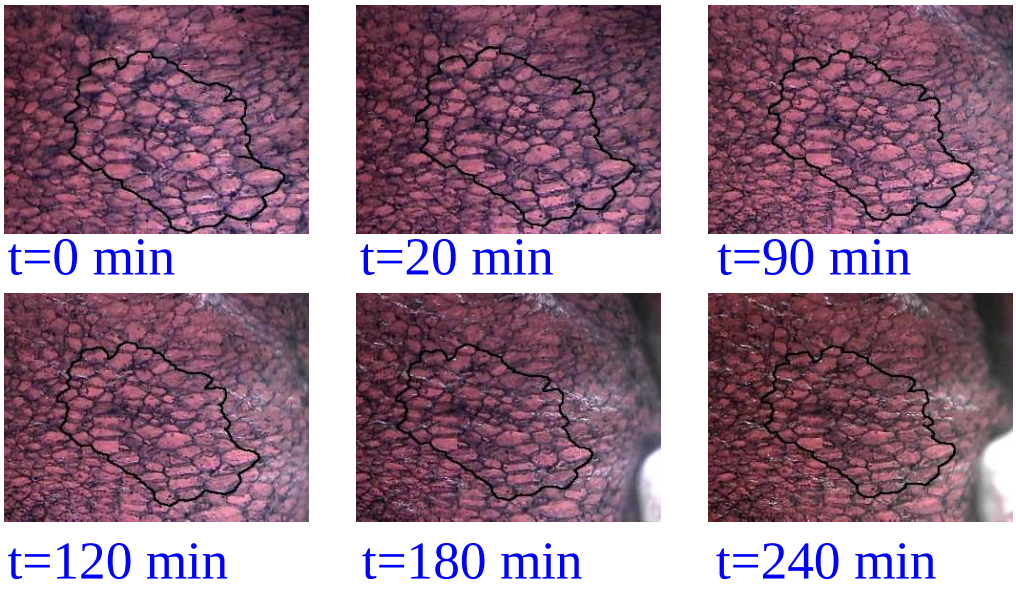


Fig 8 - Images of shrinkage of grape cells at 40ºC.

Parameters:

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

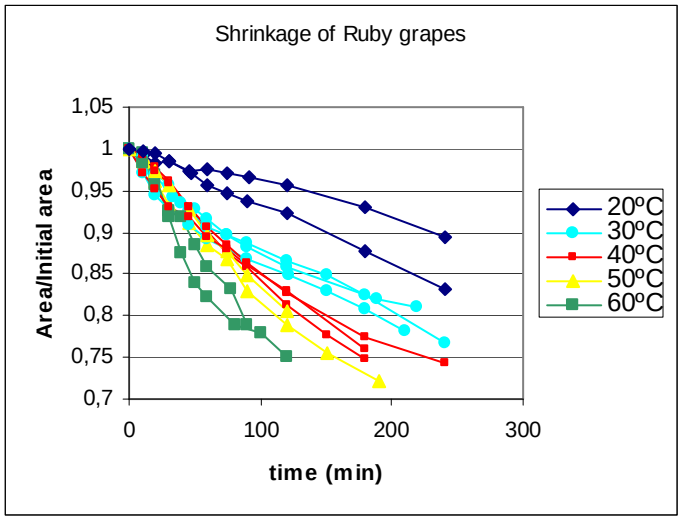
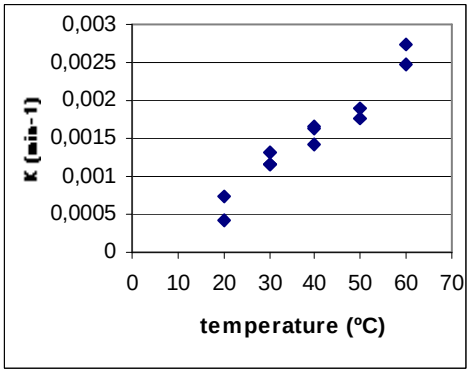


Fig 9 - Effect of air temperature on shrinkage of Ruby grapes.

- 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.

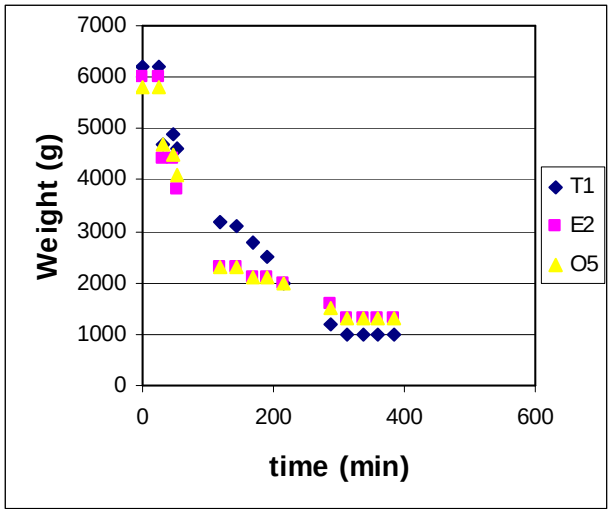


Fig 13 - Drying curves in the Solar drier.
Comparision between pre-treatments.

Blanched samples → hot water
edible oil 0.1%
→ faster drying rate

- Cyclic behaviour
  Solar drying
  → Dynamic studies
  Pilot scale drying

Pilot Scale

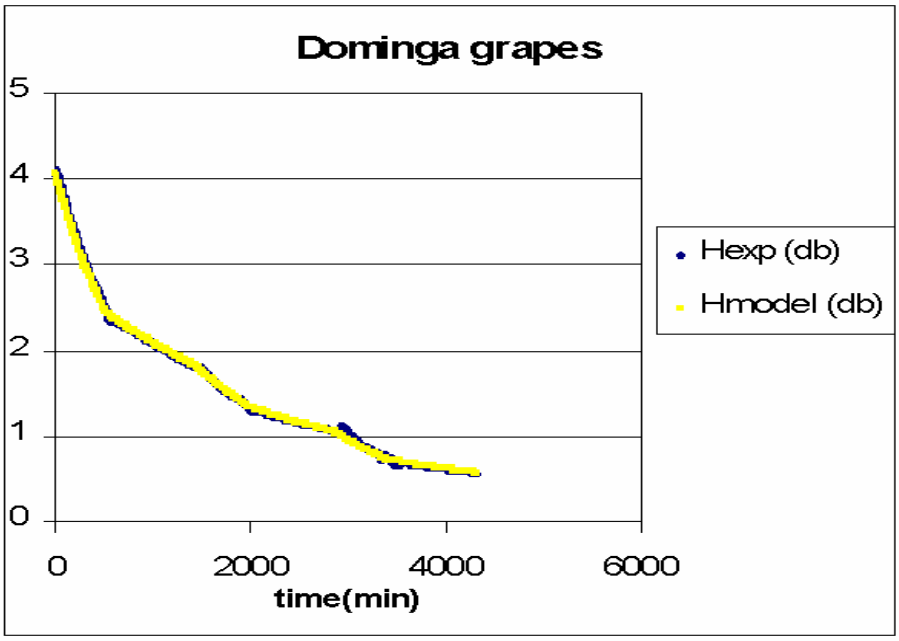


Fig 14 - Dynamic experiment at pilot scale and modeling.

- 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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