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Contribution to the Convective Drying of Green Oak Glands of Aures (Quercus ilex)

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ABSTRACT

This work deals with the drying four shapes of green oak glands in ventilated oven (LabTechOven) by natural convection at 40, 50 and 60 C°. This is to study the kinetics of water content, the mass diffusivity and the activation energy. The results show that the diffusion coefficient varies between $7{,}53 \times 10^{-10}$ and $9{,}89 \times 10^{-8}$ (m^2/s) with the increasing temperature. The values of the activation energy are respectively 65,96, 34,17, 29,88 and 22,59 (kJ/mol) for the whole oak glands, peeled glands, peeled half glands and gland powder. These results are in agreement with the literature.

Keywords: Oak, Drying, Ventilated oven, Diffusivity

I. INTRODUCTION

Vegetables and green fruits are important sources of minerals, vitamins and fiber [3]. The majority of fresh fruit contains high moisture content. After picking, they undergo aging process followed by decomposition. The water removal technique is used in order to reduce the availability of water and minimize the possible damage of plants [4]. In the food industry there are several techniques and many devices ensure the drying of food products. The drying technique is still very important because of their effect in the preservation of the quality of food. The improvement of various devices and instruments specific of drying does ceased to develop and improve (electric oven, ventilated oven, microwave ...). The mass diffusivity is the basis of property in calculating the mass transfer for drying agricultural products [5].

II. METHODS AND MATERIAL

A. Project Description

The aim of our work is the decreasing a water content in oak glands by drying technique through dry air. In the food industry, there are many tools and several devices provide drying function (microwave, electric oven, oven, etc.....). We used a ventilated oven (brand LabTechOven) for drying ours samples (whole oak glands, peeled glands, peeled half glands and gland powder) by convection at three temperatures 40, 50 and 60 C°, the transfer of heat and mass is controlled.

B. Ventilated Oven Property:

Ventilated Air drying, electronic temperature control and digital display, an inner glass door and another exterior metal door (thermal insulation), programmable drying time for more than 12 hours, alarm at end of cycle, programmable temperature to the start and stop automatically adjustable in 1 C°. The Ventilation ensures good homogeneity of the internal temperature [2].

Ventilated oven has the principle of convection drying. The heating element is not located within the specimen chamber of the oven, but in a separate external envelope. This prevents radiant heat from affecting the specimen, but the resulting temperature of the oven walls is enough to heat and dehydrate a specimen. Convective heat transfer is achieved by gravity or mechanical convection. Air intakes and exhausts can be adjusted to withhold or release humidity, Insulation reduces the rate of thermal transfer and is responsible for the energy efficiency of the oven [2].

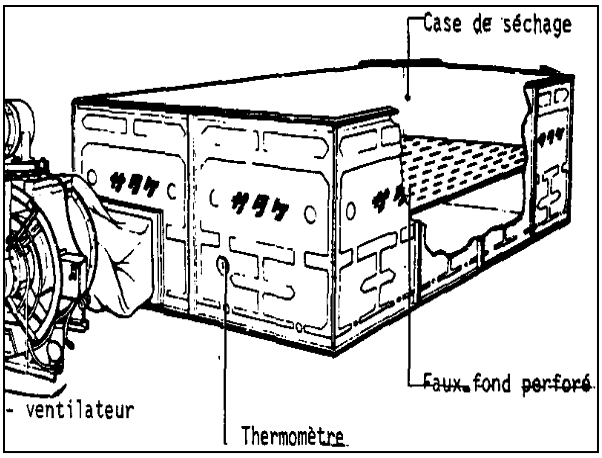

Figure 1: Composition of ventilated oven (LabtechOven) [2].

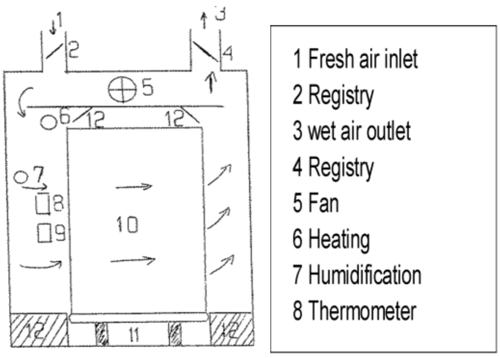

Figure 2 : The composition of the ventilated oven (Labtech) [2].

The transfer of moisture during drying is controlled by internal diffusion. The Fick's second law of diffusion was widely used to describe the drying process for most organic products. The relationship between the temperature and the mass diffusivity follows Arrhenius expression:

$$D = D_0 \cdot e^{(Ea/RT)}$$

The activation energy is calculated from the slope of the following equation:

$$LnD = LnD_0 - (Ea/RT)$$

The mass diffusivity of oak samples may be determined by the following relationship:

$$D = (K\,L^2) / \pi^2 \text{ [1].}$$

III. RESULTS AND DISCUSSION

The values of the activation energy and the mass diffusivity are shown in Table 1.

The majority of agricultural products (92%) have a mass diffusivity in the range **10^{-12} to 10^{-8} (m²/s)**.

The values obtained ranged from **7.53×10^{-10}** and **9.89×10^{-8} (m^2/s)**. The results show that the mass diffusivity increases with increasing of thickness samples and of drying temperature.

The values of the activation energy for most food material are in the range 12.7 to 110 kJ/mol. The values of the activation energy obtained are respectively **65,96**, **34,17**, **29,88** and **22,59** (kJ/mol) for the whole glands, peeled glands, peeled half glands and oak powder. The results show that the activation energy increases with increasing of diffusivity and of the sample thickness.

The values of the mass diffusivity and of the activation energy obtained are in agreement with the general line for drying food materials

TABLE I

ESTIMATED MASS DIFFUSIVITY AND ACTIVATION ENERGY OF OAK.

Sample Form	D (m^2s^{-1})	Ea (kJ/mole)
Whole Glands	$2{,}16\times10^{-8}$ to $9{,}89\times10^{-8}$	65,96
Peeled glands	$2{,}08\times10^{-9}$ to $4{,}57\times10^{-9}$	34,17
Peeled half glands	$2{,}08\times10^{-9}$ to $4{,}14\times10^{-9}$	29,88
Powder	$7{,}35\times0^{-10}$ to $1{,}23\times10^{-9}$	22,59

Drying time decreases with increasing temperature. The temperature has an influence on the evolution of the moisture content during drying (fig 3). Strong oak drying time reduction was obtained when exposed to dry air at a temperature of 60 C°.

The various velocity curves for the three temperatures (40, 50, 60 C°) have shown a decreasing drying rate. The absence of the constant speed phase was noted. This result is in agreement with the results obtained for various plant products.

Reducing the thickness of the dried form causes an increase in the heat transfer surface and thus a lengthening of the drying time. The shortest drying time corresponds to the oak powder, then peeled half glands, next peeled glands, and finally the whole glands.

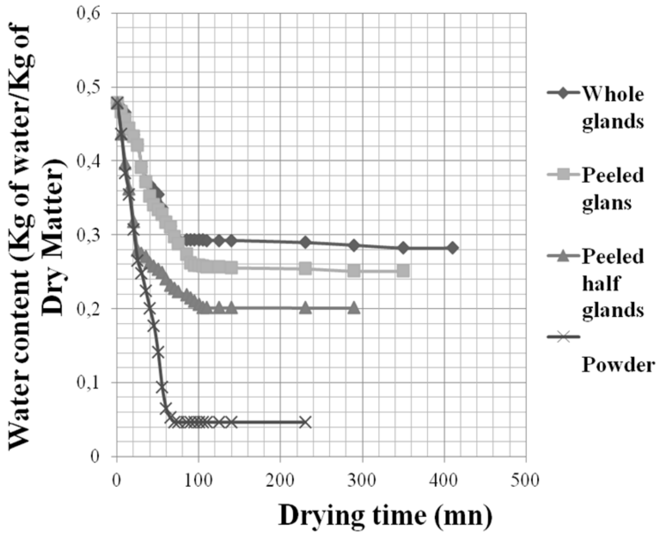

Figure 3: Evolution of the water content of the different samples of oak dried at 50 C°.

IV. CONCLUSION

This work focuses on the direct drying of oak. The dried product has a long lifetime due to its low water content. The shape of the oak powder requires very short drying time and low activation energy. It is necessary to develop new drying devices to be well equipped, have lower cost and high energy efficiency to increase food production and to preserve the quality of the food.

V. GLOSSARY

D: Mass diffusivity (m^2/s: square meter/second)
K: Drying constant (s^{-1}: $second^{-1}$)
D0: Arrhenius factor (m^2/s: square meter/second)
L: Product Thickness (m: meter)
Ea: Activation energy (kJ/mol DM: kilojoule/mol Dry Matter)
T: Air temperature (K: Kelvin)
R: Ideal gas constant (kJ/mol.
K: kilojoule/mol. Kelvin)
X: Water content (kg of Water/kg
DM: kilogram of water/kilogram Dry Mater)

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