Grasas y Aceites
Vol. 53. Fasc. 2 (2002), 226-228

Research Note

Studies on drying kinetics of olive foot cake

By **H. Kadi*** and **M.S. Hamlat**

Dept de Chimie, Faculté des Sciences, Université Mouloud Mammeri,
TIZI-OUZOU, 15 000, ALGERIE
e-mail: hokadi@yahoo.com

RESUMEN

Estudios sobre la cinética de secado del orujo.

El orujo es un importante subproducto de la industria del aceite de oliva ya que puede contener hasta el 12% del aceite, el cual puede ser extraído usando un disolvente apropiado. El uso del disolvente es a menudo inmiscible con el agua. Esta es la razón por la que su efecto está limitado por la humedad del orujo, haciendo su secado imperativo.

En este artículo se presenta el comportamiento del orujo sometido a un secado por convección. Los resultados experimentales mostraron que la velocidad de secado frente a la humedad, presenta un solo período de disminución de dicha velocidad. Se ha estudiado la influencia de los principales parámetros sobre la cinética de secado.

PALABRAS-CLAVE: Orujo – Secado – Transferencia de masa.

SUMMARY

Studies on drying kinetics of olive foot cake.

The olive foot cake is a very important by-product of olive oil industry since it can contain until 12% of oil which can be extracted using solvent. The used solvent is often immiscible with water. This is the reason why its effect is limited by the moisture of olive foot cake making its drying imperative.

In this paper, we present the behaviour of olive foot cake subjected to convective drying. The experimental results show that the drying rate versus moisture presents only one period of decreasing rate. The influence of the main parameters on drying kinetics is studied.

KEY-WORDS: Drying - Mass transfer - Olive foot cake.

1. INTRODUCTION

Among all the fatty foods, olive oil is well ranked because of its image, consumption at its virgin state and price. It is obtained through mechanical processes (crushing, pressure, separation…) leading to an important by-product: the olive foot cake which presents an important economical interest specially because of its residual oil which can be recovered by solvent extraction (1).

This oil is called olive foot cake oil or olive pomace oil. It is intended to either consumption (after refining) or industry. To illustrate the importance of the international trade, let us mention for example that in 1990, Spain exported 123 000 tonnes of olive oil and 12 000 tonnes of olive foot cake oil. In general, olive foot cake oil is less expensive than olive oil but more expensive that the majority of other food oils.

The solvent extraction of this oil can be efficient only if the olive foot cake moisture is less than 10 %. As its humidity can reach 50 % of its weight, its drying becomes imperative. Furthermore, to avoid oil deterioration, the olive foot cake has to be dried immediately after its mill exit.

In this study, we present the behaviour of an olive foot cake subjected to a convective drying.

2. EXPERIMENTS

The experiments have been carried out on a convective drying installation. Hot air whose temperature and velocity can be varied , is sent on a bed of olive foot cake of variable thickness (S). The tray supporting the drying material is connected to a balance giving the weight variations continuously.

The olive foot cake investigated was originally dry so we had to moisten it with water and to leave it two or three days in a closed phial. The material is regularly stirred in order to make the humidity uniform. The initial moisture content was 7,3 % which was increased to 50 %.

3. RESULTS OF THE EXPERIMENTS

The preliminary experiments allowed us to determine the different drying periods of olive foot cake and to present a physical model describing the drying process. We have then tried to determine the parameters which influence on the kinetics of drying.

3.1. Different periods of drying

---

* Address for correspondence: B.P 70, Poste Annane, 15010 TIZI-OUZOU, ALGERIA

The experiments carried out showed that the kinetics of drying (figure 1) versus moisture (w) graph presents:

- A short phase where the received heat is used to heat the material and its water content. A slight evaporation is noted during this phase,
- A first period where the drying rate (U) is constant. The evaporation takes place only from the water of the external surface whose temperature is equal to the one given by wet-bulb thermometer. This evaporation process is identical to the one of a liquid from a free surface. Toward the end of the constant rate period, moisture has been transported from the inside of the bed to the surface by capillary forces and the drying rate may still be constant. At this stage, the drying rate is not affected by the material proprieties but only by the characteristics of the drying agent (temperature, velocity, relative air humidity) since the process is controlled by the external diffusion of water vapours.
- A second period with a continuously decreasing rate that begins at the critical point, when the first period is finished. In this stage, the evaporation surface shifts within the bed. The drying rate decreases continuously since the resistance to the vapour diffusion through the dry zone, which becomes determining in process, adds to the resistance of the external boundary layer.

The olive foot cake presents only on period of drying with rate decreasing. Its drying is done according to the model with complete moisture migration zone in liquid state.

3.2. Presentation of the model with complete moisture migration zone in liquid state

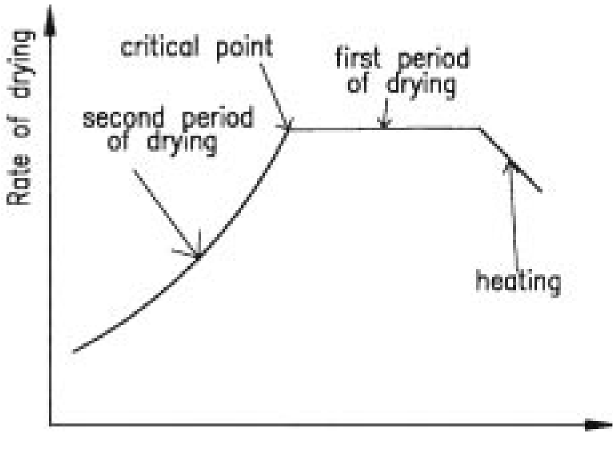

Figure 1
Different periods of drying

Some authors (2) (3) tried to explain the drying process and the distribution of humidity in the material by assuming that the main mechanism is based essentially on the moisture migration in liquid state. The migration zone thickness of the humidity (Sm) depends on both the drying rate and the migration rate of the moisture of liquid state. We correspond to this thickness three models of drying:

- model with a limited zone of moisture migration,
- model without a zone of moisture migration,
- model with a complete zone of moisture migration.

The last case is the best model for our study. If we consider that the material has an initial humidity (w_0) before the drying, the different steps of the process (figure 2.a) are:

- the first period where the drying rate is constant, the evaporation of the moisture from the external surface creates a gradient of concentration entailing a migration of the humidity in liquid state from inside to outside, over all the thickness of the material. Then, there exists, only one zone: the moisture migration zone which has a thickness equal to the material thickness (Sm = S).
- when the transport of the liquid cannot compensate the losses by evaporation, the drying surface moves to inside. In the material, there exist two zones: the external dry zone (Sd), and the internal migration zone (fig.2.b). The drying rate continues to decrease until the migration zone disappears. The drying is considered finished when the humidity of the whole bed equals the equilibrium humidity (w_e).

3.3. Influence of the main parameters on the drying kinetics

3.3.1. *Air temperature*

Figure 3 shows that the drying rate increases with air temperature (t_a). This evolution is due to the fact that the variation of the air temperature changes the

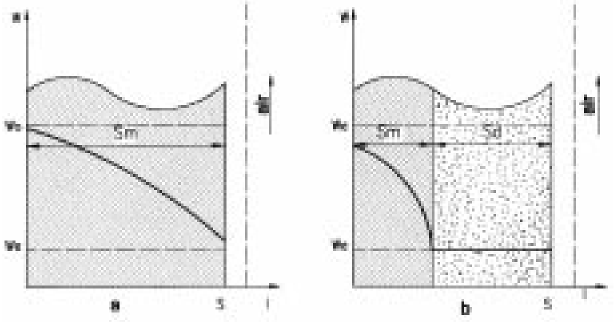

Figure 2
The drying mechanism according to the model with complete moisture migration zone

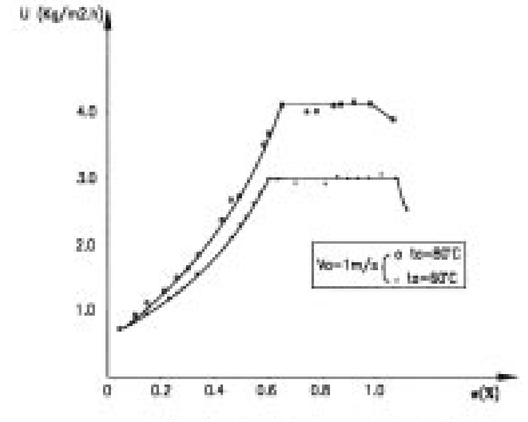

Figure 3
Effect of temperature on drying rate

coefficient of both vapour diffusion and moisture migration rate in liquid state.

3.3.2. *Air velocity*

As the air velocity (V_a) modifies the boundary layer, its influence is more important on the first period characterized by a constant drying rate than the second period with decreasing rate. This phenomenon can be explained by the fact that the process is controlled by the external diffusion of water steam in the first case; in the second case, it is the diffusion toward the dried zone which is determinant, the one through the boundary layer is being negligible.

3.3.3. *Thickness of the bed*

The thickness of the bed (S) has no effect on the drying rate (figure 5). It has influence only on the drying time: the more is the thickness of the bed important, longer is the drying time.

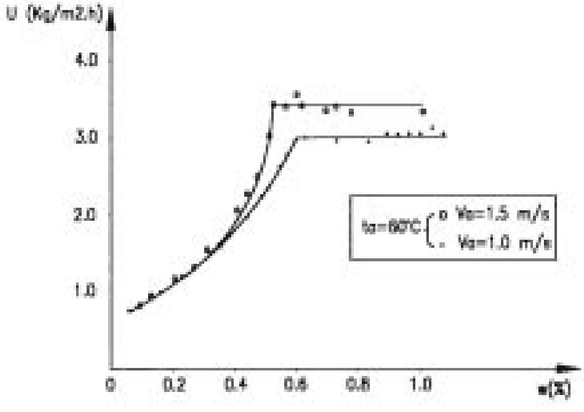

Figure 4
Effect of air velocity on drying rate

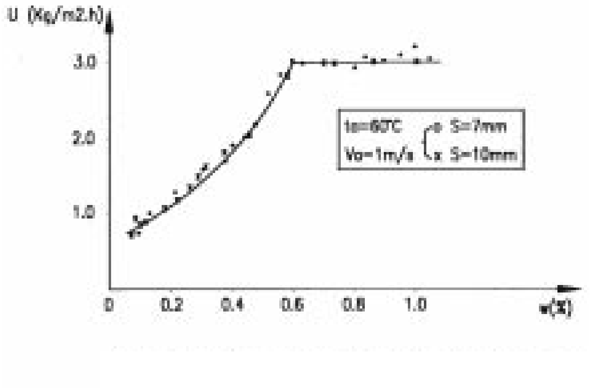

Figure 5
Effect of bed thickness on drying rate

4. CONCLUSIONS

The drying of olive foot cake is done according with complete moisture migration zone in liquid state. Its drying kinetics presents only two periods: one period where the rate is constant followed by another one where the rate is decreasing.

The air temperature has a positive effect on the drying rate because it increases the vapour pressure thus enhancing the heat transfer.

By modifying the structure of the boundary layer, the air velocity affects the drying rate mainly during the first period.

The drying rate is not influenced by the thickness of the bed.

NOMENCLATURE

S: total thickness of the bed, m
Sm: thickness of the moisture migration zone, m
Sd: thickness of the dried zone, m
ta: air temperature, ^{o}C
U : drying rate, kg/m^{2}.h
Va: air velocity, m/s
w: humidity, kg/kg
w_e: equilibrium humidity, kg/kg
w_0: initial humidity, kg/kg

REFERENCES

1. Kmieciak, S., Kadi, H., Meziane, S. and Moussaoui, R. (1991). Oil extraction from olive foot cake with acidic hexane. *Grasas y Aceites*, **42**, 46-50.
2. Tudose R.Z. and Christian, Gh. (1980). Studies on the drying kinetics. Drying'80: Proceedings of the second international symposium **2**, 43-52.
3. Tudose R.Z. and Kadi, H. (1987). Séchage d'un grain poreux sphérique. *Revue Roumaine de Chimie*, **32**, 807- 819.

Recibido: Diciembre 2000
Aceptado: Julio 2001