Drying ability of whole black olive (*Olea europaea* L.) fruits in Kabylian region (North-East Algeria)

A Boukhiar, K Kechadi, R Abdellaoui, N Iguergaziz, M Guemmane & S Benamara*

Research Laboratory in Food Technology, Faculty of Engineering Sciences, University M’hamed Bougara of Boumerdès, 35000, Algeria

E-mail: *Sbenamara2001@yahoo.fr

Received 08 July 2016, revised 29 July 2016

The present work aimed to investigate the drying ability of whole fresh black olive (*Olea europaea* L., var. *chemlal*) fruit (BO). Static oven-drying was applied to emulate the traditional open-air drying procedure applied in some localities of Kabylian region, in North-eastern Algeria. The drying ability, with and without applying freezing-thawing as pretreatment of fresh BO, was evaluated in terms of: i) equilibrium drying time which is needed to reach equilibrium water content, and ii) corresponding concentration of oleuropein, a well known bitter bioactive molecule of olive fruits. Dried and undried fruit were also analyzed for weight, length, width, K, Ca, Mg, Cu and fat. Dried olives were analyzed for water and oil uptake capability. Results showed that the equilibrium drying time decreased exponentially with drying temperature, regardless of whether the olive fruits were pretreated by freezing-thawing or not. However, the application of freezing-thawing as pretreatment enhanced the drying process by reducing the equilibrium time. The drying process implicated also a substantial debittering of BO since 47 to 70 % of the initial oleuropein content was eliminated, under the drying conditions. Dried BO showed an interesting water uptake (~ 40 %), compared to oil uptake (~ 9 %), which could be useful to better design of their preservation process by pickling.

**Keywords:** Whole black olive fruit, *Olea europaea* L., Physicochemical properties, Drying ability, Oleuropein, Water uptake, Oil uptake

**IPC Int. Cl.**: F26B, A23N 12/00, C07, C07C-C07K, A23D, A23L 27/12

In the Kabylian region (North-eastern Algeria), the olive (*Olea europaea* L.) tree is considered as food plant of prime importance due principally to the oil extracted from its fruit (olives). Olive oil is thus combined with almost any other food to make various dishes. Examples of dishes are figs dipped in olive oil, carob powder soaked in olive oil and some types of couscous. Foods prepared with olive oil as one of the ingredients allowed the local population to overcome cold, hunger and disease, knowing that the olive growing determines the economic structure of the people of Kabylia. On the other hand, the health benefits of olive oil, considered as the most characteristic of the Mediterranean diet, is worldwide admitted. In some localities of this region, open-air drying of olives spread directly on a portion of the cleansed soil, is sometimes still practiced, for two purposes, according to the locality:(i) as a pre-treatment before oil extraction, and (ii) as a preparation procedure of wrinkled table olives.

In both situations, drying of the fruit is done, on the basis of traditional know-how. The fresh olive fruit is inedible as such because of its intense bitterness induced by its high content of oleuropein. Oleuropein is well known for its nutraceutical properties and represents a characteristic glucosidic polyphenol of olive and olive oil. Some authors have studied the drying procedure as a way of preparing table olives, applying different pretreatments namely piercing, water blanching, NaCl aqueous solution blanching, salt-drying, lye debittering and fermentation, either separately or in combination. The present work aimed to investigate the drying ability of whole fresh black olive (*Olea europaea* L., var. *chemlal*) fruit (BO). Static oven-drying was applied to emulate the traditional open-air drying procedure applied in some localities of Kabylian region, in North-eastern Algeria.

**Methodology**

**Olive fruits**

The studied olive fruit belong to the *chemlal* variety, known for its dominance in the region of

*Corresponding author
Kabylia and its drought-resistance. They were hand-picked during the period of November-December 2013 in the Bouira region located 110 km East of Algiers (Fig. 1). After sorting, healthy fruit were stored in the refrigerator at +4 °C until use.

**Basic physicochemical characterization of olives**

The determination of different dimensions of olives was performed on 10 randomly selected whole fruit units and their stones as suggested by Kiliskan & Guner. Their linear dimensions (length, width, length/width ratio) and weight of the whole fruit and its separate tissues (flesh and stone) were determined using caliper (accuracy of 0.01 mm) and electronic balance (accuracy of 0.0001 gm), respectively. The water content of the olive flesh was determined by oven drying of a homogeneous flesh sample at 105 °C until constant weight, whereas that of whole olives was determined on 10 olives, under the same conditions. Potassium, calcium, magnesium and copper were determined by flam atomic absorption, using Thermo Elemental SOLAAR M6 spectrometer, as described by Tanilgan et al. Fat was analyzed on 18 gm of whole olives before and after drying by applying the conventional method of Soxhlet, the solvent of extraction being petroleum ether.

**Drying ability of BO**

The drying ability of BO, under different conditions, was assessed, based on: (i) equilibrium drying time, and (ii) corresponding concentration of oleuropein, a well known bitter bioactive molecule of olive fruits.

**Equilibrium drying time versus drying temperature**

Isothermal drying conditions (static oven-dryer of type Memmert, Germany) were chosen to simulate conditions of the traditional passive open-air drying of olives, in terms of air circulation. According to the traditional procedure, whole olives are spread on the ground which implicates a wind speed of almost zero. Under such conditions, the heat and matter transfers take place by natural convection. Olive samples (10 whole fruits, in triplicate) were dried in a thermostatically controlled oven. The weight was measured periodically, using an analytical balance of type Sartorius Entris 64-1S (± 0.0001 gm), until constant weight was reached. The fruit were dried at the following temperatures: 25, 35, 45, 55, 65 and 75 °C. An attempt was made to see whether the preliminary freezing-thawing of BO fruits influenced their drying behaviour. This test was conducted for only three drying temperatures (25, 35 and 45 °C).

**Oleuropein content**

The content of oleuropein in the olive fruit was determined by UV spectrophotometry. First, the extraction of the glycoside was made by maceration of 0.5 gm of olive flesh in 20 ml of distilled water for 3 hrs, at room temperature and sheltered from light. The optical density (OD) of the filtered extract was then measured, using a spectrophotometer (Jasco) at two wave lengths of 280 nm (oleuropein+ verbascoside) and 330 nm (verbascoside). The oleuropein content (gm/100 gm flesh) was calculated according to the following equation:

\[
\text{Oleuropeine (gm/100gm) = (A}_{280}-0.9A_{330}) FV/(75 m)
\]

where, m: sample weight, V: volume of solution, and F: dilution factor.

The benefits of mediterranean diet can be attributed not only to the monounsaturated fatty acids of olive oil, but also to the medicinal properties of its phenolic compounds, including the oleuropein.

**Water (WU) and oil (OU) uptake**

WU and OU of dried BO were determined according to a method described by Hsu et al. Briefly, five dried BO fruits were soaked in each of 10 flasks immersed in a thermostated water bath (30 ±1 °C), with olives/liquid medium ratio (w/w) of about1/3. At various time intervals, the olive sample of one flask is weighed. The soaking process was stopped once the equilibrium state was reached. The absorption indexes (in %) were calculated according the following equation:

\[
\text{WU (OU) = 100 (W}_e-W_i)/W_i
\]

where, W_i and W_e are the initial and at equilibrium state.

In Kabylial region, dried olives are sometimes preserved either by dry-salting or immersing in olive oil. In other circumstances, fallen BO fruits that naturally dried on the tree were picked, boiled in water, drained and then dry-salted. Such final products represent a kind of adjunct to the usual diet.
Statistics
The oleuropein and fat contents were determined in triplicate and reported as means ± standard deviation. Comparisons of mean values of oleuropein content were made using analysis of variance (ANOVA) and Tukey's post-hoc test. A *p*-value ≤0.05 indicates strong evidence against the null hypothesis which assumes that any kind of difference in a set of data is due to chance.

Results and discussion

Basic physicochemical characteristics of BO
Some basic physicochemical characteristics of fresh and dried olives are given in Table 1, whereas the weight proportions of flesh and seed are illustrated in Fig. 2. The weight of the analyzed BO is close to the values found (0.9 and 1.10 gm) by Feki et al.22. However, the flesh-to-stone ratio was close to values that range from 2.82 to 4.55 for two Turkish cultivars at different steps of maturation23. Furthermore, the Chemlal variety presents an interesting flesh proportion (Fig. 2), making them more appropriate for drying. Considering their water content (Table 1), the studied olives can be integrated into the category of intermediate moisture (25-50%) foods that are habitually spoiled by surface mould growth24. The water content of analyzed fresh BO is comparable to values obtained for Ghimlik Turkish variety that range from 47.55 to 52.89%25. Owen et al.26 reported a similar value of 50 % (wb) for black olives, without specifying the variety.

The drying process involved an increase in oil content of dried BO of more than 1.5 times, compared to olives before drying (Table 1). The oil content of dried BO is close to values of 20 to 28 % reported for olive paste27.

For another plant species, namely safou (Dacryodes edulis) pulp, the oil concentration increases from 12 before drying to above 70 % after drying28. The removal level of water may explain the observed differences.

Dried olives display an increase in mineral concentration of more than 2 times, compared to fresh olives. Unlike fresh olives, the dried fruit presents higher concentrations of various minerals, compared to concentrations reported for 5 Turkish olive cultivars: Ca (48-117), K (472-1144), Mg (19-27) and Cu (0.02-0.26) (in mg/100 gm)18. The obtained results allow us to note that the drying process enhances the native chemical constituents of olives.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Fresh olive</th>
<th>Dried olive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (gm)</td>
<td>Whole olive 1.88±0.08</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Flesh 1.42±0.12</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Stone 0.46±0.06</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Flesh/stone ratio 3.1</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions (cm)</th>
<th>Fresh olive</th>
<th>Dried olive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (whole olive) 1.86±0.08</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Width (whole olive) 1.27±0.06</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Length/width ratio 1.47±0.07</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Length (seed) 1.25±0.11</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Width (seed) 0.48±0.02</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water content (%)</th>
<th>Fresh</th>
<th>Whole olive 34.93 (53.76 db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>295</td>
<td>349</td>
</tr>
<tr>
<td>Ca</td>
<td>71</td>
<td>178</td>
</tr>
<tr>
<td>Mg</td>
<td>44</td>
<td>112</td>
</tr>
<tr>
<td>Cu</td>
<td>0</td>
<td>0.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minerals (mg/m/100 gm)</th>
<th>Fresh</th>
<th>Dried</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>295</td>
<td>349</td>
</tr>
<tr>
<td>Ca</td>
<td>71</td>
<td>178</td>
</tr>
<tr>
<td>Mg</td>
<td>44</td>
<td>112</td>
</tr>
<tr>
<td>Cu</td>
<td>0</td>
<td>0.36</td>
</tr>
</tbody>
</table>

WU = water uptake, OU = oil uptake

* Obtained after 20-days immersion at 30 C

Drying ability of BO

Equilibrium drying time versus drying temperature
The equilibrium drying times (t) vary in the following order: *t*<sub>25°C</sub> (24 hrs) < *t*<sub>35°C</sub> (50 hrs) < *t*<sub>55°C</sub> (80 hrs) < *t*<sub>65°C</sub> (200 hrs) < *t*<sub>75°C</sub> (350 hrs) < *t*<sub>25°C</sub> (450 hrs) (Fig. 3).

As illustrated in Fig. 3, t values decrease exponentially with increase in temperature regardless of the application or non-application of preliminary freezing-thawing. This result confirm a well known...
strong effect of temperature on drying time. In addition, the pretreated BO fruits seem to be more sensitive to the drying temperature, compared with non-pretreated ones. The following regression equations correctly describe this behaviour:

Case of non-pretreated BO (at 25-75 °C): \( t = 1331 \exp (-0.05T) \) (\( R^2 = 0.988 \)) - … (1)

Case of pretreated BO (25-45 °C): \( t = 1203 \exp (-0.06T) \) (\( R^2 = 0.991 \)) - … (2)

where, \( t \): equilibrium drying time (hr) and \( T \): drying temperature (°C).

These equations are in the form of the Arrhenius equation that is generally applied to describe the effect of temperature. The pretreatment seems to influence both the temperature coefficient and pre-exponential factor. The temperature coefficient for pretreated BO is higher than that of non-pretreated BO (Equations 1&2). However, the pre-exponential factor for non-pretreated BO is higher than that for pretreated BO. The drying ability of pretreated BO may be higher, compared with non-pretreated BO regardless of the drying temperature. The effect of drying temperature on drying time of impregnated orange peel was highlighted by Manjarres-Pinzon et al.\textsuperscript{29} Compared with air flow rate, the drying temperature significantly affected the drying time of peel samples.

**Oleuropein content**

The experimental results relating to the influence of drying conditions (temperature and application of the prior freezing/thawing) on the oleuropein content of the BO are presented in Fig. 4. The drying process induced a significant decrease in the olive oleuropein content (47 to 70% of its initial value) (p ≤ 0.05), according to the treatment conditions. The most significant reductions are recorded during extended drying at low temperatures (at 25 °C, in particular) when the BO were not preliminarily frozen. This decrease can be explained by the effect of endogenous hydrolytic and oxidative enzymes on the oleuropein molecule. We think that for low drying temperatures up to about 40 °C the enzymes remain active as long as the product water activity does not reach a critical value that depends on the nature of the enzyme. But, Garcia et al.\textsuperscript{12} have earlier demonstrated the vulnerability of the oleuropein to enzymatic action. It is usefull to note that oleuropein and its derivative molecules like hydroxytyrosol show higher antioxidant effects than natural and synthetic antioxidants on DNA and lipid oxidation\textsuperscript{30}. It must be noted that the oleuropein is generally selected as a marker of good practice in olive oil production\textsuperscript{31}. The non-uniform variation of oleuropein content on function of drying temperature may be due to the complex physicochemical and enzymatic mechanisms that occur during drying. For instance, the high temperatures could involve the acceleration of the release of the oleuropein from vacuoles and cytosol. Ramirez et al.\textsuperscript{32} demonstrated that during drying, oleuropein completely disappears in the case of previously salted olives, compared to the previously pasteurized olives. In other types of thermal treatment for example the roasting of cocoa powder, Tamrin et al.\textsuperscript{33} demonstrated the existence of a step of substantial increase in phenolic compounds, followed by a decrease stage. Malik et al.\textsuperscript{34} indicated that the concentration of oleuropein during ripening of Arbequina olive variety changed from 50 (at the first stage of development) to 0 mgm/gm (at black ripe stage). From point of view of taste, this may be enhanced in dried olives by the synergistic effect of
oleuropein decrease and reducing sugars increase. In fact, it was reported that the drying of some products (Parinari curatellifolia Planch. ex Benth. fruit syrup and zvambwa) has induced an increase in concentration of reducing sugars. On the other hand, it is well known that the sweetness of reducing sugars is higher than that of non-reducing sugars since fructose is sweeter than sucrose, a disaccharide whose molecule is made of glucose and fructose.

**WU and OU**

Compared with whole dried BO before any immersion (Fig. 5a), whole BO after 20 days-immersion in salted water presents a more firm and smooth surface (Fig. 5b). Whole dried BO after 20 days-immersion in olive oil also shows some firmness but is less pronounced (Fig. 5c). These observations are supported by data of Table 1, concerning WU and OU values. Thus, WU is about 4.5 times higher than OU. Such behavior may be explained by the fact that, only water was removed during drying process, and that the hydrophilic space thus freed up by water, is available again to absorb water. It was stipulated that water absorption by foods depends on their microstructure. The good rehydration ability of dried BO could be useful to better design their preservation process by pickling. Despite the low oil uptake, the recipe “whole dried olive-infused olive” still applied in some localities of Kabylia region, probably contributes to: i) protect whole olives against undesirable action of air or oxygen and aerobic microorganisms, and ii) enhance the sensory and textural properties of dried olives. The study proved above all the effectiveness of the drying process as applied traditionally in Kabylia region as a means of obtaining wrinkled table olives. It highlighted the debittering action of such process which can be an alternative to classic treatment with caustic soda. Therefore, the traditional drying procedure may be better controlled if carried out in isothermal conditions, i.e., in a controlled environment. Regarding the freeze-thawing of fresh olives before drying, the process is, in our opinion, conceivable especially on an industrial scale. At last, the rehydration ability of wrinkled table olives opens perspectives for a better valuation of final product, in terms of its conservation as marinade.

**Conclusion**

The drying ability of whole chemlal olives, in terms of equilibrium drying time and oleuropein content, was proved independently of the application of the pretreatment (freezing-thawing) of BO. Freezing thawing enhanced the drying ability. The drying time required to reach the equilibrium state depends strongly on the drying temperature. Such behavior was correctly described by an exponential law. In addition, the drying process implicated also a substantial debittering, according to the drying conditions. The findings demonstrated the feasibility of the traditional drying process either as pretreatment prior to the oil extraction (oil yield increase) or as preparation procedure of wrinkled olive (oleuropein content decrease). Nevertheless, the drying conditions could be better managed if the drying conditions were better mastered.

**References**


