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Effect of fruits storage conditions on the yield and the quality of *Pistacia lentiscus* oil

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A**bstract**: This study aims to determine the effect of fruit storage conditions on the yield and quality of *Pistacia lentiscus* oil. Fruits were harvested in North Tunisia, and oil was extracted using the pressing method. Three storage conditions were tested; fruit is frozen at -20°C, fruit storage in a cold room at 4°C, and air-dried fruits at 25°C. Oil yield, free fatty acids, peroxide value, and total polyphenolic content were determined after 30, 60, and 90 days of storage. During the first 30 days, the highest yield was reached by fruits stored in a cold room (15%). Oil acidity from freshly harvested lentisk fruits was around 6% and then increased during storage. With increasing storage time, the oil peroxide value and the total polyphenolic content decreased in the fruits from all treatments. The peroxide value reached the respective values of 8, 5, and 23 meq O_2/kg oil for Frozen, Cold Room, and Air Drying treatments. The total polyphenolic content varied from 0.5 EGA/g oil for air drying and frozen treatments to 0.8 EGA/g oil for the cold room. This study allowed the determination of the optimal conditions of storage of *Pistacia lentiscus* oil. These results are important to preserve the oil's quality and chemical and medicinal properties.

Keywords: Acidity; *Pistacia lentiscus;* Peroxide value; Polyphenols Seed oil; Storage conditions.

1. Introduction

Vegetable oils are fatty substances represented in various fields of application. For many people, vegetable oils are, first and foremost raw materials in the daily diet. For others, they are cosmetic products with nourishing, soothing and protective properties, while some use them mainly for their therapeutic effect and aromatherapy for their medicinal properties. It is impossible to separate these different fields of application since the same vegetable oil can have various applications.

In recent years, several vegetable oils have been developed. Among these oils, the fixed oil of *Pistacia lentiscus* has become more and more known thanks to its therapeutic and nutritional virtues.

Several studies on lentisk seed oil highlighted its biochemical and biological properties. A high nutritional value characterizes this edible oil; it contains a significant amount of unsaturated fatty acids (more than 70%) and a high level of phosphatidylinositol [1,2]. The wound healing, antiproliferative, antioxidant, antimicrobial, and anti-inflammatory effects of this oil were demonstrated in several previous studies [3-5].

Despite the increase in the production of lentisk oil and to the best of our knowledge, no study has addressed the storage conditions of lentisk fruits. The storage of fruits must be studied to preserve the quality of the oil or at least to delay its deterioration process. This is an important point to keep the therapeutic and medicinal properties of the oil.

In this work, the study pertaining to yield and quality of the extracted oil is reported for the first time on the effect of lentisk fruit in different storage conditions.

2. Results and Discussion

2.1. Oil yield

Fruits storage significantly affected the oil yield of *P. lentiscus*, as shown in Figure 1.

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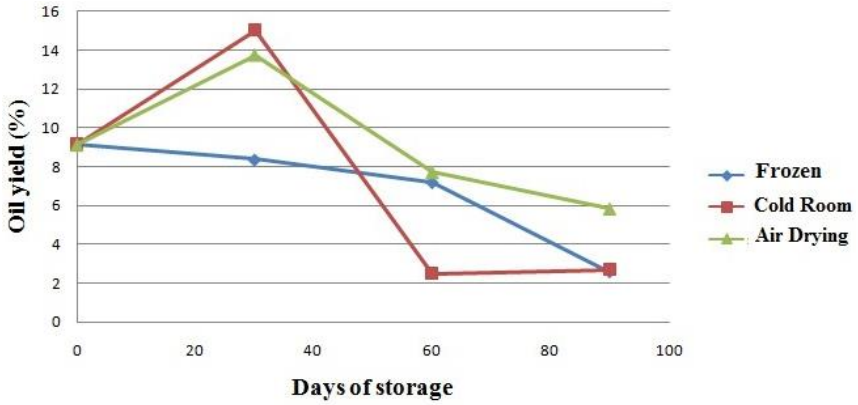

Figure 1. Effect of fruits storage on oil yield of *P. lentiscus*

Fruits storage significantly affected the oil yield of *P. lentiscus*.

Oil yield increased slightly under frozen and air-drying conditions of fruit storage during the first month. The highest yield was reached by fruits stored in a cold room (15%). After 30 days, the oil yields were decreased to 2 or 6 % for all treatment conditions studied. This decline is due to the decrease of the oil in the fruit's mesocarp because of the long-time of storage. This is probably due to oxidation and hydrolysis of oil after contact with the storage environment [6].

2.2. Chemical characterization

2.2.1. Free fatty acids

Changes in the acidity of *P. lentiscus* oil during the storage of fruits under various conditions are summarized in Figure 2.

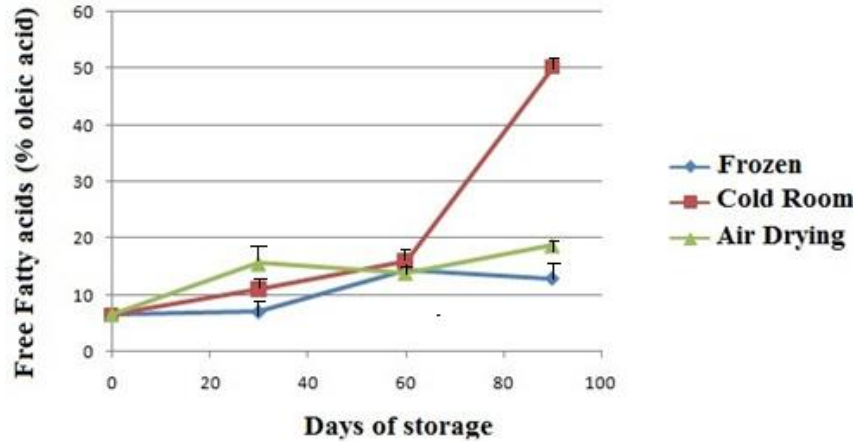

Figure 2. Changes in the acidity of *P. lentiscus* oil during storage of fruits at various conditions

Oil acidity from freshly harvested lentisk fruits was around 6% and then increased during storage. It was highest when fruits were stored in a cold room for 90 days. Prolonged storage caused damage to oil by oxidation and hydrolysis of triglycerides, resulting in increased free fatty acids [7]. Frozen condition was the best treatment to preserve the initial acidity of fruits. However, even after 90 days, the FFA was the lowest, with about 12%. It is well known that temperature is an essential factor in the degradation of vegetable oils. High temperatures were reported to accelerate the degradation of oils, contrary to low temperatures [8,9].

2.2.2. Peroxide value

Changes in Peroxide values of lentisk oils from fruits stored up to 90 days at various conditions are shown in Figure 3.

With increasing storage time, the oil PV decreased in the fruits from all treatments (Frozen, Cold Room, and Drying). The peroxide value (PV) indicates the initial stages of oxidative change in vegetable oils [10]. The PV represents the total hydroperoxide content and is one of the most common quality indicators of fats and oils during production and storage [11,12].

Determining the peroxide content in oils makes it possible to assess the oxidation level primarily produced during storage and/or oil production. The formation of peroxides is due to oxygen dissolved in oil and other factors such as UV, water, enzyme, and trace metals.

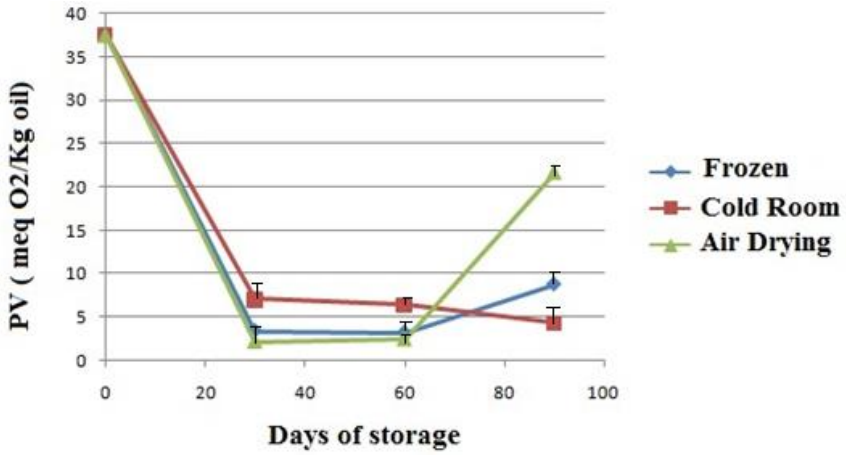

Figure 3. Resistance to oxidation of lentisk oil (change in PV) obtained from fruits stored up to 90 days at various conditions

In particular, two types of oxidation can be distinguished: auto-oxidation and photo-oxidation. In both cases, a free radical is formed from an unsaturated fatty acid that reacts with an oxygen molecule causing the formation of peroxide radical. This peroxide radical reacts with another fatty acid molecule and subsequently forms a hydroperoxide (auto-oxidation). In the photo-oxidation case, light radiation (UV) excites a molecule of the pigment, which initiates the oxidation process in the presence of oxygen. The increase of PV after 60 days of storage may reflect either increased formation of hydroperoxides or reduced decomposition [13].

2.3. Total Polyphenolic content

Variations in the polyphenol content of oil during storage of lentisk fruits at various conditions are presented in Figure 4.

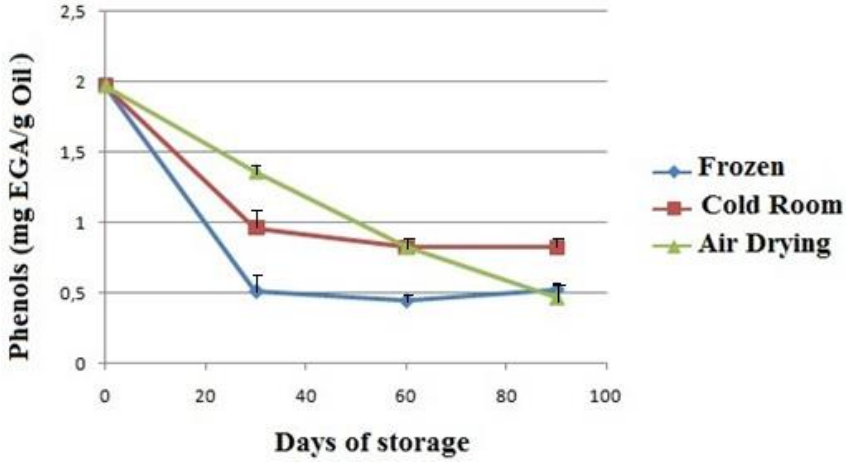

Figure 4. Changes in polyphenolic content of oils during storage of lentisk fruits at various conditions

In general, all trends of total polyphenolic content for three conservation conditions down the slope. It's observed that when the conservation period is increased, the phenol content of lentisk oil is decreased. The air drying process was shown to be the most appropriate treatment to preserve phenol content during the first 60 days of storage because it maintained the highest polyphenol amounts. After 30 days, the phenol rate was evaluated to 1.36 mg EGA/g oil against only 1 mg EGA/g oil and 0.5 mg EGA/g oil for cold room and frozen treatments, respectively.

In this work, frozen storage at –20°C significantly affected the contents of polyphenols in lentisk oil ($p<0.001$). Generally, concentrations of polyphenols were lower in frozen fruit compared with freshly harvested samples and the other storage conditions. This result is comparable with other works on different fruits and vegetable oils [14,15]. Several studies showed that the polypolyphenols concentration of vegetable oils varies greatly depending on the processing conditions and fruit and oil storage. The obtained results align with earlier published research for the total amount of polypolyphenols during storage [16-19].

3. Conclusions

The storage conditions significantly affected the oil yield and the chemical characteristics of lentisk oil. Generally, Cold Room treatment was the most

effective compared to the other therapies studied. Whatever the conditions, storage of lentisk fruits resulted in low oil quality. This damage is related to the oxidation of oil constituents; the natural antioxidants present in the fruit were destroyed, and oil resistance to oxidation was diminished.

4. Experimrntal

4.1. Plant material

Mature fruits of *Pistacia lentiscus* were harvested from wild plants growing north of Tunisia (Bizerte). Dr. A. Khaldi identified the plant from I.N.R.G.R.E.F-Tunisia, and certified specimens (VS1-PL2009) were deposited at the Herbarium run by I.N.R.G.R.E.F.

4.2. Storage conditions

To assess the effects of the conservation method on the oil quality of *P. lentiscus,* three ways were tested;

- Fruits were frozen at -20°C (F)
- Fruits were stored in a cold room at 4°C (CR)
- Fruits were air-dried at 25°C and then kept in bags at room temperature (DF)

Three replicates for each treatment were removed after 30, 60, and 90 days of storage.

4.3. Oil extraction

The oil was extracted using a pressing method. The fruits were first ground using an ordinary chopper. The resulting paste was mixed for 30 minutes in a water bath and was then placed in a hydraulic press to allow the liquid to separate from the mill. For subsequent chemical analyses, all floating oil was removed and stored in cold, dark conditions.

4.4. Oil yield

Oil yield was calculated by using the following formula:

$$\mathbf{R}\ (\%)\ =\ \mathbf{Mh/MMF\ x\ 100}$$

R (%): Yield expressed in %.

Mh: Mass in grams of the oil.

MMF: Mass in grams of fresh fruits.

4.5. Chemical characterization

4.5.1. Free fatty acids (FFA)

Free fatty acids (FFA) were determined according to official analytical methods described in NFEISO 660 [20]. First, 10 g of oil was dissolved in 100 mL of chloroform in the presence of a few drops of phenolphthalein (1g/100 mL of ethanol). Titration was done with a solution of KOH in ethanol (0.5 mol/L).

The free fatty acid content is calculated according to the following formula:

$$\mathbf{FFA} = \frac{\mathbf{V\ x\ C\ x\ M\ x\ 100}}{\mathbf{1000}} \mathbf{x\ m}$$

Where:

C: KOH concentration in mol/L

V: volume of KOH in mL

m: mass of oil in g

M: molar mass of the fatty acid in g/mol (oleic acid 282 g/mol and palmitic acid 256 g/mol)

4.5.2. Peroxide value

The Peroxide value was determined according to European standards of fatty substances of animal and vegetable origin (NFEISO 660) [20]. First, a weight (1g) of the oils was introduced into 250 mL Erlenmeyer, and then 10 mL of chloroform was added. Next, 15 mL of acetic acid, 1 mL of potassium iodide (KI) solution were added, and the mixture was shaken for 1 min. After 5 minutes of incubation at dark and at a temperature between 15 and 25°C, 75 mL of distilled water was added. Titration was done with 0.1N sodium thiosulphate while adding 1 mL of the starch indicator. The titration was finished when the sample became colorless.

The peroxide values were calculated according to the following formula:

$$\boldsymbol{PV} = \frac{\boldsymbol{V - V0}}{\boldsymbol{P}} \boldsymbol{x\ 10}$$

Where:

V – Volume of thiosulphate used in the sample titration (mL).

V0 – Volume of thiosulphate used in the titration of the blank (mL).

P– Mass of the tested oil (g).

5.6. Total polyphenolic content

5.6.1. Preparation of phenolic extract

To extract polyphenols from lentisk 5 mL of methanol/water (80/20, v/v) was mixed with 2 g of oil. The mixture was then introduced in an ultrasonic bath and separated at room temperature for 15 min. The mixture was then centrifuged. The phase containing polyphenols (methanolic phase) was removed and stored until its use.

5.6.2. Determination of total polyphenols

The method described by Singleton and Ross [21] was conducted to estimate the total polyphenolic content in the studied oils.

Briefly, 500 µl of the phenolic extracts were mixed with 100 µl of the Folin–Ciocalteu reagent and 2 mL of sodium carbonate Na_2CO_3. The mixture was incubated at dark for half an hour. The Absorbance was carried out using a spectrophotometer apparatus at 755 nm.

Different concentrations of gallic acid were used to plot the calibration curve, and results were expressed as mg EGA/g oil.

4.7. Statistical analysis

The statistical analysis was conducted using the General Linear Models procedure of the SAS software. In addition, an analysis of variance was carried out, and the most significant correlations were retained.

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