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Effect of harvesting period and drying time on the essential oil yield of *Pistacia lentiscus* L. leaves

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ABSTRACT

This work focuses on the influence of the harvesting period and the drying time on the essential oil yield extracted from leaves of Moroccan Pistacia lentiscus by hydrodistillation process. The result of this study showed that the highest yields are obtained on May. After 15 days of leaves shade drying, the yield increased from 0.32% to 0.42% for the first seven days. However, further than this period, a decrease in yield was observed. During the same period, the moisture content of the plant material decreased from 53.6% to 8.2%.

Keywords: *Pistacia lentiscus*, essential oil, yield, harvesting period, drying.

INTRODUCTION

In Morocco, the existing activities in medicinal plants sector allow the export of around 1,000 tons of essential oils, various extracts and about 400 tons of dried herbs, with a total value of approximately 300 million dirhams [1]. Given the large role of this sector in the national economy, several studies have focused on the essential oils extraction and plant conservation. Nevertheless, some related studies on the plant drying operation indicate considerable changes, especially in quantitative terms of essential oils [2].

Pistacia lentiscus L. belongs to the family of *Anacardiaceae*, also known as pistachio mastic or mastic tree. It is a shrub native of the Mediterranean and which grows wild in the forests, scrub of the plains, low mountains [3] and on all kinds of soils [4].

Several studies have also reported that the essential oil of mastic has significant antibacterial [5, 6], antifungal [7], insecticide [8] and antioxidant proprieties [9]. It is also used in cosmetics, perfumery and as a flavor in food preparations [10].

In order to contribute to drying process development, we have focused on the evaluation of the drying effect on the essential oil yield extracted by hydro-distillation process from Moroccan *Pistacia lentiscus* leaves to optimize this parameter.

MATERIALS AND METHODS

For this study, we performed the following experiments:

- At first, we made a monthly extraction monitoring by hydrodistillation of the essential oil of mastic leaves (from January to December of the same year).
- Then, the extractions of the essential oil of mastic leaves by hydrodistillation were performed each day, during 15 days of storage in the open air and away from the sun during the month in which the yields are higher.

2.1. Plant material

The adult *Pistacia lentiscus* leaves used for this study was harvested from the province of Taounate in Morocco (Altitude: 475 m, 34° 35'12.5" N 4° 38'31.1" W). Plant material studied was collected from shrubs random.

2.2. Treatment before distillation

Harvested leaves were brewed in order to homogenize the mixture which was placed in the shade and in the open air. The plant material was spread in thin layers and returned frequently throughout the drying period.

2.3. Extraction of the essential oil

The hydrodistillation experiments were carried out in a Clevenger-type apparatus [11]. A quantity of plant material (about 100g) was extracted in each test. The plant material moisture determined after drying at 105 ° C for 4 hours [12], by the formula (1):

$$M(\%) = \frac{Ww - Wd}{Ww} \times 100 \qquad (1)$$

M: Moisture content in the plant material (%)
Ww: Wet weight of plant materiel (g)
W_d: Weight of dry plant matter (g)
Yields are expressed relative to the dry matter by the formula (2):

$$Yield(\%) = \frac{Weo}{Wd} \times 100 \qquad (2)$$

Yield: essential oil yield (%)
Weo: essential oil Weight (g)
The essential oil obtained was dried over anhydrous sodium sulfate and stored in a dark container at 4°C until used.

RESULTS AND DISCUSSION

3.1. Effect of harvest period

The results illustrated in Figure 1 show that the essential oil content depends on the harvesting season. Thus, the maximum oil is obtained in May corresponding to the flowering stage of the *Pistacia lentiscus* from taounate region, which corresponds to an average of 0.32%.

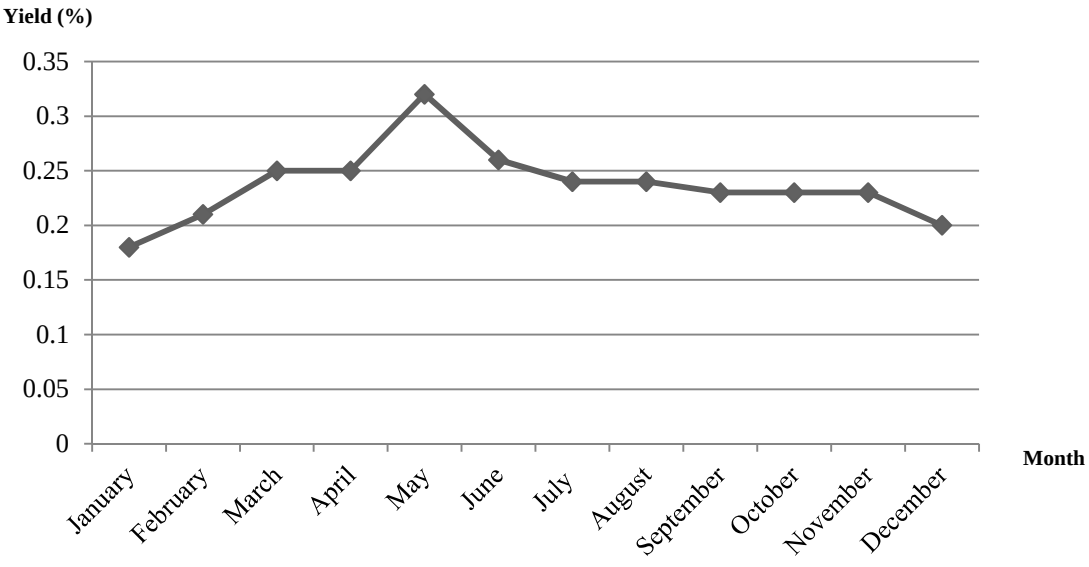

Figure 1: Effect of harvest period on the yield of *Pistacia lentiscus* leaves

In June, the average content of essential oil was relatively interesting (about 0.26%), while in January, it was decreased to 0.18%. Our results are consistent with those found in other species [13, 14, 15].

3.2. Effect of drying time

The results of the essential oil yield obtained from fresh *Pistacia lentiscus* and its evolution during drying in the open air are represented in table 1; this showed an increase in yield during storage in the open air. The moisture content decreased gradually and the leaves moisture increased from 53.6 to 8.2%.

Table 1: Effect of drying time on the yield and moisture of *Pistacia lentiscus* leaves

Drying time (days)	Moisture (%)	Yield (%)
1	53,6	0,323
2	50,8	0,356
3	48	0,375
4	42,6	0,392
5	38,6	0,407
6	27	0,421
7	22,6	0,420
8	15,2	0,383
9	13,4	0,375
10	10	0,353
11	9,2	0,351
12	8,8	0,329
13	8,4	0,328
14	8,2	0,327
15	8,2	0,327

The analysis of Figure 2 showed also that during the drying in the shade and in the open air, the yield increased from 0.32 to 0.42% after 7 days, which corresponds to an increase of 31%. Beyond this period, the yield decreased gradually and then became almost constant. Thus the maximum essential oil content is obtained on the seventh day to dry in the shade (0.42%) and until the 15th days of drying, the essential oil yield was still higher than that of fresh leaves (0.32%). It expressed relative to the dry matter evolved during the drying of the plant material before distillation. In a first phase, yield began with a significant increase to reach a maximum. Then in a second phase, it has declined steadily.

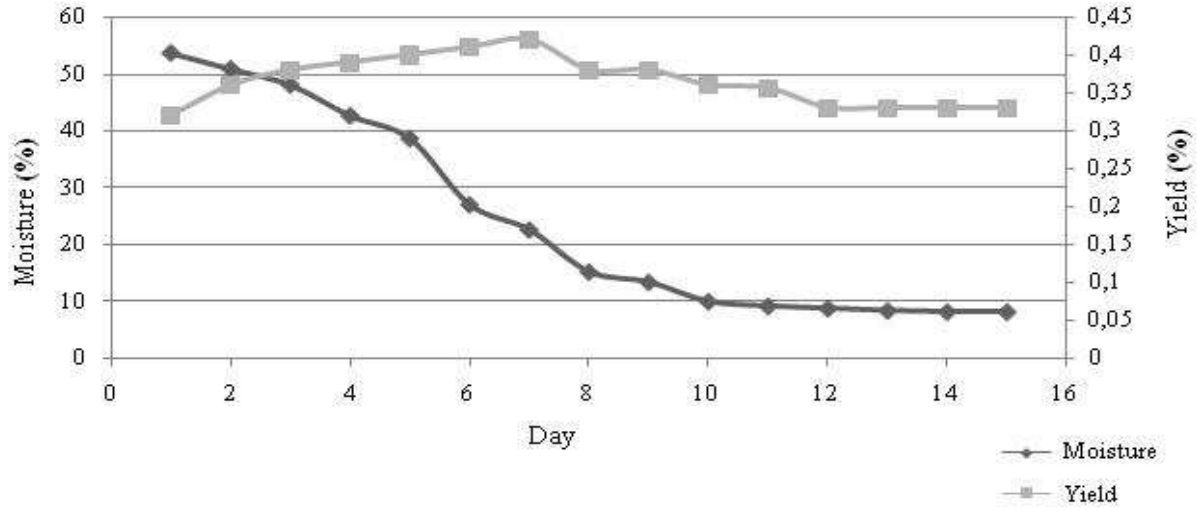

Figure 2 : Evolution of yield and moisture of *Pistacia lentiscus* leaves with drying time

The increase in essential oil content during the first days of drying is proportional to the Moisture decrease Statistical analyzes showed that the essential oil yields vary significantly with the moisture content of *Pistacia lentiscus* leaves. The plant drying prior to its distillation is a treatment that has net effects on essential oil yield [16]. The variation in the essential oil content of *Pistacia lentiscus* leaves depending on the drying time is similar to what has been found for several other aromatic species, such as eucalyptus [17], myrtle [18], spearmint [19], lemon balm [2], rosemary [20].

"Zrira concluded that it is a biological phenomenon. In fact, the plant after harvest continues to live and its biosynthetic activity of terpenes and derivatives is increasing. This is may be explained by plant development of defense strategies against water stress "[12]. This result would elucidate the increase in essential oils yields from

Pistacia lentiscus leaves in the first phase of the curve shown in Figure 2. After the final death of the plant all biosynthesis activities stop and essential oils losses by evaporation are no longer compensated, therefore a decrease in distillation yield [12].

3.3. Modeling performance against moisture

We searched the model linking the essential oil yield to moisture in *Pistacia lentiscus* leaves. To achieve this objective, we used modeling by linear regression. Which has led us to think that the most suitable model will be a polynomial of degree 2 (3):

$$Y = a_0 + a_1 X + a_{11} a X^2 \quad (3)$$

The statistical treatment was performed using the JMP statistical analysis software Version 8.1 [21]. According to Table 2 of the variance analysis, we can say that the main effect of the regression is significant since the significance probability of risk p-value is inferior than 0.05. The R2 coefficient is 97%, this value reflects the correlation between experimental and predicted values of the adapted model. Model adjustment was given by Ra2 coefficient which takes a value equal to 96%. These two factors seem to be very adequate.

Table 2 : Analysis of variance of the linear model linking yield to moisture

Source	Sum of squares	Degrees of Freedom	Mean Square	F	Probability
Model	0,0163	2	0,00812	161,68	<0,0001
Error	0,0006	12	0,00005		
Total	0,0169	14			
R^2	97%				
R^2 ajusted	96%				

The effects of all studied factors, the statistical values of t-student and the observed probability (p-value) are summarized in Table 3.

Table 3 : Effects of the regression model coefficients linking yield to moisture

Model terms	Coefficient	Effect	Standard Deviation	*t-student*	*p-value*
Constant	a_0	0,361	0,00325	111,12	<0,0001
Moisture (%)	a_1	0,002	0,00015	15,65	<0,0001
Moisture (%) × Moisture (%)	a_{11}	-0,0002	0,00001	-17,25	<0,0001

The results indicated that the factors a_0, a_1 and a_{11} have a statistically significant effect, since their p-value is inferior than 0.05.

The mathematical model used for modeling the essential oil yield according to the moisture rate of the mastic leaves is represented by the following equation (4):

$$\text{Yield}(\%) = 0.361 + 0{,}002 \times \text{Moisture}(\%) - 0{,}0002 \times \left(\text{Moisture}(\%)\right)^2 \quad (4)$$

The quadratic model postulated and validated explains about 97% of the total variability with a better adjustment. Thus, this model can be used to estimate the essential oil yield of individuals in the study area and can be a useful tool for performance prediction and estimation of essential oil by only knowing the moisture content of *Pistacia lentiscus* leaves.

CONCLUSION

This study showed that the yield of essential oils of *Pistacia lentiscus* leaves increased significantly with harvest and drying time. Thus, the highest yields were obtained in May.

The drying of *Pistacia lentiscus* leaves in the shade and in the open air can increase their essential oils yields. The maximum efficiency is achieved in about 7 days and until 15th days of drying; the essential oil yield is still higher than that of fresh leaves. For industrial applications, storage for seven days in the shade of harvested *Pistacia lentiscus* leaves in May before distillation is recommended.

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