

## RESEARCH ARTICLE

## Algeria's *rosmarinus officinalis* l, *juniperus phenicea*, and peel grenadine reactions to shade and solar and convective drying methods

Hicham Bendehina <sup>1,\*</sup> , Asma Abdenbi <sup>2</sup> , Brahim Dennai <sup>3</sup> 

<sup>1</sup>Department of Science and Technology, Faculty of Technology and Engineering, University of Tahri Mohamed, Laboratory ENERGAR-ID, Béchar 08000, Algeria

<sup>2</sup>Department of Science and Technology, Faculty of Technology and Engineering, University of Tahri Mohamed, Laboratory ENERGAR-ID, Béchar 08000, Algeria

<sup>3</sup>Department of Science and Technology, Faculty of Technology and Engineering, University of Tahri Mohamed, Laboratory ENERGAR-ID, Béchar 08000, Algeria

### Abstract

Rosemary (*Rosmarinus officinalis* L.), juniper (*Juniperus phoenicea*), and pomegranate peel are widely used in the food and medical industries in the Mediterranean region. However, preventing determination of the most accurate drying method; likewise, studies on the effectiveness of their extracts against bacteria and fungi—and on the most effective post-extraction combinations—are scarce. Therefore, this experimental study aimed to produce a natural disinfectant free of any chemicals and to investigate the drying of thin layers of *Rosmarinus officinalis* L., *Juniperus phoenicea*, and pomegranate peel using three methods: shade drying, solar drying, and convective drying. Dried plants were obtained from each herb, and extracts were prepared from each plant using the three methods, resulting in three types of natural disinfectants, each made from the extracts of one single drying method. The research was conducted in a region in the southwest of Algerian. The main results were as follows: Production of a natural disinfectant effective against bacteria and fungi, and the best drying results were as follows: the optimal drying results for the juniper plant Convective Forced drying 54.3%; solar drying for rosemary 51.33%; for pomegranate peel convective forced drying 37.31%. The aim of this comparative study is to find the best method for drying these plants and to examine determine which of the three plants yields the best extracts, to prepare them for producing a natural disinfectant. Storing grains such as wheat and barley leads to the proliferation of promoting proliferation of bacteria and fungi, and the purpose of this disinfectant is to address this issue by preserving the grains from bacteria and fungi during storage and this disinfectant is intended to prevent such proliferation during storage.

**Keywords:** *Rosmarinus officinalis* l, *juniperus phenicea*, grenadine peel, solar drying, shade drying, convective drying

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### 1. Introduction

Since antiquity, people have recognized the ability of plants to alleviate pain. Over the millennia, human societies have evolved their knowledge and use of medicinal plants. Conversely, certain medical treatments appear more realistic and effective, while others appear strange or supernatural. However, all aim to improve human well-being and reduce suffering. [1,2]. As the effectiveness of antibiotics, which are widely regarded as an almost-universal treatment for serious illnesses, declines, herbal therapies are becoming more popular. Drug

resistance in bacteria and viruses has increased due to their progressive adaptation. [1] *Rosmarinus officinalis*, *Juniperus*, and grenadine peel, especially its active ingredient, are used to combat bacteria and fungi. The commercial industry places a great value on rosemary and its oil [3]. Herbalists at the community pharmacy sell the therapeutic and fragrant plants together with their oil. The herb is used to treat a variety of common everyday ailments, such as stomachaches, colds, and coughs [4]. Traditional medicine has long recognized the benefits of grenadine in treating fever, diarrhea, and chronic cough. It can also be used to deter worms. Asthma can be

\*Corresponding Author

E-mail Address: [bendehina.hicham@univ-bechar.dz](mailto:bendehina.hicham@univ-bechar.dz)

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treated with fresh flowers, tenia with root bark, and dysentery with a strong grenadine bark infusion [5,6].

Many methods exist for drying plants. We documented the findings of a previous study, [8] investigated the sequential combination of radiofrequency (RF) waves with low humidity air (LHA) for drying rosemary with the goal of improving product quality. [9-11] Studies have shown that keeping the drying air temperature below 50°C can stop the loss of volatile chemicals.

Many studies on drying using electromagnetic radiation, including microwave (MW), infrared (IR), and radiofrequency (RF), have been reported recently. Most of these studies use conventional drying procedures in sequential or combination modes [11-16]. dried pomegranate peels at three drying air temperatures (50°C, 60°C, and 70°C), with a constant air velocity of 2.0 m/s and an initial thickness of 2.8 cm. As drying air temperature increased, drying time decreased [17]. His experiment showed that drying time increased as oven-drying temperature increased. The drying process was mostly carried out in the period of diminishing rates.[18] A thermal drier with variable air temperature and hot air velocity was used to investigate the thin-layer drying characteristics of pomegranate byproducts [19].

We dried three medicinal materials: Phenicia Juniperus, grenade peel, and Rosmarinus officinalis L. (Figures 1–6 original source). Three different drying techniques were used: shade, solar, and convective drying. The objective was to determine the optimal approach regarding time, quantity, and quality, and to prepare the raw material to produce a natural product specifically intended to disinfect agricultural products destined for food.



**Figure 1.** Tree of Juniperus



**Figure 2.** Leaves Juniperus



**Figure 3.** Rosemary



**Figure 4.** Leaves rosemary



**Figure 5.** Tree of Grenadine



**Figure 6.** Peel of Grenadine

## 2. Material and Method

### 2.1. Preparations and dehydrating methods

A collection of *Rosmarinus officinalis* L., *Juniperus phoenicea*, and grenadine peels was gathered from Bechar Province in southwestern Algeria, 80 Km from the Moroccan border and 1150 Km from the capital city of Algeria, as shown in Figure 7 (latitude 31°37'00" north; longitude 2°13'00" west), prior to sunrise. This study aimed to explore various drying techniques for these medicinal herbs. The study employed the following methods.



**Figure 7.** Geographic map of the study area (google earth, 2024)

## 2.2. Shade drying

Shade drying uses solar energy to warm the herb and is carried out in the shade to prevent direct sunlight from damaging it, as shown in Figure 8. Using this technique, heated ambient air dries the herbs; the process requires low humidity and adequate ventilation in the drying area. In addition, the method minimizes chemical changes, such as oxidation, in essential oils and other light-sensitive materials. Compared to sun drying, this method of drying has the disadvantage of a long drying time [20].



**Figure 8.** Shade drying Grenade rosemary and juniper (original source)

We dried the plants *Rosmarinus officinalis* L, *Juniperus Phenicia*, and Grenadine peel in the shade in a room away from direct sunlight, following standard procedures. We measured the temperature 3 times a day: in the morning [23-27.1 °C], in the evening [22.8-25.9 °C], and at night [23.3-25.6 °C]. The plant material was spread on a cloth and weighed daily until the weight stabilized.

### 2.2.1. Digital thermometer

Measuring range: -50°C\_+300C ° 58F°\_+572F° Memory of last measure, Low battery sensation and display

10 minutes auto shutdown for power saving (option), C° and F° display selectable

### 2.2.2. Precise balance

High-resolution weight to monitor the dehydration processes.

## 2.3. Convective drying

Conventional drying, also known as convective hot air drying, is a widely adopted technique in the food and pharmaceutical industry as shown in the following figures 9-11(original source), however, this process can change the structure of the plants, affecting the phytochemicals due to thermal degradation [21].



**Figure 9.** Convective dryer CE 130 The air flow was set at 2.5 m3 and the temperature was set at 40 C°



**Figure 10.** Rosemary



**Figure 11.** Juniper

## 2.4. Solar drying

Among available renewable energy sources, solar energy is the preferred option due to its inherent characteristics, including abundance, availability, and cleanliness. It can be utilized in two primary ways: through photovoltaic systems for electricity generation and through solar thermal applications [22].

### 2.4.1. Specifications for solar dryer

In this study, we employed an indirect solar drying system consisting of two main components: a solar collector and a drying chamber (Figure 12). The solar collector, illustrated in Figure 1, has dimensions of 176 cm in length, 90 cm in width, and 10 cm in height. It incorporates a single circulation system and a single glazing layer. The

collector is inclined relative to the horizontal plane to face south, maximizing solar radiation absorption.

The materials used in constructing the solar collector—namely Mishler plates, polystyrene, and glass—were readily available in the local market. The drying chamber is designed in the shape of a rectangular parallelepiped, with dimensions of 81 cm in length, 81 cm in width, and 55 cm in height.

The chamber is constructed using Mishler plates and is connected to another rectangular parallelepiped unit, namely the heating chamber, which measures 80 cm in length, 26 cm in width, and 53.5 cm in height. The heating chamber is fabricated from galvanized sheet material.

The heating chamber contains a heating unit comprising two resistive heating elements: one rated at 1500 W and the other at 800 W, as shown in Figure 13. To maintain a consistent temperature throughout the drying process, the system ensures controlled operation of these heating elements.



Figure 12. Solar dryer [23]



Figure 13. Resistance, drying chamber and fans

An additional rectangular parallelepiped constructed from galvanized sheet material. Within the drying chamber, we integrated eight rectangular plastic racks, each measuring 50 cm in length, 30 cm in width, and 4 cm in height. These racks act as support for the drying trays or shelves. Installing a rooftop radiation-monitoring device on our laboratory premises enables the continuous monitoring and quantification of radiation levels. This addition was introduced to improve the accuracy and precision of our ongoing experiments. Using this device, we can efficiently measure and record cumulative radiation exposure, thereby facilitating a comprehensive evaluation of our experimental procedures. This professional enhancement further strengthens the scientific integrity and reliability of our research endeavors.

The device was oriented south at an inclination of 31 degrees.

Figure 14 represents indirect solar drying Juniperus rosemary and grenade.



Figure 14. Indirect solar drying juniper and rosemary and peel grenade

### 2.5. Conservation

The plants are stored in a plastic bag sealed tightly until use, as shown in Figure 15 (original source).

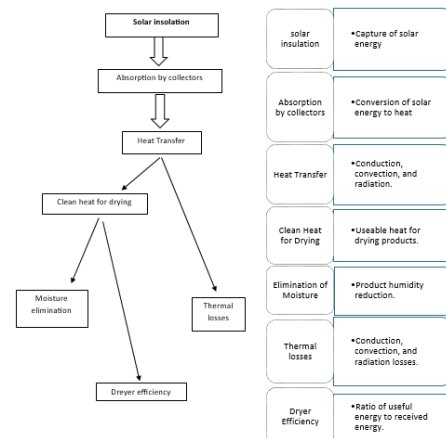


Figure 15. Plastic bag

### 2.6. Preparation of aqueous extracts

The extraction method involves the combination and fractionation of plant parts, their immersion in cold water and subsequent boiling, and the maintenance of temperature for 2 hours.

### 2.7. The flowchart of the energy balance in the solar dryer(original source)



### 2.7.1. Description of the steps

The mathematical model for the energy balance of an indirect solar dryer typically comprises several components that account for the heat transfer mechanisms and energy flows within the system. The following is a concise summary including key formulas and references:

### 2.7.2. The moisture content of the samples was then expressed in a non-dimensional way using equation (1)[24]

$$MR = \frac{X(t) - X_{eq}}{X_0 - X_{eq}} \quad (1)$$

Where: MR is the dimensionless moisture content

X(t) is the moisture content after a drying time (t) (kg water/kg dry matter, d.m.),

X<sub>0</sub> is the initial moisture content of the samples (kg water/kg d.m.).

X<sub>eq</sub> (kg water/kg d.m.) is the equilibrium moisture content.

### 2.7.3. The drying rate (Dr)of leaves was calculated using the following equation (2) [25]

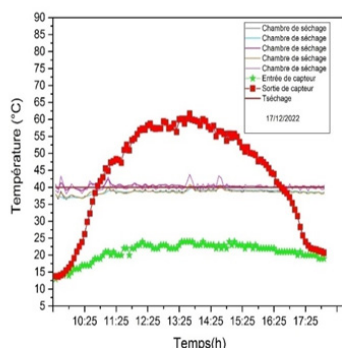
$$DR = \frac{Xt + dt - Xt}{d} \quad (2)$$

### 2.7.4. The extraction yield (Re) was calculated according to Equation (3)

$$Re = \frac{ML}{M.100} \quad (3)$$

where (Re)is the extraction yield and (ML)is the weight

## 3. Result and discussion



The graph illustrates the operational performance of a solar dryer under specific operating conditions, focusing on temperature control. During the monitoring period, the solar dryer consistently maintained a temperature of approximately 40 °C, as indicated by the inlet and outlet air temperatures at the thermal collector (Figure 16) (original source)..

Figure 16. A curve representing how the solar dryer worked over-time in terms of temperature

The graph depicts steady-state operation, with the temperature closely aligned with the target value of 40°C. The consistent maintenance of temperature indicates the solar dryer's ability to provide a controlled and stable environment for the drying process.

The graph demonstrates a steady state of operation, with the temperature remaining within a proximity to the

target value of 40°C throughout the monitored duration. Consistent temperature maintenance is a significant indicator of the dryer's ability to provide a stable, controlled environment for the drying process.

17/12/2022 drying of peel grenade: The graph shows the temporal variation of total solar radiation on the day of the solar drying experiments, as shown in Figure 17(original source).. The data depicted in the graph show gradients that may indicate minor cloud cover or obstructions, such as a bird partially blocking the radiation reaching the solar collector.

The collector was installed on the exterior surface of the ENERGAR-ID laboratory. This graph provides valuable insights into the fluctuations in solar radiation throughout the day, which can directly affect the performance of solar drying systems. Factors such as cloud cover or shading can influence the amount of solar energy available for the drying process. By analyzing these variations, researchers can better understand the external factors influencing solar-drying efficiency and make necessary adjustments to optimize system performance.

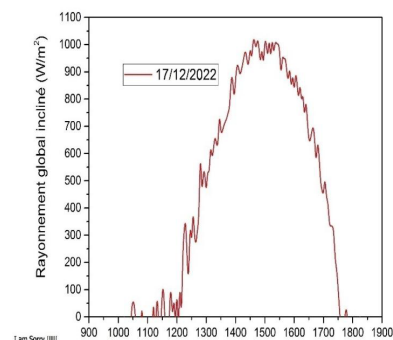


Figure 17. The curve represents how the total irradiance of out Solar radiation is one of the most important environmental 17/12/2022 drying of peel grenade.

Drying of rosemary and juniper on 07/02/2023, as shown in Figure 18(original source). The graph shows the temporal variation in total solar radiation on the day of the solar-drying experiments. The data depicted in the graph includes observed gradients, which may indicate minor cloud cover or obstructions caused by factors such as a bird blocking a portion of the radiation reaching the solar

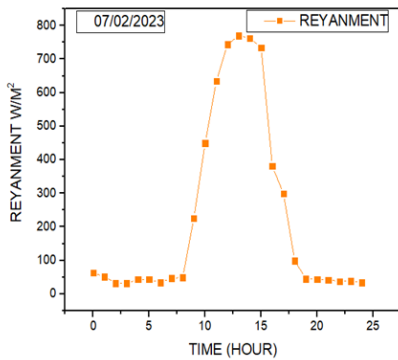


Figure 18. The curve represents how the total irradiance of out Solar radiation is one of the most important environmental 07/02/2023 drying of rosemary and juniper

collector. It should be noted that the collector was installed at the surface of the ENERGARID laboratory.

This graph provides valuable insights into the fluctuations of solar radiation throughout the day, which can have a direct impact on the performance of solar drying systems. Factors such as cloud cover or shading can influence the amount of solar energy available for the drying process.

By analyzing these variations, researchers can better understand the external factors affecting solar drying efficiency and make necessary adjustments to optimize the system’s performance.

Table 1-3(original source). represents result of natural convective and indirect solar drying of juniper rosemary and grenade.

Table 1. Juniper

	Natural Drying	Convective Drying	Solar Drying
Time of drying	16Day	23 Hour	25 Hour
Fresh mass	600Gr	600Gr	600Gr
Dry mass	358.5Gr	325.8 Gr	402.6Gr

Table 2. Rosemary

	Natural drying	Convective drying	Solar drying
Time of drying	16Day	23 Hour	25 Hour
Fresh mass	300Gr	300 Gr	300Gr
Dry mass	167Gr	208.75 Gr	154Gr

Table 3. Grenade Peel

	Natural drying	Convective drying	Solar drying
Time of drying	10 Day	26 Hour	24 Hour
Fresh mass	450Gr	432.3 Gr	442.8Gr
Dry mass	195Gr	161.3 Gr	208.6Gr

### 3.1. Electric consumption

The solar dryer consumed 19.8KWH to dry pomegranates, 21.37KWH to dry Juniperus, and 20.46KWH to dry rosemary. This electrical power was used to maintain the temperature at °40C during the dehydration process. Record the temperature and store the results.

Figures 19–22 (original source) drying curves for juniper, rosemary, and pomegranate.

### 3.2. Juniperus

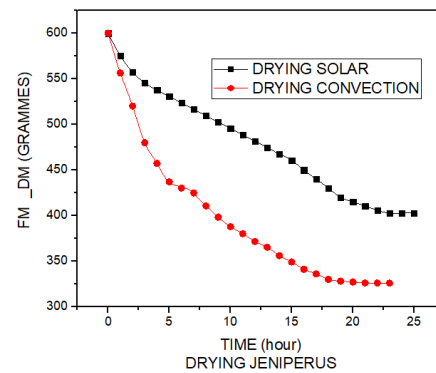
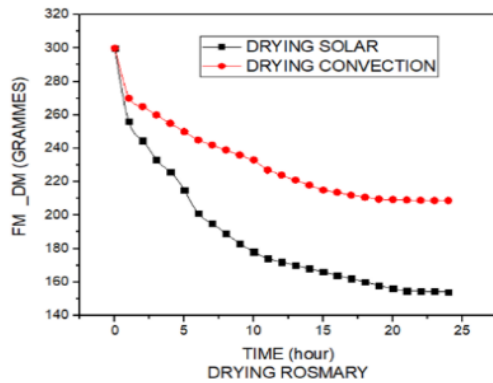


Figure 19. The following curve represents the result of drying solar and drying convective of juniper

Convective drying time is 23 hours with a dry mass of 325.8 Gr On the other hand; solar drying gave a dry mass of 402Gr: in time one can long to 25 hours. As for the natural drying (in the shade) to give a mass of 358.5 Gr; but the disadvantage in this type of drying and the long time required to have the sewing (16Day). Its advantage in our case is that this type of drying retains product properties better than other drying modes.

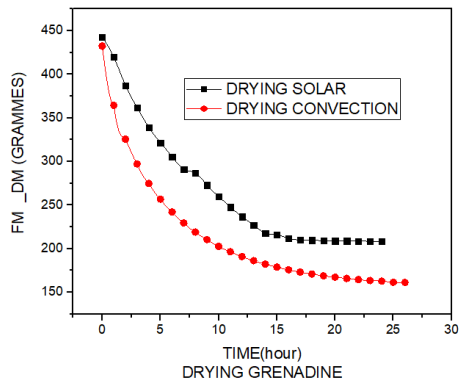
### 3.3. Rosemary



**Figure 20.** The following curve represents the result of drying solar and drying convective of rosemary

Convective drying time is 23 hours with a dry mass of 208.75 Gr. On the other hand; the solar drying has given a dry mass of 154 Gr; in time one can long to 25 hours. As for the natural drying (in the shade) given a mass of 167 Gr; but the disadvantage in this type of drying and the long time required to have the sewing (16 Days). Its advantage in our case is that this type of drying retains more of the properties of the product than other drying modes.

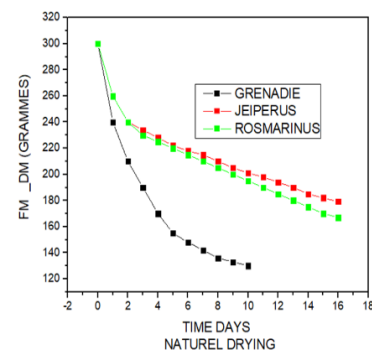
### 3.4. Grenade



**Figure 21.** The following curve represents the result of drying solar and drying convective of grenadine

Convective drying time is 26 hours with a dry mass of 161.3Gr on the other hand, solar drying gave a dry mass of 208.6Gr; in time one can long to 24 hours. As for the natural drying (in the shade) to give a mass of 195 Gr; but the disadvantage in this type of drying and the long time required to have the sewing(10 Days). Its advantage in our case but this type of drying retains more the properties of the product than other drying modes.

### 3.5. Natural drying grenade, juniper and rosemary



**Figure 22.** The following curve represents the result of drying natural of rosemary and grenadine peel and juniper

Juniper: Natural drying (in the shade) yielded a mass of 358.5 Gr; however, the disadvantage of this drying method is the long time required for drying (16 Days).

Rosemary: As for the natural drying (in the shade), it gave a mass of 167 Gr; the disadvantage of this type of drying is the long time required to have the sewing (16 Days).

Grenade As for the natural drying (in the shade) to give a mass of 195 GR; but the disadvantage in this type of drying and the long time required to have the sewing (10 Days).

The table presents a comparison of the dry mass results from natural drying, forced convective drying, and indirect solar drying of juniper, rosemary, and pomegranate plants (original source).

**Table 4.** Dry Mass

Mass Fresh	Juniperus 600gr	Rosemary 300GR	Grenade m= [450-432]GR
Dry mass Convection	325.8GR	208.75GR	161.3GR
Dry mass Solar	402.3GR	154GR	208.6GR
Dry mass Naturel	358.5GR	167GR	195GR

Table 5 (original source) represents the order of drying efficiency.

**Table 5.** The order of drying efficiency

Juniperus	Rosemary	Grenadine
1- convection	1- solar	1- convection
2- naturel	2- naturel	2- naturel
3- solar	3- convection	3- solar

Table 6 (original source) represents the order of drying time and preservation of property

**Table 6.** The order of drying time and preservation of property

Drying time: in decreasing order	preservation of property
1-convectoin (23hour)	1-naturel
2-solar (25hour)	2-convexion
3-naturel(15day)	3-solar

### 3.6. Preparation for disinfectants

We prepared three disinfectants from the extracts, as shown in Figure 23 (original source).



**Figure 23.** Our product

### 4. Conclusion

The originality of our approach lies in the systematic resort to experimentation. For the process of drying rosemary, juniper, and pomegranate peels in a thin layer using

Indirect solar dryer with forced convective heat and natural shade drying. Because the drying process is both difficult and important, we conducted this study.

1.A comparative study on the drying of three plants: rosemary, juniper, and pomegranate peels using three drying methods.

2.The drying procedure for each operation was monitored by measuring humidity, temperature, hot-air flow, and plant mass. Specifically, for the indirect solar dryer, total solar radiation and the dryer's operation were monitored using temperature and humidity sensors, and the weight of the plants was measured.

3.This tracking yielded a set of drying curves that reveal the drying-air thermal parameters (humidity and temperature) with the greatest impact on the product-drying process.

4.Since the drying time is similar between the indirect solar dryer and the convective dryer.

5.Indirect solar drying yielded the best moisture removal results for rosemary, whereas forced-convection drying was optimal for pomegranate peels and Phoenician juniper leaves.

6. Nine extracts were obtained, three from each plant, using each drying method.

7.Three types of natural disinfectants were produced each drying method involved mixing extracts from the three plants to create a natural disinfectant.

8.This natural disinfectant has demonstrated efficacy against bacteria and fungi.

1. In this paper, we propose studying the effectiveness of this natural disinfectant on agricultural food products to determine how long it can protect them from bacterial and fungal contamination.

2. Study the effectiveness of this disinfectant on various agricultural food products.

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