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Study the effect of drying methods On the quality characteristics for dill and parsley

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Abstract

This research studied the effects of three drying methods (solar, electric oven, microwave) and two different drying duratiqcontent (%), drying rate (kg/h), and dry matter color. The experiment werer conducted in the Medicinal Plants Laboratory at the College of Agricultural Engineering Sciences, University of Baghdad, for the winter season of 2022/2023. The goal of the experiment was to determine the best drying method for dill and parsley plants that would give the best quality for each of them.

Thirty-six samples were randomly divided into 6 groups (3 for dill and 3 for parsley). Each group of one plant was dried using one of the three studied drying methods. Each group was further divided into two parts (three samples each) with different drying durations (first duration, second duration).

The results showed that Parsley had a lower moisture content (81.86%) compared to dill (83.67%), suggesting that parsley is more resistant to moisture loss than dill. The microwave drying had the lowest moisture content (80.69%) and the highest in electric oven drying (84.02%). For the drying rate, the highest value (0.01378 kg/h) was observed in dill, while the lowest rate (0.0115 kg/h) was in parsley. Drying methods had a significant effect on the drying rate, with the microwave method having the highest rate (0.113 kg/h) and the electric oven method the lowest (0.011 kg/h) .The microwave drying resulted in a significantly shorter drying duration compared to electric oven and solar drying, with a reduction of 5.6% and 6.4%, respectively. The drying methods showed a significant difference in terms of color, with the highest color value of 8 observed in the microwave drying method and the lowest value of 7.17 in the solar drying method. The electric oven drying method had a color value of 7.83, indicating that microwave drying preserved color quality. The drying duration did not have a significant effect on the studied parameters.

Keywords: drying methods, moisture content, drying rate

1-Introduction

Drying (of fruits, vegetables and herbs) is the process of removing a portion of the moisture from food materials, reducing their moisture content to a level where it becomes difficult for microorganisms to thrive while causing minimal changes in the nutritional composition [1]. Alternatively, it can be defined as the process of removing moisture from food materials to ensure the preservation of these materials for a longer period, allowing for their rehydration for later use [1] (The primary goal of drying food materials, using various drying methods, is to reduce their weight and volume. This has economic significance in packaging, transportation, and prolonging the shelf life of food products[1][2]. In addition to that, drying reduces water activity and weight, lowering microbial activity, saving energy by eliminating the need for cooling, and ensuring the availability of products year-round. Additionally, drying is considered a mean to increase the nutritional value of food products [3], [4].

Drying can be achieved through various methods, including natural and industrial drying. Natural drying is one of the oldest methods used and involves drying food materials using sunlight. However, this method may not be feasible everywhere and at all durations, as it depends on uncontrollable climatic and environmental conditions. Natural drying can also expose the dried material to external contaminants like dust and soil. To overcome those problems of natural drying, hot air dryers are used, where drying takes place inside controlled chambers or boxes, or electric ovens. Hot air drying is the primary method used for drying vegetables, exposing them to hot air temperatures ranging from 50 to 90 degrees Celsius [5], [6]. Heat is transferred from the hot air to the vegetables, and as the materials absorb the heat, two types of moisture diffusion (moisture loss) occur. The first is external diffusion, where moisture moves from the material's surface to the external environment. The second is internal diffusion, where internal moisture moves to the material's surface. These processes occur simultaneously until the moisture content reaches a level at which the materials can be safely stored [7], [8]. In this way, hot air drying offers benefits in terms of resource conservation and excellent performance in vegetable drying. However, modern techniques such as microwave drying, infrared drying, and freeze drying have specific advantages in certain cases, such as preserving the nutritional value or reducing drying duration. Therefore, the appropriate technique should be selected based on processing needs and requirements to maintain the quality of the final product, particularly for high-moisture and high-sugar content products like tomatoes[5] and pumpkins[9] Microwave drying is considered an important method in the process of drying plants. Microwave radiation falls within the electromagnetic spectrum with relatively short wavelengths and frequencies of around 2500 megahertz. The mechanism of microwave drying relies on dielectric heating, which is based on two main mechanisms. The first is dipolar molecule excitation where water molecules, due to their dipolar nature, tend to follow the oscillations of the electromagnetic field of microwave waves when they rotate at very high frequencies. This results in an increase in the temperature of water molecules, leading to evaporation and drying. The second mechanism is ionic conduction, which occurs when ions, such as those present in salty foods, migrate under the influence of the electric field of microwave waves which cause heat generation [10], [11].

The process of extracting DNA genetic material from blood samples in the microwave in a short time and at a very low[33] cost compared to the expensive commercial kit, and therefore drying is cheaper

Dill (***Anethum graveolens L***.) is a herbaceous plant that typically grows up to 30 inches (75 cm) in height. It has a straight, hollow stem, feather-like leaves, and numerous small yellow flowers arranged in clusters. The fruits are very light and spicy [12]. It has a many medical uses.

In addition to its medical uses, dill and its essential oils have industrial and agricultural applications. It was found that coating eggs with dill oil increases their shelf life, reducing losses [13]. In another study, the dried dill powder improved the blood serum of poultry when added to their feed [14]. The percentage of potassium in dill plant is 2.194%[34]

Parsley (Petroselinum crispum L.) is a herbaceous perennial plant that typically grows to a height of 1 foot (30 cm). It has a rectangular-shaped root that can reach up to 20 cm in length, with a yellow color and minimal fibers. The stem is straight, and it has vibrant green, compound leaves that can be either smooth or curly. It flowers from June to July in its second year, producing small white flowers arranged in clusters. Its seeds are small and ribbed in shape. Its leaves can be harvested from spring to autumn, and the seeds are collected when fully ripe.The leaves, root, and seeds of parsley are all utilized [12], [15]. The carvone (L) present in the essential oils of the dill plant has an anti-protective effect in acute lung injuries [32].

Parsley oil has several uses, including pesticide areas, as it can affect the percentage of corrected destruction, the decrease in eggs and the hatchability rate of the fifth phase nymphs of the fifth phase.[35]

Parsley seeds can be used in poultry feed Parsley plant seeds with goat diet by 8% have shown an increase in the level of hemoglobin, stacked cell size, increased white blood cells, and the proportion of lymphocytes and monocytes[36]

Moisture content expresses the amount of moisture present in a product, typically measured in percentage(%) . Moisture content is a critical factor that needs to be carefully controlled during drying processes to obtain a dried product that is resistant to spoilage, suitable for preservation, storage, transportation, and consumption.[16]

In drying study of parsley and dill using two methods: sunlight (air) drying at temperatures ranging from 18-25 degrees Celsius and electric oven drying at 50°C.

The research found that electric oven drying reduced the drying duration by 50% for both herbs. For instance, the wet basis moisture content for electric oven drying was 6.3%, requiring six hours for parsley and 11 hours for dill to reach that level. In comparison, the moisture content for air drying took 12 hours for dill and 6 hours for parsley. Consequently, the drying rate in the electric oven was higher than that in the air drying process [17]. In a study of the impact of microwave power on drying characteristics of parsley leaves using a microwave device, it was found that moisture content decreased faster with increased power, but this was accompanied by higher energy consumption and the occurrence of burning effects on the samples [18]

Drying rate represents the amount of water that evaporates during a specific duration period. The drying rate is affected by various factors, with air temperature being one of the most significant. Higher temperatures reduce drying duration. Additionally, the speed of dry air also contributes to a shorter drying duration. Other factors that influence drying rate include the type of product being dried and weather conditions [19], [20].

The drying rate is typically high in the first hour of drying and decreases over duration due to the decreasing internal resistance of moisture at the beginning of drying. Toward the end of the drying period, the moisture content decreases, leading to a decrease in the drying rate [21]. The drying method used is also an important factor affecting the drying rate. Özcan and his team found that the duration required to dry parsley to a low wet basis moisture content of 6.3% took six hours in an electric oven, while it took 11 hours for air drying. For dill, the electric oven drying duration was six hours, while air drying took 12 hours. Thus, the drying rate in the electric oven was significantly higher than in the air drying method[17].

The color is an important indicator of the final product's quality in the drying process. Various drying factors, including temperature and drying duration, as well as the drying method, can affect the color of the final product. A study comparing microwave drying with oven drying at different temperatures for various herbs, including coriander, mint, parsley, and dill. The results showed that the color value of the dried product decreased in both microwave and oven drying compared to fresh leaves. However, microwave drying better preserved the color quality compared to hot air drying [22]. It was determined the optimum drying temperature for parsley and dill leaves to be 60°C. This temperature maintained color quality better than other temperature settings [23]. So this temperature degree was used in oven dryer in this study.

2-Materials and Methods

Devices and Materials Used

1-Measurement Device

a-Sensitive Balance

b-Electric Drying Oven: An electric heating oven was used in this experiment, a gravity convection heating oven (ED 210, serial no.: 10-15865), which is naturally ventilated.

The temperature can affect the inhibition rate, as it was found when increasing the temperature exposed to the bush from 154 to 164 and then 174 degrees Celsius, which led to an increase in the inhibition rate of the bush from 62.67% to 84.37%.[37]

c-Microwave Oven: A 30-liter microwave oven was used, the technical specifications outlined in Table (1)

Table (1) Microwave Oven Specifications

Brand name	ASDA
Model	P80D20ETP-YWA
Supply voltage	AC230-240V
Rated power input	1200W
Microwave frequency	2450MHz
Batch No	4/6/14
Serial no	1514w0864

2-Experimental Design

The experiment was conducted using a Completely Randomized Design (CRD) with three replicates. The Least Significant Difference (LSD) was used to compare the means of the treatments. Gen stat 12.1 software (2009) was used to analyze the data.

3- Experiment Execution

Twelve different experiments were carried out for dill and parsley plants using three drying methods (sun drying, electric drying, and microwave drying) and two drying durations, as follows:

1- Solar drying Experiment

Dill plant of the local variety "graveolens" and parsley plant were collected from local markets in Baghdad for the spring season

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of 2022. They were then cleaned, damaged parts and portion of the large stems were removed. Subsequently,12 samples, each weighing 100 grams, were placed in aluminum containers and stored in a refrigerator at 5 degrees Celsius. In the morning, the samples were weighed and placed under direct sunlight. The samples were weighed every hour until a stable weight was reached. The first drying duration took 6 hours, while the second experiment took 7 hours for dill and 7 hours for the first duration, and 8 hours for the second duration for parsley. Temperature was measured using a locally made device. Figure 1 shows the samples before and after solar drying

DURATIONFigure (1):illustrates samples of dill and parsley before and after sun drying.

A: Dill plant before drying. B: Dill plant after sun drying.

C: Parsley plant before drying. D: Parsley plant after sun drying.

2- Electric Drying Experiment

12 samples of 100 grams of dill and parsley (6 for each) were prepared for electric drying. The samples were transferred from the refrigerator to the experiment site and placed in the oven at 8:30 AM. Before placing the samples in the oven, their weight was measured, and the samples were weighed every hour until a stable weight was reached. The first experiment took 7 hours, while the second experiment took 8 hours for dill and 6 hours for the first duration, and 7 hours for the second duration for parsley. Figure (2) shows samples of dill and parsley before and after electric drying.

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Figure (2): Samples of dill and parsley before and after electric drying.

A: Dill samples before drying. **B:** Dill samples after drying.

C: Parsley samples before drying. **D:** Parsley samples after drying

3.Microwave Drying Experiment

12 samples of 100 grams of dill and parsley (6 for each) were prepared for microwave drying. The samples were transferred from the refrigerator to the experiment site and placed in a Pyrex glass container with high heat resistance. A paper towel was added to absorb moisture during the drying process. The microwave power level was set to 40%, equivalent to 320 watts, with a total input power of 860 watts. The samples were placed in the microwave and taken out every three minutes for weighting until a stable weight was reached. The first drying duration was 21 minutes, and the second duration was 24 minutes for dill. For parsley, the first duration was 24 minutes, and the second duration was 29 minutes. Figure (3) illustrates samples of dill and parsley before and after microwave drying.

Figure (3): Illustrates samples of dill and parsley before and after microwave drying.

A: Dill samples before drying. **B:** Dill samples after drying.

C: Parsley samples before drying. **D:** Parsley samples after drying.

Moisture Content Measurement Method

Moisture content, in the context of a wet basis for a substance, refers to the wetness level of the material. This term is commonly used in agriculture and food industries. It is denoted by the symbol

MC_wb and is calculated using the following equation [24]

$MC_{wb} = (m_i - m_f) / m_i * 100$

Where:

MC_{wb}: is the moisture content on a wet basis

m_i: is the initial moisture content of the material.

m_f: is the final moisture content of the material.

To plot the percentage of moisture content and drying rate in the dried sample over

drying duration, equations described by Okonkwo and his group [25], as shown in the following table 2, were adopted: These equations can be used to create the desired moisture content and drying rate curve.

Table (2): mathematical equations for plotting the moisture content curve and drying rate during each hour.

Time T(min)	Weight of the sample WS (g)	Loss in the weight of the sample WL(g)	Moisture content MC(g)	Percentage moisture content MC(%)	Drying rate DR(g/min)
t_0	WS_O	-	$WS_O - WS_7$	$\left(MC_O/WS_O\right) \times 100$	-
t_1	WS_1	$WS_O - WS_1$	$MC_O - WL_1$	$\left(MC_1/WS_1\right) \times 100$	$\frac{WL_1}{t_1 - t_0}$
t_2	WS_2	$WS_O - WS_2$	$MC_O - WL_2$	$\left(MC_2/WS_2\right) \times 100$	$\frac{WL_2}{t_2 - t_0}$
t_3	WS_3	$WS_O - WS_3$	$MC_O - WL_3$	$\left(MC_3/WS_3\right) \times 100$	$\frac{WL_3}{t_3 - t_0}$
t_4	WS_4	$WS_O - WS_4$	$MC_O - WL_4$	$\left(MC_4/WS_4\right) \times 100$	$\frac{WL_4}{t_4 - t_0}$
t_5	WS_5	$WS_O - WS_5$	$MC_O - WL_5$	$\left(MC_5/WS_5\right) \times 100$	$\frac{WL_5}{t_5 - t_0}$
t_6	WS_6	$WS_O - WS_6$	$MC_O - WL_6$	$\left(MC_6/WS_6\right) \times 100$	$\frac{WL_6}{t_6 - t_0}$
t_7	WS_7	$WS_O - WS_7$	$MC_O - WL_7$	$\left(MC_7/WS_7\right) \times 100$	$\frac{WL_7}{t_7 - t_0}$

Measurement of Drying Rate:

The drying rate is the ratio between the mass of water evaporated from the material during drying and the total drying duration. It is calculated using the following equation [24].

$$M_w = \frac{(M_i - M_f)}{(100 - M_f)}$$

Where:

M_w: is mass of sample.

M_i :is the initial moisture content of the material.

M_f: is the final moisture content of the material.

$M_{dr} = M_w / t_d$

Where:

M_{dr}: is the drying rate.

t_d :is the drying duration.

M_w :is the mass of evaporated water.

3- Color: The evaluation of the color attribute for samples of dill and parsley was carried out based on sensory evaluation using the Hedonic Scale method [26]. The evaluation was performed by judges to assess the samples, and the scores were given as follows: 1 - Very poor 2-3 - Poor 4-5 - Acceptable 6-7 - Good 8-9 - Very good.

3-Results and Discussion

1-Moisture Content:

The results of moisture content are represented in Table3. The results show significant difference in moisture content between dill and parsley plants. Dill had the highest moisture content 83.67%, while parsley had the lowest value 81.86%. This suggests that parsley is more resistant to moisture loss than dill. These findings are consistent with the results reported by Özcan and his team [17], in which dill had a higher moisture loss compared to dried parsley using both solar and electrical drying methods.

The drying method had a significant effect on the moisture content of both studied plants, as shown in Table 3. The highest moisture content was recorded in the electrical drying method 84.02%, while the lowest was 80.69% in the microwave drying method. Solar drying resulted in a moisture content of 83.59%.It can also be observed from Table 3, that there was no significant difference in moisture content between the drying durations (first and second duration), indicating that longer drying duration are unnecessary and would result in wasted duration and energy, and so increasing drying cost.

The two-way interactions between the studied factors (plant/drying methods, plant/duration, drying methods/duration) and the three-way interaction between plant, duration, and drying methods did not show any significant differences.

Figure 3 and Figure 5 showed the percentages of moisture content over the drying duration for dill and parsley, respectively. It is noticeable from the graphs that the microwave drying curve had a sharp decline with a very high slope compared to electrical and solar drying methods. This can be attributed to the short drying duration required for the microwave method (29 minutes) compared to the much longer durations needed for the other two methods (7 hours). Figure 1 also illustrates that dried parsley by the microwave method retains a higher moisture compared to the other two drying methods. This indicates that microwave drying for parsley is less efficient in terms of moisture content compared to solar and electric drying methods.

Table (3): effect of drying methods and drying duration on the moisture content of dill and parsley

Plant type	Drying method	Interaction between plant type, drying method and duration		Interaction between the plant and the drying method
		Duration		
		1	2	
Dill	electrical	83.31	81.72	81.02
	Microwave	81.89	81.2	83.01
	Solar	86.16	81.76	83.96
Parsley	electrical	83.31	81.72	81.02
	Microwave	78.87	77.8	78.31
	Solar	83.2	83.23	83.22
LSD=0.05	1.37			3.091
Average duration	X	82.79	82.71	X
LSD=0.05	1.787			
Plant type	Interaction between plant type and duration			Average plant type
	1	2		
Dill	83.78	83.56		83.67
parsley	81.79	81.92		81.86
LSD=0.05	2.527			1.787
Drying methods	Interaction between drying methods and duration			Average drying methods
	1	2		
electrical	83.31	81.72		81.02
Microwave	80.38	81		80.69
Solar	81.68	82.19		83.59
LSD=0.05	3.091			2.188

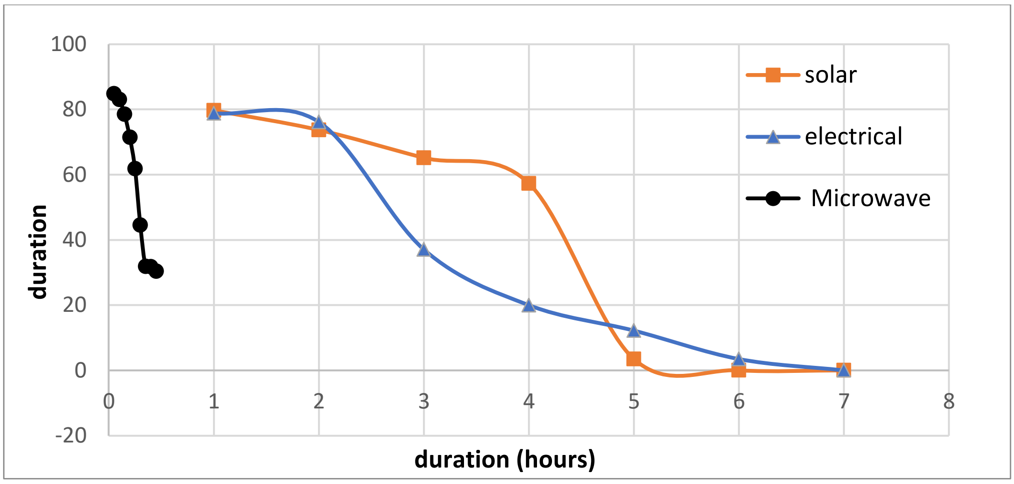

Figure (4): Curve of percentages of moisture content during drying duration of parsley.

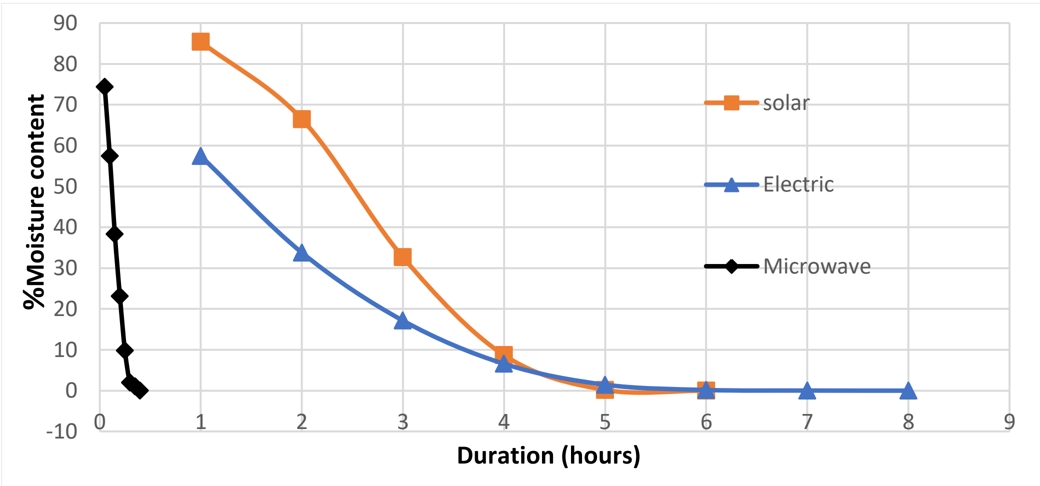

Figure (5): Curve of percentages of moisture content during drying duration of dill.

2-Drying rate and drying duration:

Table 4 shows the impact of different drying methods on the drying rate of dill and parsley plants during the studied duration periods.

The results obtained in Table4 indicate a significant difference in the plant type factor on the drying rate. The highest value of drying rate was 0.01378 (kg/hour) for dill, while the lowest value was 0.0115 for parsley. This suggests that parsley is more resistant to moisture loss compared to dill, the same result that obtained from the moisture content analysis mentioned earlier.

Table 4 also demonstrates a highly significant difference between the drying methods (solar, electric, microwave). The highest drying rate was achieved using the microwave method 0.113 (kg/hour), while the lowest rate was observed in the electric drying method at 0.011 (kg/hour). The solar drying method yielded a rate of 0.01265 (Tkg/hour). The shorter drying duration achieved by microwave contributed to the highest drying rate, with drying duration values of 27 minutes and 29 minutes for dill and parsley, respectively, compared to 8 hours and 7 hours for electric drying and 7 hours and 8 hours for solar drying,

respectively.

The drying duration results obtained with the instruments (electric oven and microwave) were consistent with findings from other studies, which can be attributed to the controlled conditions in drying processes using these instruments. In a study [27], which investigated the effect of different microwave power levels on the drying process of dill plants The duration required for drying at 360 watts was 25 minutes, and this duration is considered close to what was obtained in current study (27 minutes using power of 320 watts

Table (4) Effect of drying methods and drying duration on the drying rate of dill and parsley

Plant type	Drying method	Interaction between plant type, drying method and duration		Interaction between the plant and the drying method
		Duration		
		1	2	
Dill	electrical	0.01181	0.0101	0.01112
	Microwave	0.215	0.231	0.01378
	Solar	0.016	0.0113	0.01112
parsley	electrical	0.01181	0.01	0.00285
	Microwave	0.11	0.11	0.01151
	Solar	0.01151	0.01152	0.1151
LSD=0.05	0.005078			0.003591
Average duration	X	0.01199	0.0162	X
LSD=0.05	0.005078			
Plant type	Interaction between plant type and duration			Average plant type
	1	2		
Dill	0.08109	0.08137		0.08273
Parsley	0.00889	0.0081		0.00819
LSD=0.05	Drying rate			0.002073
Drying methods	Interaction between drying methods and duration			Average drying methods
	1	2		
Electrical	0.01181	0.01013		0.01112.
Microwave	0.10931	0.11681		0.11306.
Solar	0.01381	0.01115		0.01265

LSD=0.05	0.003591	0.002539

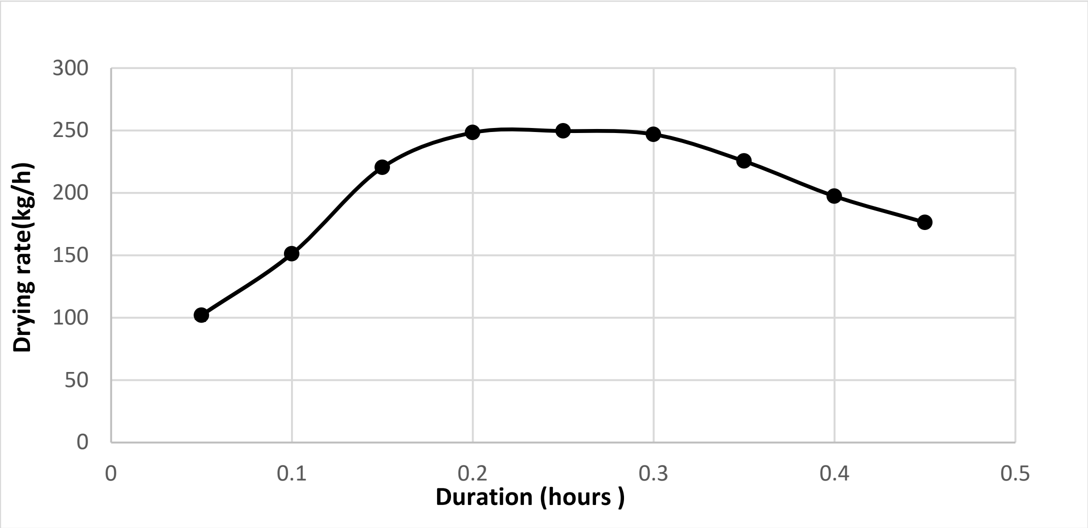

Figure (6): Drying rate curve of parsley plant by microwave method

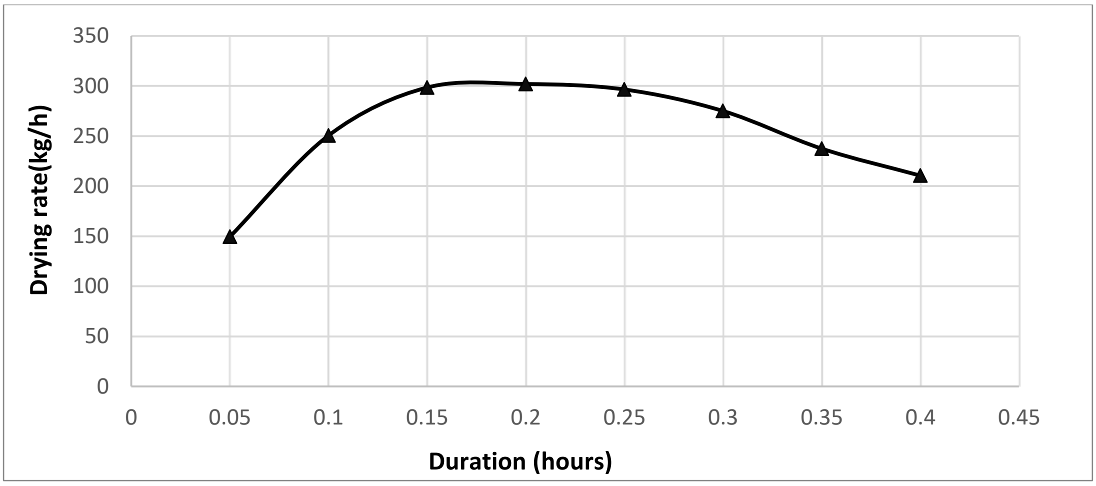

Figure (**7**): Drying rate curve of dill plant by microwave method

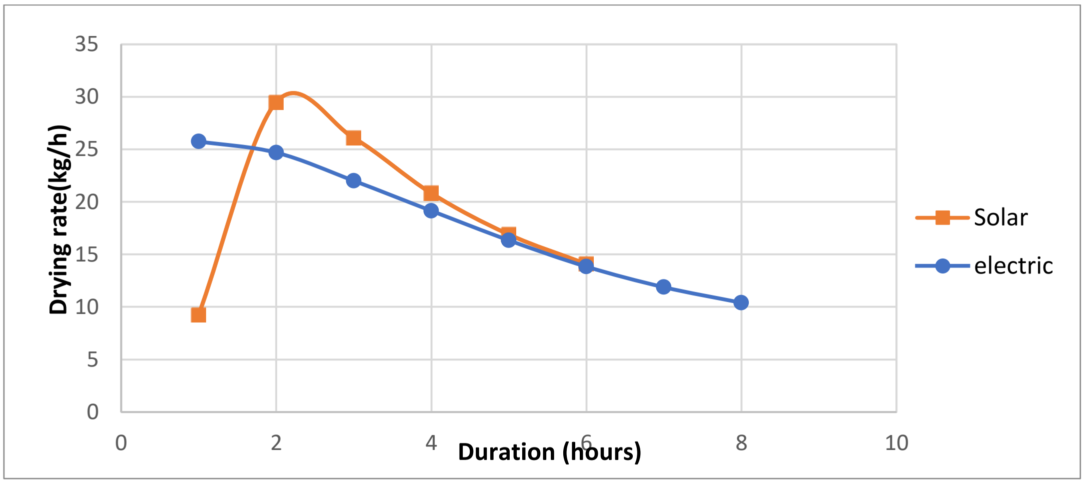

Figure (8): Drying rate curve of dill plant by solar and electric drying methods

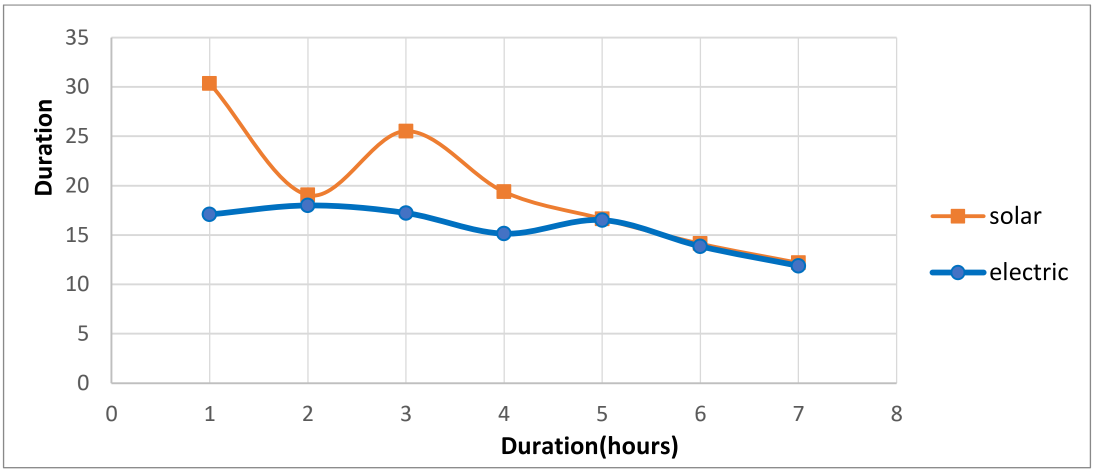

Figure (9): Drying rate curve of parsley plant by solar and electric drying methods

In another study [17] the duration required for drying dill and parsley plants in an electric oven at 50 degrees Celsius was 8 hours, while in this study, the shortest drying duration (the first duration) for drying parsley and dill in an electric oven at 60 degrees Celsius was 6 hours and 7 hours, respectively. The first drying duration was depended as there was no significant effect of duration on moisture content and drying rate Table 4. The decrease in drying duration in this study is attributed to the higher temperature used.

the solar drying method, it is subject to climate variations, including temperature differences between different regions and seasons, as well as fluctuations throughout the day, along with the lack of control of relative humidity and wind, which are important factors in the drying process. Therefore, in this study, the first drying duration for solar drying (40-46) degrees Celsius in May) for both dill and parsley was 6 hours and 7 hours, respectively, while in study of Özcan and his gruop [17], the drying duration for both plants using solar drying (18-25 degrees Celsius in May) was 12 hours.

The duration factor did not show any significant difference in drying rate, as indicated in Table 4. Therefore, longer drying durations are unnecessary and are considered a waste of duration and energy, resulting in increased drying cost. This conclusion is consistent with the moisture content analysis mentioned earlier. also the interaction between plant type and duration, showed no significant effect on drying rate.

Table 4 shows that the two-way interaction between plant type and drying methods (solar, electric, microwave) had a significant effect, with the highest values in microwave and lowest values) in the electric drying method. These results attributed to the shorter drying duration in the microwave.

Furthermore, the three-way interaction between plant type, drying methods, and duration (first and second durations) showed significant differences. The highest drying rate for dill in the first duration was 0.21 (kg/hour) in the microwave drying method and the lowest was 0.011 (kg/hour) in the electric drying method. In the second duration, the highest rate was 0.23 (kg/hour) in the microwave drying method, and the lowest was 0.01 (kg/hour) in the electric drying method. For parsley, the highest rate in the first duration was 0.115 (kg/hour) in the microwave drying method, and the lowest was 0.011 (kg/hour) in solar drying. In the second duration, the highest rate was 0.115 (kg/hour) in the microwave drying method, and the lowest was 0.010 (kg/hour) in the electric oven drying method. These results show that microwave drying led to a significantly higher drying rate, with dill having about twice the drying rate value of parsley, so again parsley is more resistant to moisture loosing.

Drying rate curves (6, 7, 8, 9) demonstrate that drying rates for dill and parsley were initially low in the first hour for solar drying and the first few minutes for microwave drying, this can be attributed to the initial resistance to evaporation. Then, the drying rates reached their peak in the second hour for solar drying and during the period between 9 and 15 minutes for microwave drying. Subsequently, these values started to decrease until they reached their lowest levels at the end of the drying process in both microwave and solar drying. In the case of electric oven drying, the drying rate curves showed the highest values in the first two or three hours of drying, followed by a gradual decrease, reaching the lowest levels at the end of the drying process. The initial high drying rate is due to the high moisture resistance at the beginning of the drying process [21], while the decreasing moisture content towards the end of the drying leads to a reduction in the drying rate [28].

3-Color Characteristic

When comparing the results obtained and showed in Table5 to the highest value of 9 for the fresh plant on Hedonic scale for plant color, we observed a decrease in color quality for both dried dill and parsley using the three drying methods (solar, electric, microwave). From the results obtained in Table 5, there was no significant difference between plant types. But there was a significant difference between drying methods (solar, electric, microwave), with the highest color grade value of 8 observed in the microwave drying method and the lowest value of 7.17 in the solar drying method. These results agree with findings from previous studies [17], [29], [30]

These results indicate that microwave drying preserved color quality compared to electric and solar drying. This can be attributed to the shorter drying duration in microwave compared to solar and electric drying. Additionally, temperature plays a crucial role in determining the quality of the dried plant's color where in the microwave drying method, the liquid is pushed to the surface as water vapor is released. This process results in drying without causing excessive surface heating, significantly improving the quality of the dried herbs [31].

Finally, the table5 shows that the duration, the two way interactions and the three-way interaction did not have any significant effect.

Table (5) shows the effect of drying methods and drying duration on the color characteristic of dill and parsley plants

Plant type	Drying method	Interaction between plant type, drying method and duration		Interaction between the plant and the drying method
		Duration		
		1	2	
Dill	electrical	8	7.67	7.83
	Microwave	8	7.67	7.83
	Solar	7.33	7.67	7.5
parsley	electrical	8	7.67	7.83
	Microwave	8.33	8	8.17
	Solar	7.33	6.33	6.83
LSD=0.05	1.132			0.801
Average duration	X	7.83	7.5	X
LSD=0.05	0.162			
Plant type	Interaction between plant type and duration			Average plant type
	1	2		
Dill	7.78	7.67		7.72
parsley	7.89	7.33		7.61
LSD=0.05	0.651			0.162
Drying methods	Interaction between drying methods and duration			Average drying methods
	1	2		
electrical	8	7.67		7.83
Microwave	8.17	7.83		8
Solar	7.33	7		7.17
LSD=0.05	0.801			0.566

5-Conclusions

1- Parsley plant exhibited grea

2- ter resistance to moisture loss compared to dill plant, where the moisture content in parsley plant is higher than in dill plant and the drying rate in dill is approximately twice as high as in parsley plant.

3- Electrical drying method showed the highest moisture content value. Conversely, the lowest moisture content was observed with the microwave drying method.

4- Increasing the drying duration did not have a significant effect on moisture content, drying rate, or color characteristics. This means that longer drying durations are not necessary and can be a waste of duration and energy, leading to increased drying costs.

5- Regarding drying durations, microwave drying took much less duration compared to solar and electrical drying. And this lead to higher drying rate in microwave with a 9 and 10 durations greater than solar and electrical respectively.

6- Microwave drying preserved color quality compared to electric **and solar** drying

4-Aknowlgment

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