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# Hot oven drying of mint leaves: modeling weight loss, phenolic compounds and antioxidant properties variation by using response surface method

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## ABSTRACT

In this study, the effect of hot oven drying condition (drying temperature and time) on weight loss, total phenolic compounds and antioxidant properties of mint leaf was investigated and optimized by response surface methodology. The results showed that with increasing drying time and temperature, weight loss and total phenolic compounds of mint leaves increased and drying time had more effect on changes of these two parameters compared to drying temperature. Total phenolic compounds of samples increased with increasing drying time, but with increasing drying temperature at the beginning of the process, the amount of total phenolic compounds of samples increased. The DPPH radical scavenging activity of the samples decreased by increasing the drying time (up to 176 min) and then increased with increasing the drying time. The results showed that applying drying temperatures up to 50 °C increased DPPH scavenging activity and higher drying temperatures resulted in a decrease in DPPH scavenging activity of the samples. Increasing the drying time and temperature reduced the antioxidant capacity and ferric reducing power (FRAP) of the samples, which the slope of the changes in the FRAP and antioxidant capacity of the samples with the changes in drying time is more severe than the drying temperature changes**.** The best conditions for hot oven drying of mint leaves are using drying temprature of 59.91 °C for 52 minutes and by applying the optimal conditions, the amount of weight loss, total phenolic compounds, and DPPH scavenging percentage of produced dry mint were 69.98%, 6.90 mg/gram of dry weight, 89.68% respectively and the desirability of this optimal condition was 0.746. The results of optimal conditions validation in real conditions are very similar to the results related to the predicted optimal conditions by response surface methodology.

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# 1. Introduction

mint withscientific name (*Mentha sativa* L.) herbal is correctminty Anddark Mints openvegetables Food that containsessential oil are widely cultivated as industrial products for the production of essential oil, but due to the high volume of mint production, a major part of it remains untouched, which is subject to corruption due to the high humidity of mint, and the amount of its waste is very high, and if it is not Most of it will be lost due to proper use or maintenance. The leaves, flowers, and stems of mint are traditionally used asDrinks and herbal spices in many dishes to addperfume and taste are used. Mint is used as dry or fresh leaves to create a minty aroma in cooking. Mint leaves have a warm, fresh, aromatic, sweet taste with a cool aftertasteTea, drinks, jellies, syrups, candies and in the dairy industry foryogurt, buttermilk and ice cream are used. Mint originally asHerb It has been used to treat stomach pain and chest pain. Mint essential oil is also used in the pharmaceutical industry with the purpose of deodorizing the mouth in productionToothpaste And mouthwash is used. Since mint production is very high, it is necessary to pay attention to its processing and storage methods. Dried mint leaves are widely used as a seasoning and have a high economic value, but the drying process should be done in a way to produce a product with maximum aroma and taste. Drying, as one of the oldest methods of food preservation, includes mass and heat transfer phenomena at the same time [1]. Drying has advantages such as increasing the shelf life, reducing the volume and weight and packaging of the product, reducing the costs of transportation and storage, and the possibility of obtaining seasonal fruits and food products throughout the year and with excellent quality [2]. In the drying process, three general principles should be observed, and neglecting any of these principles may cause serious damage to the product in terms of quality and texture. These principles include: choosing the best type of dryer for the product, choosing the best treatment in each of the drying mechanisms and maintaining the quantitative and qualitative properties of the product during drying [3]. Due to the long drying processes, the physicochemical and qualitative characteristics of the product such as shape, color, texture, taste, etc. are affected and may have adverse effects on the composition of nutrients, qualitative and chemical characteristics of the product [4]. The most important adverse changes in food during the drying process include changes in color and nutritional value due to browning reactions, odor, decomposition and reduction of fat-soluble vitamins due to oxidation of fats, color loss due to the decomposition of carotenoid pigments, wrinkling and lack of reabsorption. The appropriateness of the product water and its solubility, the unfavorable texture changes (hardness and rubberiness of the product shell) and finally the loss of volatile organic compounds are responsible for the creation of aroma and flavor in food [5-7]. Many factors such as drying time and temperature, size and thickness of the food, distance from the heat source, moisture level and surface of the food, etc. are effective on the drying speed of the food [8]. In the field of optimization and modeling of the drying process, many studies have been conducted in order to increase the speed and efficiency of drying and reduce the adverse effects of prolonged drying time on food. The results of the experiments of Duimaz et al. (2006) in examining the drying behavior of a thin layer of mint leaves in the temperature range of 30-05 degrees Celsius in a cabinet dryer showed that increasing the temperature significantly reduced the drying time of mint leaves and with increasing temperature , the intensity of drying increased [9]. Based on the research of Akpinar et al. (2006) in the investigation of the drying behavior of parsley leaves in a convective dryer with different temperatures with an air speed of 1 m/s and traditional drying with sunlight with natural convection, it was observed that in the drying curves of the constant speed period does not exist and the drying process is always associated with a decrease in moisture per unit of time [10]. In the studies of Uzbek and Dadali (2007) on the drying of thin mint leaves by microwave, the results indicated that by increasing the output power of the microwave from 180 to 900 W, the drying time decreases from 12.5 to 30 minutes [11]. Many studies have been conducted in the field of fast drying methods such as microwave drying, deep fryer drying and combined dryers in different food products, all of which confirm the effectiveness and significant effect of drying with these methods in increasing the drying speed and removing moisture from the tissue. food and reduce drying time. Reducing the process time during drying leads to the production of a product with minimal loss of nutrients and undesirable color changes. However, due to the fact that most workshops and food drying factories use hot air dryers, it is very important to determine the optimal drying conditions in order to obtain a product with a long shelf life and having the most bioactive and effective compounds. Therefore, in this research, the possibility of producing optimally dried mint leaves using hot air drying method and the effect of temperature parameters and hot air drying time on weight loss, phenolic compounds and changes in antioxidant properties (radical inhibition)DPPH, FRAP and total antioxidant capacity) of dried mint leaves were investigated and optimized by response surface method.

## 2- Materials and methods

### 2-1- Hot air drying

In this study, mint was purchased from Hamadan fruit and vegetable market and after washing and cleaning, it was dried at temperatures (40-60°C) and times (50-300 minutes) in a fan oven made in Iran (Fan Azma Gostar). . The temperature range and time used for drying were selected through trial and error and reaching equilibrium moisture. The amount of weight loss of mint leaves during drying was expressed as moisture loss and was calculated from equation (1):

$WR= M_0-M_t / M_0 \times 100$

In the above relation WR, the weight loss percentage of mint leaves, $M_0$ The initial mass of mint leaves (gr), $M_t$ The mass of mint leaves after drying at time t is (gr) [12-13].

### 2-2- Measuring the amount of total phenolic compounds

The amount of total phenolic compounds was evaluated using Folin Ciocalto method [14].In this way, first 0.5 ml of each extract was diluted with 2.25 ml of distilled water and 250 microliters of Folin reagent was added to it, and after 5 minutes in a dark environment, 2 ml of 7.5% sodium carbonate solution was added to it. The solution was added, then the tubes were kept in a Bain-Marie at 40°C for 30 minutes. The absorbance of the samples was read by a spectrophotometer at a wavelength of 760 nm. The amounts of total phenolic compounds of the extracts using the standard curve based on mg of gallic acidDry weight of the sampleWas calculated [14].

### 2-3- Measurement of antioxidant activity by reducing power method

Measurement of antioxidant activity by the method of reducing power of trivalent iron by the method of Yıldırım et al [35], Done. In this method, one milliliter of extracts was mixed with 2.5 milliliters of phosphate buffer and 2.5 milliliters of potassium ferricyanide. The above solution for 30 minutes at 50 degrees Celsiusappointment took Then 2.5 ml of trichloroacetic acid was added to the mixture. Centrifuge samples for 10 minutes(g1700) became Then, the supernatant solution was mixed with 2.5 ml of distilled water and 0.5 ml of iron 3 chloride and its absorption by spectrophotometric device.It was read at a wavelength of 700 nm. Gallic acid standard was used to draw the standard graph.The amount of absorption shows the regenerative power of the extracts [16-17].

### 2-4- Measurement of antioxidant activity by DPPH radical scavenging method

To measure the DPPH inhibition percentage of the extracted extracts, first, 1 ml of a 1 mM DPPH methanolic solution was combined with 3 ml of the sample extract solution and mixed vigorously. The resulting mixture was kept for 30 minutes at room temperature in the dark and finally their absorbance was read at a wavelength of 517 nm. The activity was calculated in terms of DPPH inhibition percentage according to equation 2 [18-19].

DPPH inhibition percentage=

100 × <u>Control absorption percentage – sample absorption percentage</u>

Witness absorption percentage

### 5-2- Measurement of antioxidant activity by total antioxidant capacity method

In order to measure the antioxidant activity by the total antioxidant capacity method, first 500 ml reagent solution (mixture of sulfuric acid, sodium phosphate, ammonium molybdate) it is ready. Half a milliliter of the extract was mixed with 5 milliliters of the reagent solution, then it was placed in a Bain-Marie at 95°C for 90 minutes, and after cooling to room temperature, the absorbance of the samples was read at a wavelength of 695 nm with a spectrophotometer. Gallic acid was used to prepare the standard chart[21 and 20].

## 6-2- Statistical analysis and optimization

In this study, a range of independent temperature variables ($_1X$) and drying time ($_2X$) was determined from the preliminary tests. Optimizing hot air drying conditions of mint leaves under the influence of drying time and temperature using the response surface method (Design Expert 11.1.2.0 software)[1](and the central composite plan)[2]CCD) was performed with 3 levels and 5 repetitions at the central point (+1, 0, -1) (Table 1). The experimental plan with the actual levels of the independent variables of time and temperature of hot air drying and the results related to changes in weight, antioxidant properties and phenolic compounds of mint leaves under the influence of independent variables using the response surface method are presented in Table (2).

**Table 1** Independent variables and their applied levels for optimizing hot oven drying of mint leaves

| Independent variables | Variables level | | |
|---|---|---|---|
| | -1 | 0 | +1 |
| Drying temperature ($^0$C) | 40 | 50 | 60 |
| Drying time (minute) | 52 | 17<br>6 | 300 |

**2-4-1- validation of optimal conditions for hot air drying of mint leaves**

In order to evaluate the accuracy of the models and relationships resulting from the optimization with the response surface method and also to validate the resulting optimal conditions, mint leaf samples in real conditions (optimal conditions of temperature and time resulting from modeling), dry and qualitative characteristics such as weight loss, amount of phenolic compounds The total and antioxidant properties of the production samples were investigated and used to evaluate the accuracy of the predicted model with the software.

# 3. Results and Discussion

**3-1- Changes in weight loss (moisture) of mint leaves during hot air drying**

As in Fig(1) It can be seen that the rate of weight loss of the samples increases with the increase of drying time up to 176 minutes, but the rate of weight loss of the samples decreases in longer drying times (above 176 minutes). Also, by increasing the drying temperature to 50°C, the weight loss (moisture loss) of mint leaves decreases and then increases with increasing drying temperature. As you can see, time dryMore impactIt affects the weight loss of mint leaves compared to the drying temperature. The highest amount of weight loss (81.70%) corresponds to the temperature range of 60°C and drying time of 176 minutes, while the lowest amount of weight loss (23.48%) is at the drying temperature of 50°C and drying times less than 52 minutes were viewed. As can be seen, drying time and temperature have an intensifying effect on the weight loss of mint leaves, but at the end of the drying time, the weight loss curve begins to decline, which can be due to reaching the decline period during drying. During drying, due to the closing of the pores and capillary tubes inside the food tissue, due to the phenomenon of surface hardening.[3] The amount of moisture leaving the food is reduced and the drying speed is fixed and reduced. The results of this research were consistent with the results of Mazandarani et al. (2017), Salehi et al. (2017) and Aghajani et al., 2021. These researchers stated that the drying time and temperature had a significant effect on the weight loss of pomegranate seeds and eggplant slices, and with increasing drying time and temperature, the weight loss of these products increases [4, 23-22].

Nouri et al. (2013) showed that at the beginning of the drying process of parsley with hot air dryer and microwave, the drying rate is high, but with the passage of time, due to tissue shrinkage, the moisture content decreases rapidly, but in the later stages, the moisture content decreases slowly. takes place Also, the time required to reduce a certain amount of moisture content depends on the operating conditions, so it took 240 minutes at 70°C and 420 minutes at 50°C to completely remove the moisture from the samples. They observed that the intensity of drying at the beginning of the process is higher than at the end stages, which is due to the high amount of moisture at the beginning of the drying process and as a result, the intensity of evaporation of moisture from the surface of parsley pieces is high. Also, the wrinkling of the product surface in the final

[1]. Design Expert, 11.1.2.0 Trial, Stat-Ease Inc.

[2]. Central Composite Design

[3] . Case hardening

stages of drying causes a resistance in the transfer of water to the product surface, which reduces the intensity of drying in the final stages of the drying process, which is consistent with the results of the present study [24].

## 2-3- Changes in the amount of phenolic compounds of whole mint leaves during infrared drying

Phenolic compounds are an important part of the effective substances of medicinal plants that are affected by environmental factors, growth conditions and post-harvest operations. Qi et al. (2008) stated that increasing the drying temperature has an effect on the amount of phenolic compounds. According to them, the formation of phenolic compounds at high temperature (90°C) can be due to the availability of phenolic compounds with non-enzymatic exchanges between these molecules. The increase in antioxidant activity due to heat treatment is attributed to the release of phenolic compounds due to the breaking and decomposition of cellular components and the formation of new compounds with high antioxidant properties. On the other hand, a decrease in the antioxidant properties and the amount of phenolic compounds of plant samples under thermal treatments has been reported for some plants, which is related to the decrease of enzymes [25]. In this research, the trend of changes in total phenolic compounds of mint leaves under the influence of drying time and temperaturehot airIt is shown in figure (2).As can be seen, by increasing the drying time up to 176 minutes, the amountTotal phenolic compounds There is an upward trend, while at longer drying times (above 176 minutes) the amountTotal phenolic compoundsSamples are in a downward trend. Also by increasing the drying temperatureTotal phenolic compoundsMint leaves have a downward trend with a constant and slow slope At the beginning of the drying process, the amount of phenolic compounds increases due to the evaporation of moisture, but due to the destructive effect of heat, the amount of phenolic compounds decreases with the increase in temperature. As can be seen, drying time has a more severe destructive effect than drying temperature on the amount of total phenolic compounds. So that with the increase of drying temperature, the amount of total phenolic compounds shows a slow and slight upward trend, but with the increase of drying time, the amount of total phenolic compounds shows a more drastic change. Total phenolic compounds are heat-sensitive compounds that are quickly oxidized so that they begin to decompose and decrease rapidly with increasing drying time and temperature. In order to maintain the nutritional value and prevent the degradation of phenolic compounds, as well as to achieve the highest drying efficiency, the use of high-temperature-short-time processes (HTST) is recommended [23] Therefore, by using higher temperatures and drying times of less than 176 minutes, the loss of total phenolic compounds is lower, and at the same time, the amount of moisture is also reduced to an optimal level.

## 3-3- Changes in antioxidant properties of mint leaves during hot air drying

Changes in the antioxidant properties of mint leaves during hot air drying are shown in Figures 3 to 5. As seen in Figure 3, the amount of DPPH radical inhibition decreases with increasing drying time up to 176 minutes and then increases with increasing drying time and shows an increasing trend with increasing drying temperature up to 50°C and application of dry temperatures A higher concentration leads to a decrease in the DPPH radical scavenging ability of the samples. The DPPH free radical scavenging ability of the samples in the range of drying time between 114-238°C increases with increasing infrared drying temperature up to 50°C, while it slightly decreases in the temperature range above 50°C (Figure 3).

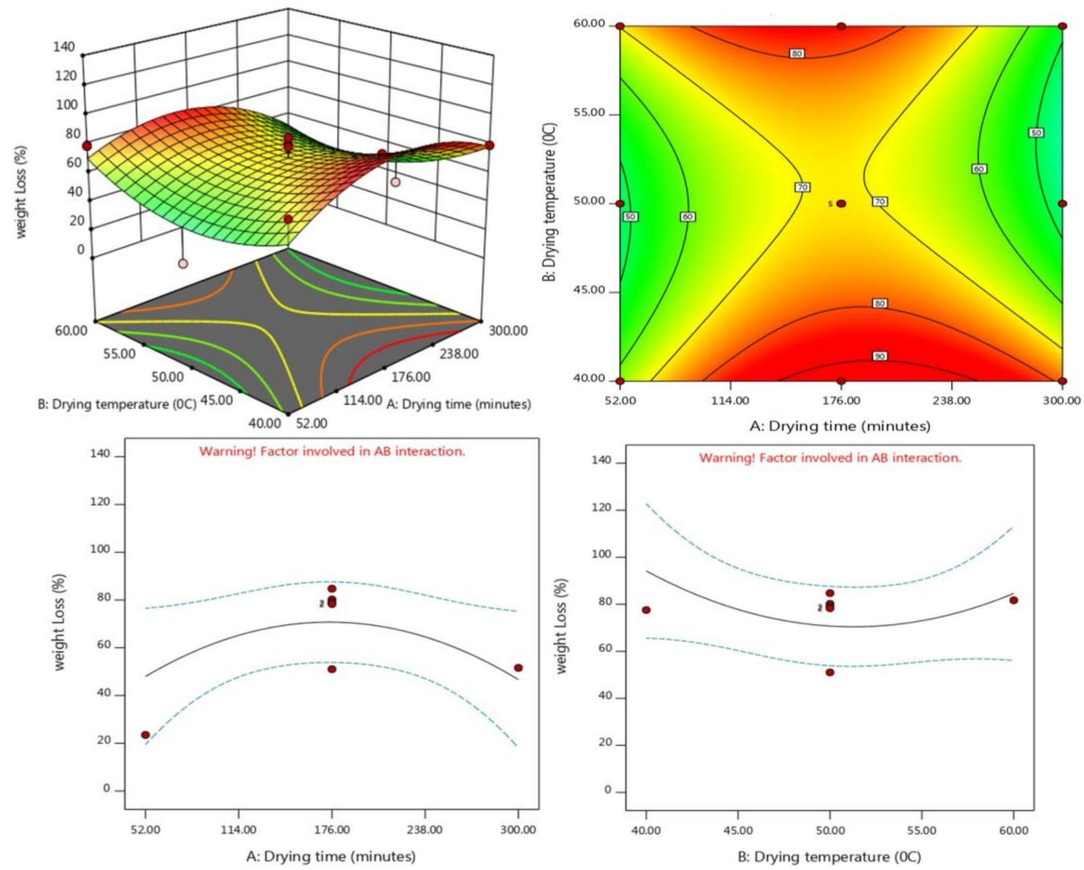


**Fig 1** 3D surface, contour plot and one factor effect of the simultaneous effect of different drying temperature and drying time on water loss (moisture content) of hot oven dried mint leaves

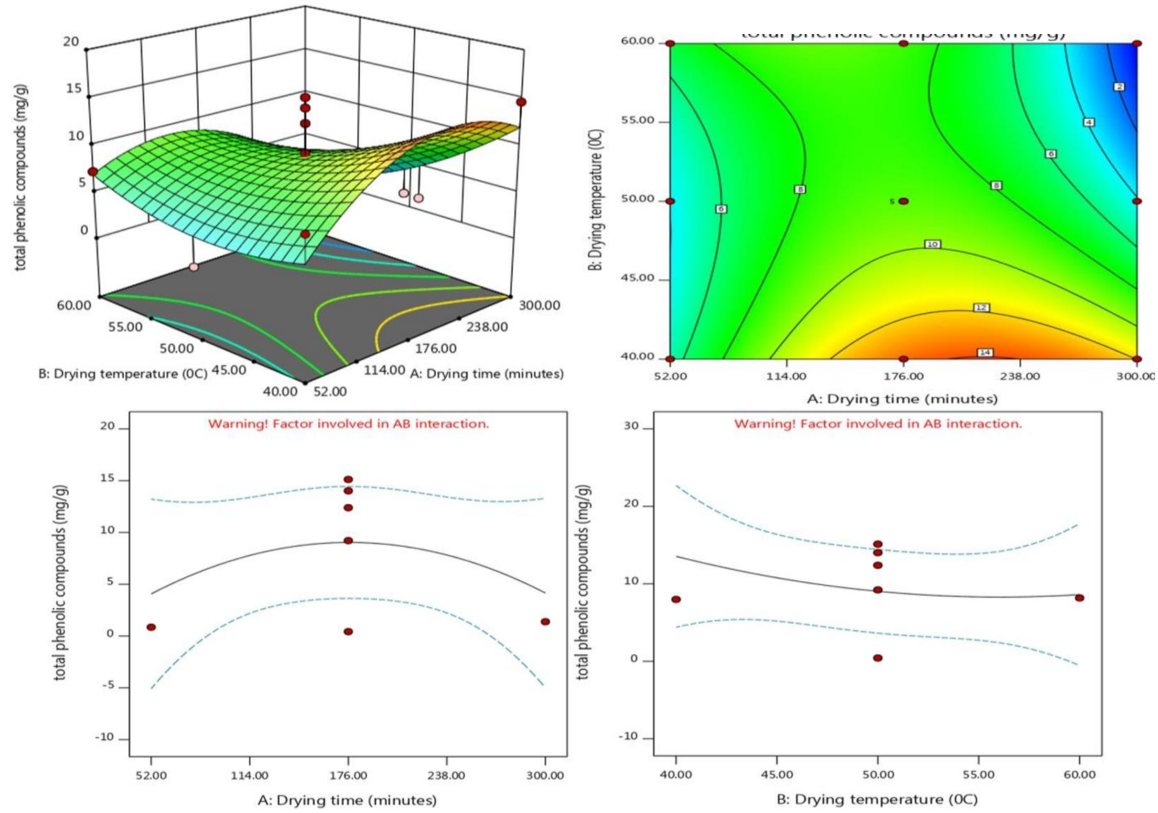


**Fig 2** 3D surface, contour plot and one factor effect of the simultaneous effect of different drying temperature and drying time on total phenoloic compounds of hot oven dried mint leaves

As can be seen in Figure 4, with the increase of drying time and temperature, the antioxidant capacity of the dried samples has a downward trend, and the drying time has a greater effect on the amount of changes in the antioxidant capacity of the samples compared to the drying temperature. The results of Fig**5** It shows that the characteristic of regeneration power of dried samples has a downward trend with increasing drying time and temperature, and the slope of changes in regeneration power of samples with changes in drying time is more severe than changes in drying temperature.

During drying, various physicochemical changes occur in the food material, which changes the quality characteristics of the final dried product compared to the initial fresh product [26]. Antioxidant properties of fruits and vegetables due to phenolic acids (gallic acid, caffeic acid, caffeic acid, ferulic acid, chlorogenic acid and p-coumaric acid) and flavanols (epicatechin, epicatechin gallate, epigalactocatechin gallate and catechin) and compounds such as vitamin It is related in the composition of fruits and vegetables. The decrease in antioxidant activity is largely related to the decrease in the concentration of polyphenols, as well as the phenomena of oxidative degradation and polymerization-condensation of some compounds [27-29]. In addition, the results of the present study are consistent with the studies of other researchers, which show that the amount of phenolic compounds and antioxidant activity are affected by processes such as cooking with steam, boiling or drying [30-32]. Many reactions that occur during drying lead to the change of compounds responsible for color and affect the phenolic and antioxidant compounds of the product. Among these reactions, we can mention the degradation of pigments, oxidation of ascorbic acid, enzymatic browning, non-enzymatic browning (Millard) and polymerization of phenols. Other factors such as acidity, variety or type of product, temperature and time of the thermal process are also effective on the existing color and phenolic compounds that are responsible for the antioxidant properties in the product [33]. During the drying process, the product usually becomes darker, and this color change is due to the degradation and decomposition of the pigment and enzymatic and non-enzymatic browning reactions [34].

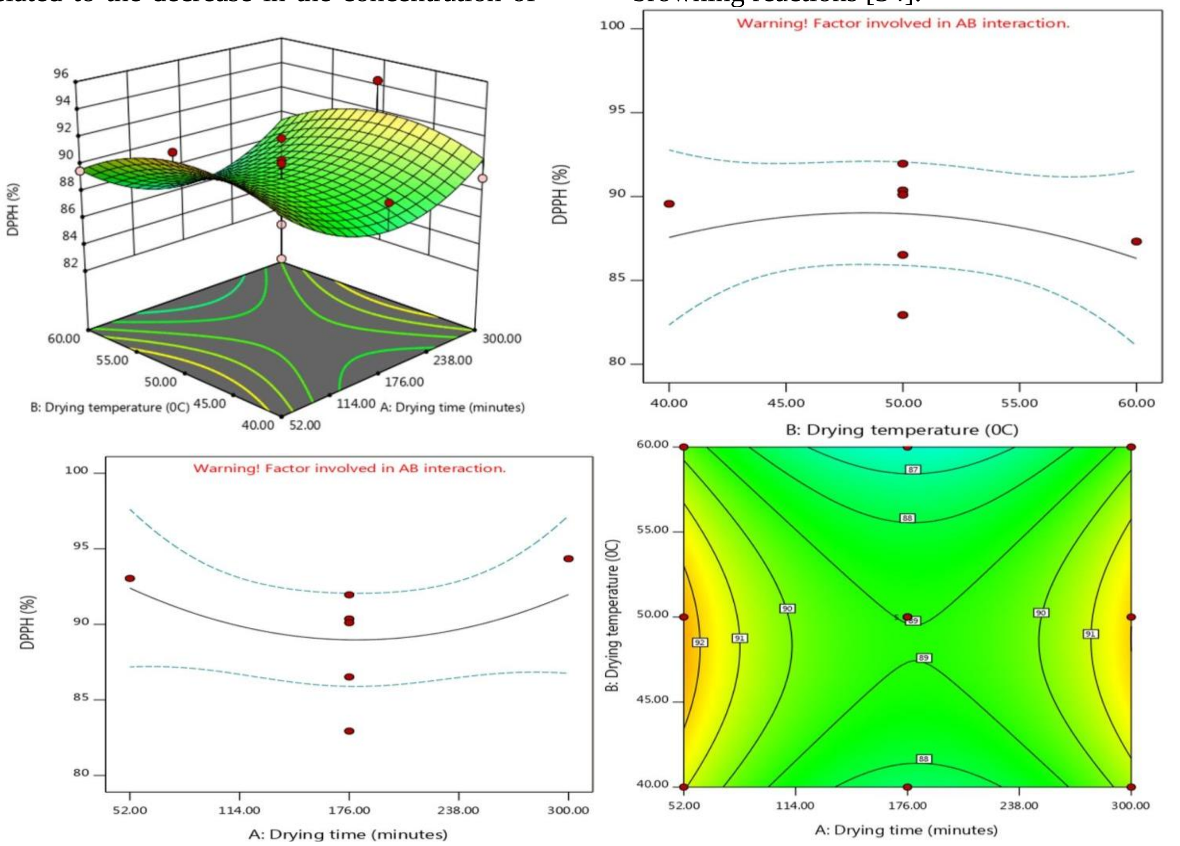


**Fig 3** 3D surface, contour plot and one factor effect of the simultaneous effect of different drying temperature and drying time on DPPH radical scavenging activity of hot oven dried mint leaves




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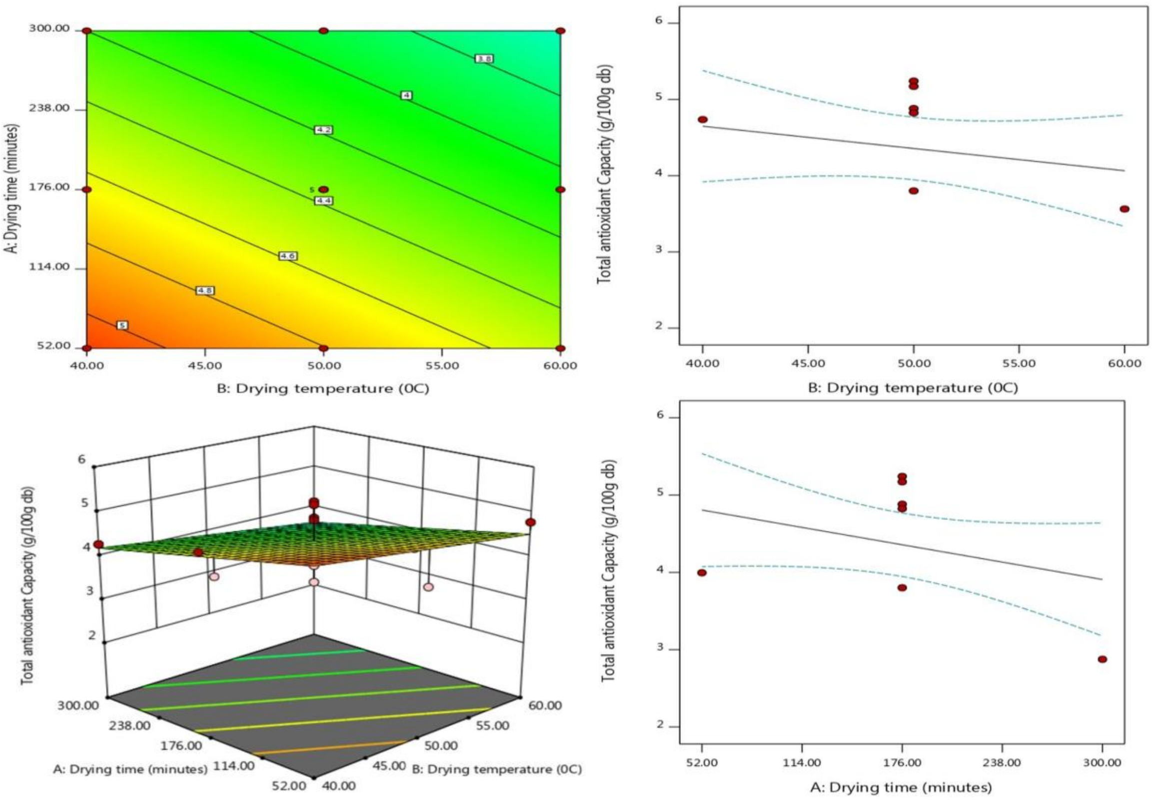



**Fig 4** 3D surface, contour plot and one factor effect of the simultaneous effect of different drying temperature and drying time on total antioxidant capacity of hot oven dried mint leaves

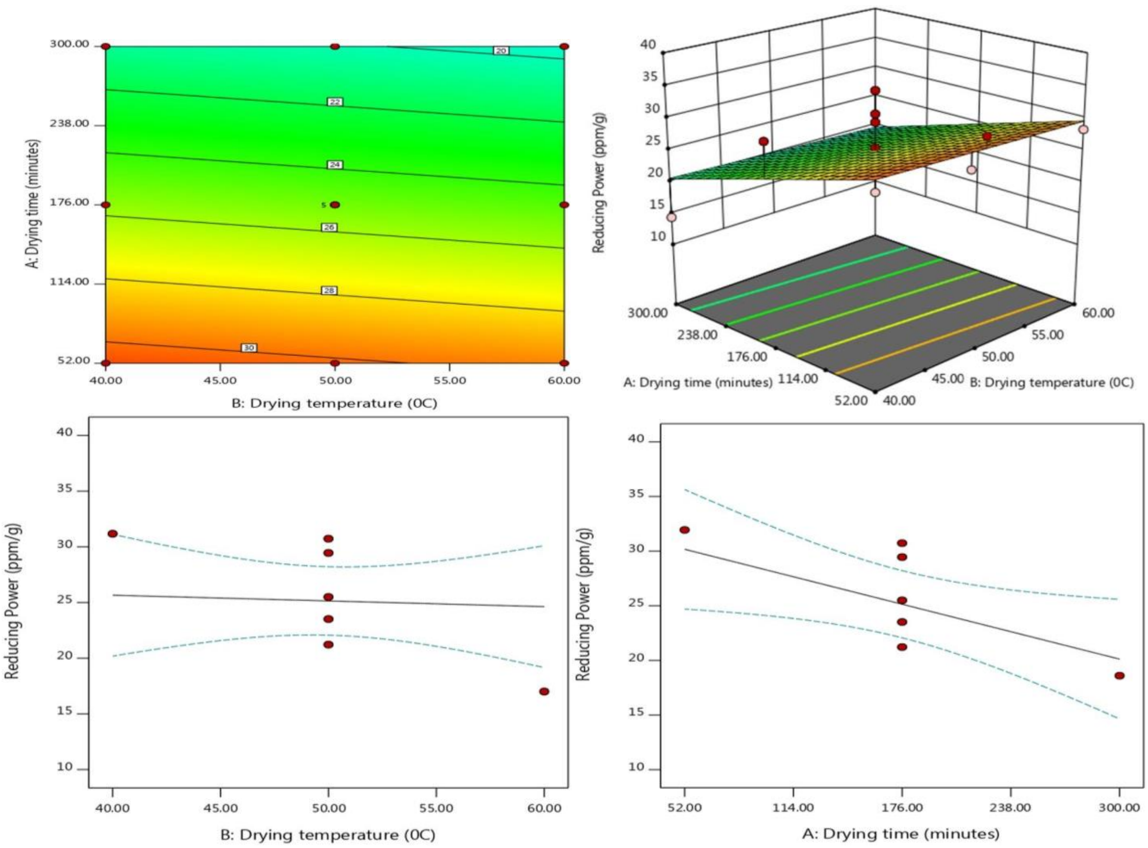



**Fig 5** 3D surface, contour plot and one factor effect of the simultaneous effect of different drying temperature and drying time on Ferric reducing ability of plasma (FRAP) of hot oven dried mint leaves

Turkman et al. (2020) showed that increasing the temperature in different drying methods led to an increase in the antioxidant properties and phenolic compounds of cherry fruit compared to the fresh sample, which could be due to the increase in the proportion of phenolic compounds in the dry matter of the samples [35]. Hossein et al. (2010) showed that drying increased phenolic and antioxidant compounds in mint plants compared to fresh samples [36]. On the other hand, Chan et al. (2007) reported the reduction of phenolic and antioxidant compounds of ginger plant as a result of drying [37].

### 3-4- Optimizing hot air drying conditions for mint leaves

The experimental plan with the actual levels of the independent parameters of hot air drying and the results related to the changes in the quality characteristics of mint leaves using the response surface method and optimal correlation are presented in Table (2) and Figure 6. Considering the destructive effect of long times on the destruction of nutritious and bioactive compounds in food, the idea of HTST process was used to determine the range of independent variables of temperature and drying time of hot air [23]. For this purpose, the maximum drying temperature and the minimum drying time were considered, while the amount of weight loss within the scope of the experiments and the antioxidant properties of total phenolic compounds were considered to be maximum as the goal of the process. In the optimization process, all independent parameters were given the same weight and importance. According to the desired conditions, the predicted solutions based on the highest desirability are presented in Figure (6) and the closer the desirability is to 1, the most appropriate and best conditions will be, and the first solution is considered as the best conditions to achieve the optimal conditions. was taken and by applying the process conditions obtained in the optimization, a product with the appropriate amount of moisture and the maximum amount of phenolic compounds and antioxidant properties will be obtained. As seen in Figure (6), the best conditions for hot air drying of mint leaves include the use of a temperature of 59.91 degrees Celsius and a drying time of 52 minutes, and by applying the optimal conditions, the amount of weight loss (moisture loss), total phenolic compounds , and the antioxidant characteristics include DPPH inhibition percentage, total antioxidant capacity and FRAP of the produced dry mint are equal to 69.98%, 6.90 mg/g dry weight, 89.68%, 4.52 and 29.66, respectively. The desirability of this optimal condition is 0.746.

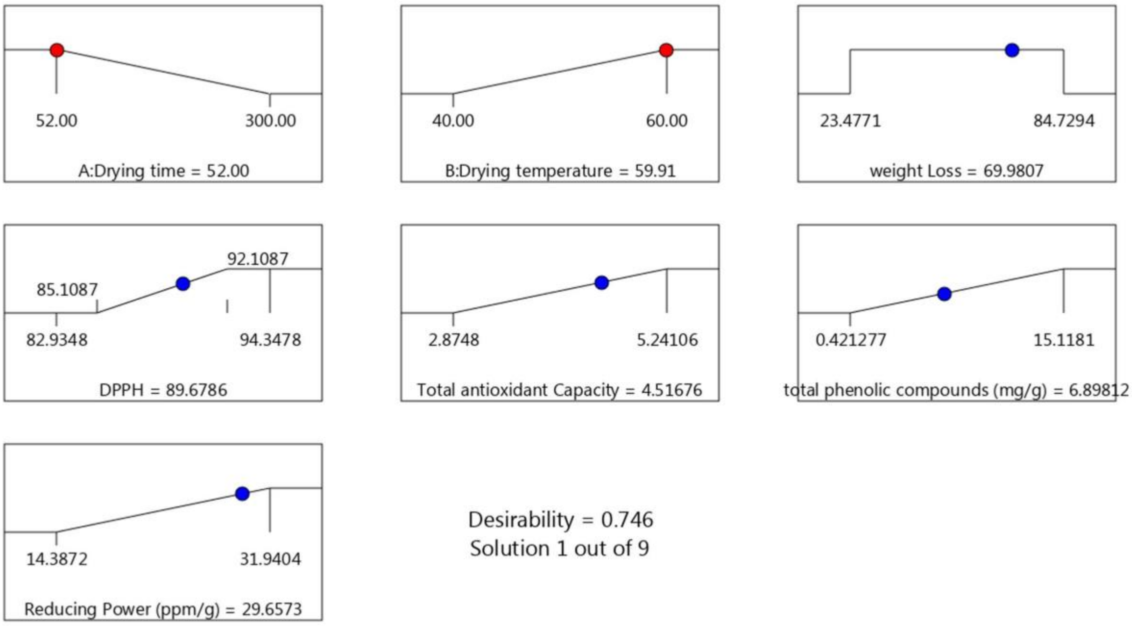
The validation of the optimal conditions obtained from the response surface method was done by drying the mint leaf samples at the optimized temperature and hot air drying time. The results of the validation showed that the quality characteristics of the produced product such as weight loss, the amount of total phenolic compounds and antioxidant characteristics including DPPH inhibition percentage, total antioxidant capacity and FRAP of the produced samples were equal to 79.18 and 7.27 mg/g, respectively. The dry weight was 89.57%, 4.78% and 28.33%, which is very similar to the results related to the optimal conditions predicted by the response surface method.

## 4- General conclusion

The results of this research showed that with increasing the drying time and temperature, the weight loss and phenolic compounds of the whole mint leaf increased and the time **dry**More influence on**The changes of these two parameters were compared to the drying temperature.** The trend of changes in the total phenolic compounds of the samples with drying time was similar to the weight loss of the samples, but with the increase in the drying temperature at the beginning of the process, the amount of total phenolic compounds of the samples increased. The DPPH radical scavenging ability of the samples decreased with increasing drying time (up to 176 minutes) and then increased with increasing drying time. The results showed that applying drying temperatures up to 50°C increased DPPH inhibition and higher drying temperatures led to a decrease in DPPH radical inhibition ability of the samples. Increasing the drying time and temperature decreased the antioxidant capacity and reductive activity of the samples, and the slope of changes in the reductive power and antioxidant capacity of the samples with changes in drying time is more severe than changes in drying temperature. The best conditions for hot air drying of mint leaves include the use of a temperature of 59.91 degrees Celsius and a drying time of 52 minutes, and by applying the optimal conditions, the amount of weight loss (moisture loss), total phenolic compounds, and antioxidant properties including the percentage of DPPH inhibition , the total antioxidant capacity and FRAP of dry mint produced are equal to 69.98%, 6.90 mg/g dry weight, 89.68%, 4.52 and 29.66, respectively, and the desirability of these optimal conditions is 0.746.

**Table 2** Central composite design, Actual levels of independent variables and different quality attributes (response) of hot oven dried mint leaves

| Independent variables | | | Actual dependent variable (Response) | | | | |
|---|---|---|---|---|---|---|---|
| Treatment number | Drying Temperature ($X_1$) ($^0$C) | Drying Time ($X_2$) (minute) | water loss (%) | Total phenolic compounds (mg/g) | DPPH (%) | Total antioxidant Capacity (g/100g) | FRAP (ppm/g ) |
| 1 | 50 | 300 | 51.56 | 1.38 | 94.35 | 2.87 | 18.6 |
| 2 | 50 | 52 | 23.48 | 0.85 | 93.04 | 3.99 | 31.94 |
| 3 | 50 | 176 | 78.32 | 14.02 | 90.11 | 5.17 | 29.45 |
| 4 | 60 | 176 | 81.70 | 8.18 | 87.32 | 3.56 | 17.00 |
| 5 | 60 | 300 | 46.18 | 0.52 | 88.48 | 3.71 | 26.07 |
| 6 | 50 | 176 | 80.21 | 12.39 | 91.96 | 4.88 | 25.49 |
| 7 | 40 | 176 | 77.55 | 7.99 | 89.57 | 4.74 | 31.17 |
| 8 | 60 | 52 | 79.18 | 7.27 | 89.57 | 4.78 | 28.33 |
| 9 | 50 | 176 | 78.98 | 9.21 | 90.36 | 4.82 | 30.73 |
| 10 | 40 | 52 | 78.57 | 8.16 | 90.52 | 4.78 | 28.93 |
| 11 | 40 | 300 | 79.57 | 14.64 | 89.02 | 4.28 | 14.39 |
| 12 | 50 | 176 | 84.73 | 15.12 | 86.52 | 5.24 | 23.51 |
| 13 | 50 | 176 | 51.03 | 0.42 | 82.93 | 3.80 | 21.22 |



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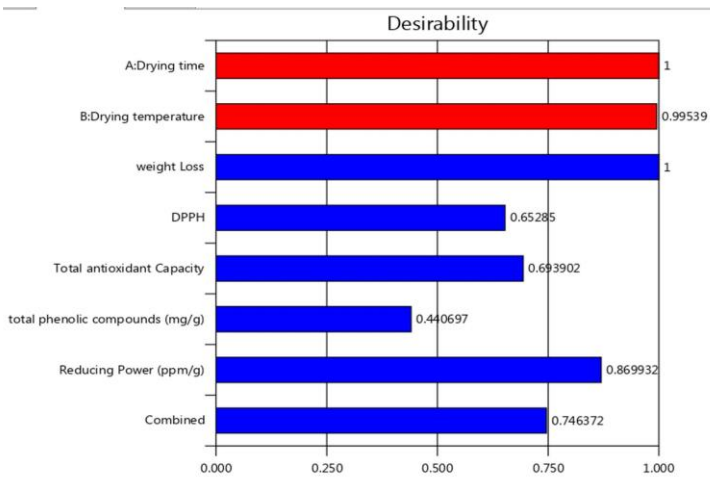


**Fig 6** The optimum conditions and desirability graph for hot oven drying process of mint leaves

The results of the validation of the optimal conditions showed that by applying the conditions obtained from the optimization, the quality characteristics of the produced product such as weight loss, the amount of total phenolic compounds and antioxidant characteristics including the percentage of DPPH inhibition, total antioxidant capacity and FRAP of the produced samples were equal to 18 respectively. 79/79, 7.27 mg/g of dry weight, 89.57%, 4.78 and 28.33 were obtained, which are very similar to the results related to the optimal conditions predicted by the response surface method.

## 5- Resources

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مقاله علمی_پژوهشی

# خشک کردن هوای داغ نعناع: مدلسازی تغییرات افت وزن، ترکیبات فنولی و خواص آنتی اکسیدانی با روش سطح پاسخ

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**در این تحقیق تأثیر دما و زمان خشک کردن هوای داغ بر میزان افت وزن، ترکیبات فنولی کل و ویژگی‌های آنتی اکسیدانی برگ نعناع بررسی و با روش سطح پاسخ بهینه سازی شد. نتایج نشان داد که با افزایش زمان و دمای خشک کردن میزان افت وزن و ترکیبات فنولی کل برگ نعناع افزایش یافت و زمان خشک کردن تأثیر بیشتری بر تغییرات این دو پارامتر در مقایسه با دمای خشک کردن داشت. ترکیبات فنولی کل نمونه‌ها با افزایش زمان خشک کردن افزایش یافت اما با افزایش دمای خشک کردن در ابتدای فرآیند میزان ترکیبات فنولی کل نمونه‌ها افزایش یافت. قابلیت مهار رادیکال فعال DPPH نمونه‌ها با افزایش زمان خشک کردن (تا ۱۷۶ دقیقه) کاهش و سپس با افزایش زمان خشک کردن افزایش یافت. نتایج نشان داد که اعمال دماهای خشک کردن تا ۵۰ درجه سانتی‌گراد باعث افزایش مهار DPPH شد و دماهای خشک کردن بالاتر منجر به کاهش قابلیت مهار رادیکال DPPH نمونه‌ها شد. افزایش زمان و دمای خشک کردن باعث کاهش ظرفیت آنتی اکسیدانی و فعالیت احیاء کنندگی آهن (FRAP) نمونه‌ها شد که شیب تغییرات FRAP و ظرفیت آنتی اکسیدانی نمونه‌ها با تغییرات زمان خشک کردن شدیدتر از تغییرات دمای خشک کردن می‌باشد. بهترین شرایط برای خشک کردن هوای داغ برگ‌های نعناع شامل استفاده از دمای ۵۹/۹۱ درجه سانتی‌گراد و زمان خشک کردن ۵۲ دقیقه می‌باشد و با اعمال شرایط بهینه میزان افت وزن، ترکیبات فنولی کل، درصد مهار رادیکال DPPH نعناع خشک تولیدی به ترتیب برابر ۶۹/۹۸٪، ۶/۹۰ میلی‌گرم بر گرم وزن خشک و ۸۹/۶۸٪ می‌باشد که مطلوبیت این شرایط بهینه ۰/۷۴۶ می‌باشد. نتایج اعتبار سنجی شرایط بهینه در شرایط واقعی بسیار به نتایج مربوط به شرایط بهینه پیش‌بینی شده با روش سطح پاسخ شبیه می‌باشد.**