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Full Research Paper

Evaluating the effects of blanching and microwave pre-treatments on variations in some selected physiological factors of artichoke leaves in fluidized bed dryer

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Abstract

In this study, temperatures (40, 50, and 60°C), air velocity (3, 5, and 7 m/s) and pre-treatment (without pre-treatment, blanching, and microwave) were used as variables for investigation of antioxidant activity of dried artichoke leaves. The results revealed that variations in temperature and air velocity of the drying chamber and different pre-treatments significantly affected the free radical scavenging level and total phenol content in this plant. Based on the results obtained, it can be concluded that by increasing the temperature and air velocity and using blanching and microwave pre-treatments, the free radical scavenging level and total phenol content increased. The maximum percentage of free radical scavenging was 72.08% at 60°C and an air velocity of 7 m/s in the drying state by using microwave pre-treatment. The maximum total phenol content was 3.55 mg/g of dry matter at 60°C and an air velocity of 7 m/s in the drying state by using microwave pre-treatment.

Keywords: artichoke, fluidized bed dryer, microwave, blanching

Introduction

Artichoke (*Cynara scolymus L.*) is a perennial and cold-sensitive plant with an average life span of 4 years which its height reaches 2 meters (Dermarderosian *et al.*, 2001). Artichoke has important application in food and pharmaceutical industries owing to having polyphenolic compounds such as caffeic acid and its derivatives such as chlorogenic acid, cynarine, cinnarizine, and other natural antioxidants. Based on studies conducted, artichokes and their chemical compounds have a strong source of polyphenolic compounds (Melillia *et al.*, 2007). Dry leaves of artichoke contain 9 to 11% water and 12 to 15% minerals, and they are rich in potassium and magnesium salts. Many phenol, flavonoid, and acidic compounds are found in artichoke (Graifenberg et al., 1995). Cynarine in the artichoke plant is also used in the treatment of Jaundice (Gebhardt, 1998). The preservation of agricultural products is the only method to reduce the loss of food and medicinal plants. It can be stated that drying is the best method for preserving food and agricultural products, such as medicinal plants. Its important role has been

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proven in many countries (Motevali *et al.*, 2011). Drying increases the time of maintenance of harvested products, improves the quality, improves the market conditions of the farmer to keep the prices fixed in the market, and reduces transportation costs due to the removal of water. In addition, using conventional methods of drying the plants can change the amount of chemical compounds (Soysal *et al.*, 2001). Among drying methods, fluidized bed dryer has many advantages, including a high intensity of drying, high thermal efficiency, uniformity in drying, precise control of temperature in the bed, and also the short time needed for drying due to the high rate of heat and mass transfer (Topuz *et al.*, 2004). In order to increase the efficiency and quality of dried products, it is recommended to use assistance methods, which increase the yield of drying process and also the quality of the dried product. One of these methods is using pre-treatment and type of preparation during the drying process (Gholami *et al.*, 2009). The results of many studies have shown that using pre-treatment such as ultrasound (mechanical pre-treatment), microwave (pulse pre-treatment), osmotic (chemical pre-treatment) and blanching (thermal pre-treatment) can cause high variations in quality of the dried product (Ayoubi *et al*., 2015). Microwave is one of the suitable pre-treatments to increases the diffusion coefficient of moisture in the product and reduces the drying time while maintaining the quality of the product *(Wang et al.*, 2004). Microwave causes oscillation in bipolar molecules, such as water molecules, and the oscillation of water molecules in foods causes friction between molecules and creates heat. As a result, all parts of the food uniformly absorb the microwave energy and heat and reduced the initial moisture content of the substance in a short time (Azarpazhooh *et al.*, 2011). On the other hand, using blanching as pre-treatment damages the membrane resistance of the cell at high temperature and this membrane layer is lost. The moisture can be transferred from the inner part of the product to the external surface. Its outflow speed increases, causing an increase in the product's internal mass transfer coefficient or penetration coefficient. Increasing the mass transfer reduces the drying time and reduces energy utilization during the drying process (Motevali *et al.*, 2017). To examine the effect of drying temperature on some quality characteristics of Artichoke (*Cynara scolymus* L.), GhasemNejad et al. (2013) studied five drying temperature of 40, 50, 60, 70 and 80°C. The results revealed that the maximum content of phenol was obtained at 60°C. The maximum content of flavonoid (5.15 mg/g), percentage of free radical scavenging (144.67%) and leaf caffeic acid (4.91 mg/kg) were obtained in samples dried in shadow. Among the temperature treatments with drying device, with increasing drying temperature, the antioxidant performance level was increased, indicating a change in simple phenolic compounds to antioxidant compounds (Ghasemnezhad *et al.*, 2013). By studying the dry temperatures of the oven (30, 40 and 50°C) on phenol content of leaves of plantain, Zubaira et al. (2011) found that drying temperature had a significant effect on phenolic content and total phenol decreased by increasing the temperature. It was also indicated that increasing the drying temperature in a plantain plant decreased the concentration of biological compounds (Zubair *et al.*, 2011). Examining the effect of different temperatures (55 and 75°C) on polyphenolic materials and percentage of free radical scavenging in two apricot cultivars, Madrau et al. (2009) found an increase in temperature reduced ascorbic acid, epicatechin, quercetin, rutin, chlorogenic and neo-chlorogenic. However, by increasing the temperature, antioxidant capacity increased (Madrau *et al.*, 2009).

In other similar studies on the different plants, the effect of temperature on the change in secondary composition was well reported (Parker, 1999; Rushing *et al.*, 2004; Shabby *et al*., 1995). Thus, this study aims to find a suitable drying method to maintain the maximum antioxidant and total phenol content of artichoke leaves in a fluidized bed dryer. To perform this process, temperature and velocity of different air were tested. The effect of using blanching and microwave pre-treatments on the

antioxidant and phenolic properties of artichoke leaves was also examined.

Materials and methods

Sample preparation

The newly-harvested leaves of the artichoke were prepared from Gorgan Medicinal Plants agro-Industry Company and kept in a laboratory fridge at 3°C. Then, 20 g of leaves were divided into smaller pieces and used for drying. A Laboratory fluidized bed dryer manufactured in the Bio System Mechanics Engineering Department of Gorgan University of Agricultural Sciences and Natural Resources was used (Figure 1).

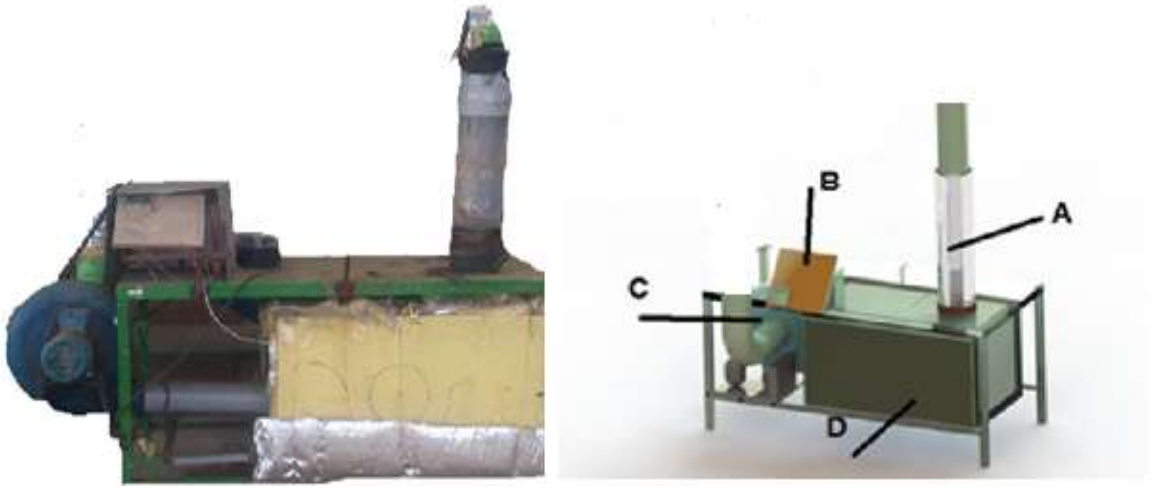

Fig. 1. Fluidized bed dryer and its components: A- Fluidizing chamber B- heater control C- fan D- heaters chamber

Method of testing

Drying of Artichoke leaves was performed in three states include: without pre-treatment, using microwave pre-treatment, and blanching pre-treatment. To apply blanching pre-treatment and given the sensitivity of the medicinal plant to contact with water; first, the water was heated to the boiling point so that the required steam for blanching operation was supplied. To determine the best level of applying blanching pre-treatment, samples were placed in the vicinity of steam at three different time of 30, 60, and 90 s and after completion of the pre-treatment process; the samples were placed on dry paper for two minutes to remove the moisture resulting from the blanching (steam) operation. The pre-treated samples were dried in a fluidized bed dryer and the percentage of free radical scavenging and phenol content of samples were determined after the drying process. The maximum level of effective compounds in blanching pre-treatment was obtained with a duration of 60 seconds.

Additionally, to apply microwave pre-treatment, the samples were placed in three different power levels of 90, 180, and 360 watts in the microwave chamber. To apply the same energy on the samples by microwave radiation, the microwave pre-treatment was applied on the samples at the power of 90 180, and 360 watts for 2.5, 5, and 1.25 minutes, respectively. The basis of the microwave condition in this experiment was the pre-tests that were performed. The pre-treated samples were transferred to the fluidized bed dryer environment and after the drying process, the phenol and antioxidant content were measured.

Considering the level of effective compounds, the pre-treatment of 90 Watts for 5 minutes was selected at the best experimental level. Thus, the samples were dried in three methods without using pre-treatment, blanching pre-treatment with steam for 60 seconds, and microwave pre-treatment with a power of 90 watts for 5 minutes at different temperatures of 40, 50 and 60°C and air flow velocity of 3, 5 and 7 m/s. A data logger (As Instrument Model 88598) with a precision of

0.1 m/s was used to measure the temperature. To measure the wind velocity of dryer, an anemometer (LUTRON, AM-2416) with a precision of 0.1 m/s was used. This dryer equipped with a temperature controller, operating automatically with a precision of 0.1°C. The weight of the samples was also measured using a Dj 2000A scale with a precision of 0.01 g.

Preparation of methanol extract

To measure total phenol and antioxidant activity, the samples were powdered using an electric mill, and one gram of each sample with 10 ml of 80% methanol (ratio of 1 to 10) was homogenized and samples were placed on a shaker device for 24 hours. The methanol extract of the sample was then filtered by filter paper and the extract was used to measure the considered biochemical characteristics.

Measuring the percentage of free radical scavenging of the extract

To calculate the percentage of free radical scavenging (ability to trap free radical), the Brand William method was used. The extraction method is the same as the methanol extraction method. The DPPH method was used to measure antioxidants. Accordingly, 1 ml methanol extract along with 1 ml of DPPH reagent (Dimethyl Sulfur Salicylic) of 1 mM (0.002 grams of DPPH reagent in 50 ml methanol) were added to the test tube. For the control sample, methanol of 80% was used instead of methanol extract and the remaining steps were similar to phenol measurement. The samples were stored in dark conditions for 30 minutes to inhibit the free radical to be applied by DPPH. After passing the required time, the absorption rate was measured by a spectrophotometer at 517 nm. For measurement, first, the device was calibrated with methanol of 80%. Then, the absorbance of control and other samples were recorded. Using the following formula the antioxidant activity was calculated (Brand-Williams *et al*., 1995).

$$\% \text{ DPPH} = \frac{Ac - As}{Ac} \times 100 \quad (1)$$

In which, A_C is the rate of control sample absorption and A_S is rate of absorption of each of the samples.

Measurement of total phenol content

To calculate the phenol content, the method used by Ragazi and Veronese (1973) was used. The amount of 20 µl of methanol extract was diluted with 100 µl of Folin Sioculteus reagent in 1.16 ml of deionized water. It was then placed in a dark place to rest and to apply the effect of the Folin-Sioculteus reagent for 6 min. After adding 300 µl of sodium carbonate, the solution was placed in a water bath at 40°C for 30 minutes. To prepare the control solution, only methanol of 80% was used and the rest of the steps were as described above. The control sample was used to calibrate the spectrophotometer. First, the spectrophotometer was calibrated using a control solution at 765 nm to measure the total phenol. Then, the methanol extract of the leaf was determined and the absorbance number was recorded at the given wavelength. Total phenol content was calculated in terms of gallic acid equivalent in 1g of dry plant leaf (Ragazzi *et al*., 1973).

Statistical Analysis

In this study, all experiments were performed in three replications and the results were analyzed using factorial experiments that can be analyzed using ANOVA analysis in a completely randomized design using SAS statistical software. The samples were tested at three temperatures (40, 50 and 60°C), air velocity (3, 5 and 7 m/s) for pre-treatments (without pre-treatment, blanching and microwave), an antioxidant and phenol content factors were measured.

Results and discussion

Table 1 presents analysis of variance results (ANOVA) for the effect of temperature, air velocity and their interaction.

The effect of different parameters on free radical scavenging

Figures 3, 4, and 5 show the level of free radical scavenging of artichoke leaf in different

states of experimental conditions (using blanching pre-treatment, using microwave pre-treatment, and without using pre-treatment).

The maximum level of this activity (72.08%) was obtained in the state of drying by using microwave pre-treatment at 60°C and air velocity of 7 m/s. The minimum anti-oxidant activity (19.36%) was obtained at the state of drying without using pre-treatment at 40°C and air velocity of 3 m/s. The results suggest that the antioxidant content increases with increasing temperature. With increasing temperature and faster absorption of moisture from the leaf surface, the intracellular vapor pressure increases and with the increasing pressure into the cellular cytoplasm, the cells are swollen and put pressure into the cell wall and increase the withdrawal of cellular contents from the cells (Wang *et al*., 2010; R. Wang *et al*., 2008).

Table1- Analysis of antioxidant and phenol content in different pre-treatment

		Antioxidant content		Phenol content	
		Microwave pre-treatment			
	DF	MS	F value	MS	F value
Temperature	2	1779.70	29.90**	0.215	4.36**
Air velocity	2	63.77	1.06ns	0.035	0.50ns
Temperature× Air velocity	4	598.03	9.93**	0.48	6.92**
Error			60.19		0.069
		Blanching pre-treatment			
Temperature	2	652.26	6.57**	5.76	88.65**
Air velocity	2	467.31	4.70*	0.084	1.31ns
Temperature× Air velocity	4	651.82	6.56**	1.12	17.22**
Error			99.33		0.065
		Without pre-treatment			
Temperature	2	299.41	1.86ns	1.072	14.01**
Air velocity	2	28.25	0.18ns	0.868	1.91ns
Temperature× Air velocity	4	871.95	5.41**	0.146	11.35**
Error			161.1		0.076

** Significant difference at the statistical level of 1%, * Significant difference at the statistical level of 5%, ns no significant difference

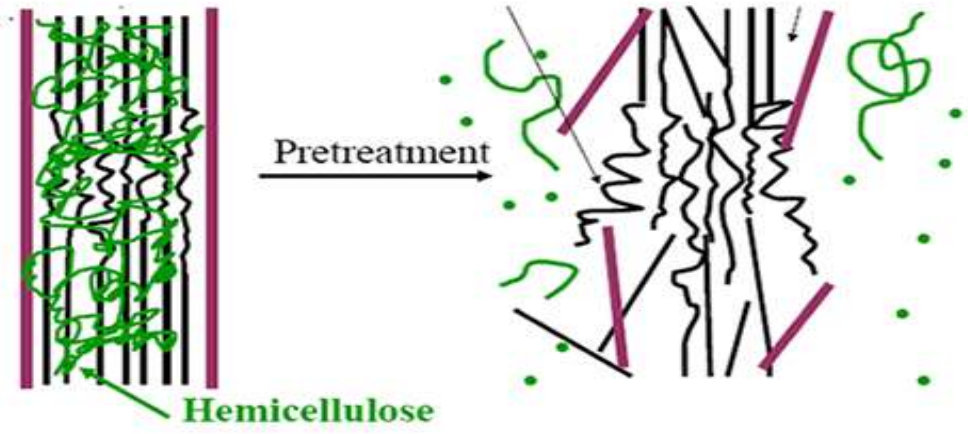

Fig. 2. The effect of using blanching pre-treatment

As shown in Figure 2, drying with blanching pre-treatment, destroys the cell wall and causes stress in the product texture. It also leads to porous products and a hard surface remains due to moisture withdrawal from the product. This increases the mass and moisture transfer from

the product. As the velocity of drying increases, the amount of extraction of free radical scavenging increases compared to the previous state.

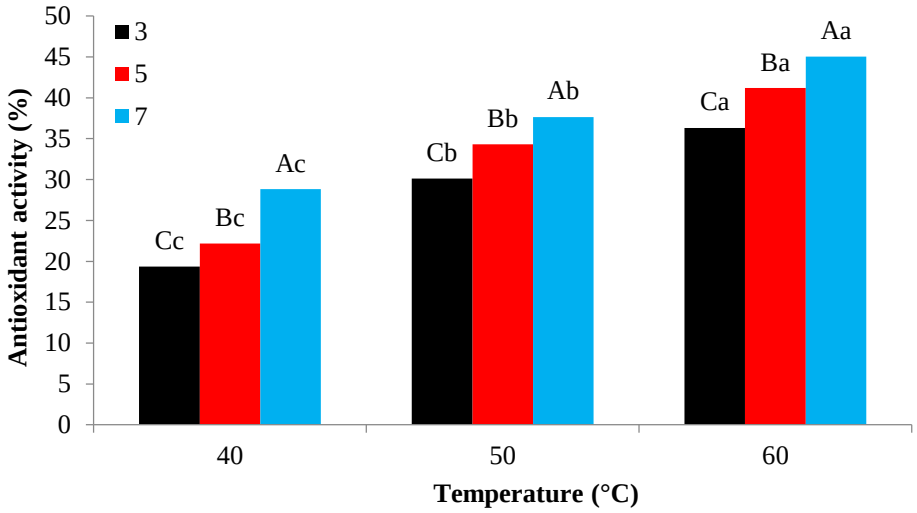

Fig. 3. The effect of temperature and air velocity on percentage of free radical scavengingin the state of drying without pre-treatment

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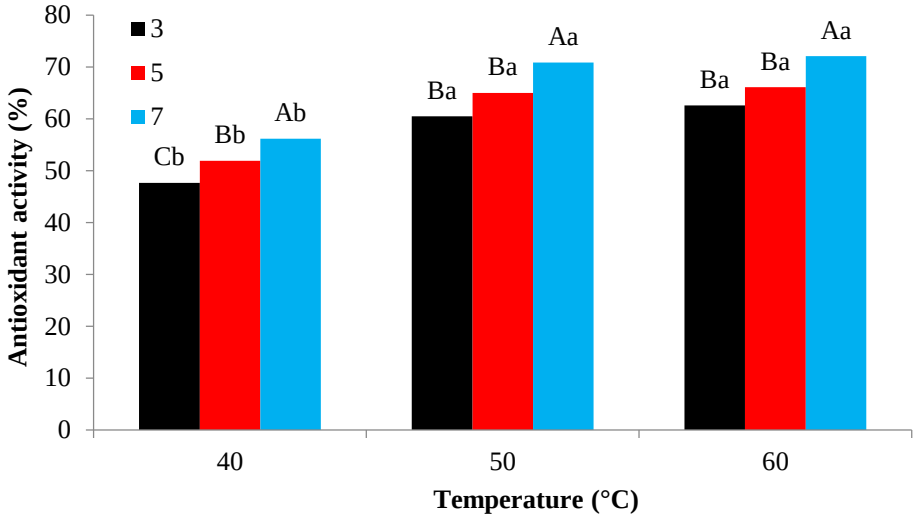

Fig. 4. The effect of temperature and air velocity on percentage of free radical scavengingin the state of drying with blanching pre-treatment

Big letters similar to no significant difference in a fixed Temperature and small letters similar to no significant difference in a fixed air velocity

These results are consistent with those of Madrau et al. (2009), who indicated that by increasing the temperature from 55 to 75°C, the apricot antioxidant capacity increases. The results also showed that blanching pre-treatment, compared to the control (drying without pre-treatment), decreased the drying time. These results are consistent with those of Heras-Ramírez et al. (2012), who examined the effect of blanching and drying temperature on phenol compounds and the free radical scavenging of apple in a cabinet dryer. Moreover, in the state of drying with microwave pre-treatment, the cell wall of the product is destroyed due to increase vapor pressure caused by applying microwave waves.

In such condition, the samples are swollen and try to return to their initial state. Their returning destructs the cell wall leading to the creation of more open pores. This creates a texture with lower resistance against moisture and mass transfer in the drying process, followed by reducing drying time and increasing the amount of extraction of free radical scavenging compared to the two previous pre-treatments. Our results are consistent with those of research conducted by Shamaei and EmamJome (2011) and Aslnejadi et al. (2015) in drying the mushroom layers

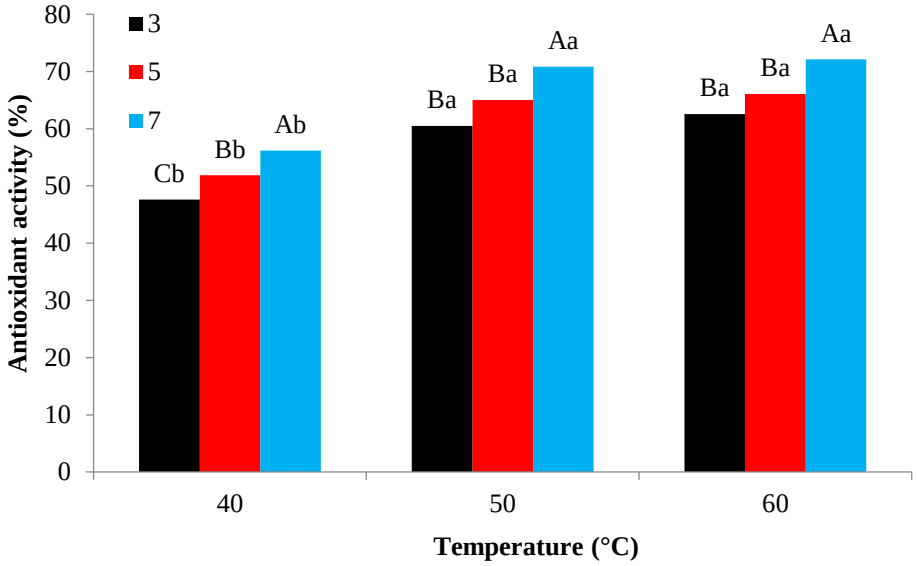

Fig. 5. The effect of temperature and air velocity on percentage of free radical scavengingin the state of drying with microwave pre-treatment

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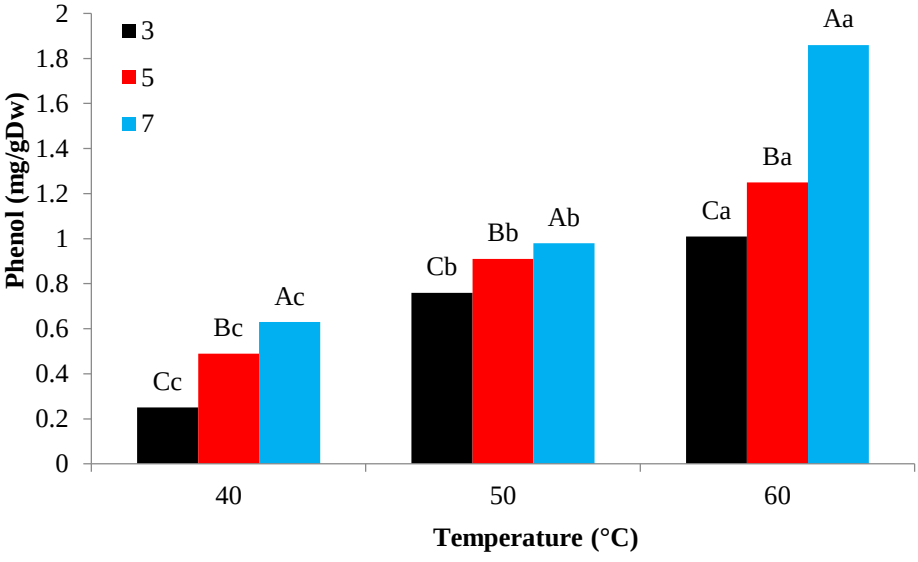

Fig. 6. The effect of temperature and air velocity on total phenol content in the state of drying without pre-treatment

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The effect of different parameters on total phenol content of leaf

the maximum and minimum phenol content were 3.55 and 0.25 mg/g dry matter at 60 and 40°C of air and 7 and 3 m/s of air velocity in the state of drying with microwave pre-treatment and without pre-treatment respectively. The results showed in Figures 6, 7 and 8. Increasing the temperature led to increase the phenol content of artichoke leaves. This finding was similar to GhasemNejad et al. (2014), on the effect of drying temperature on some of the qualitative characteristics of artichoke medicinal plant leaves. Their results revealed that the maximum phenol was obtained at a temperature of 60°C. It is also consistent with the research results conducted by Katsubeh et al. (2009), who investigated the effect of drying temperature on the free radical scavenging capacity and total phenol content in white berries.

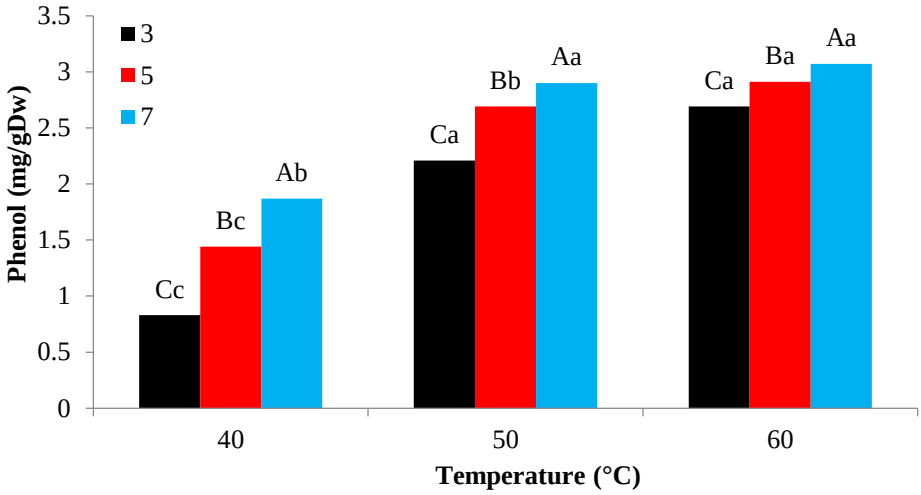

Fig. 7. The effect of temperature and air velocity on total phenol content in the state of drying with blanching pre-treatment

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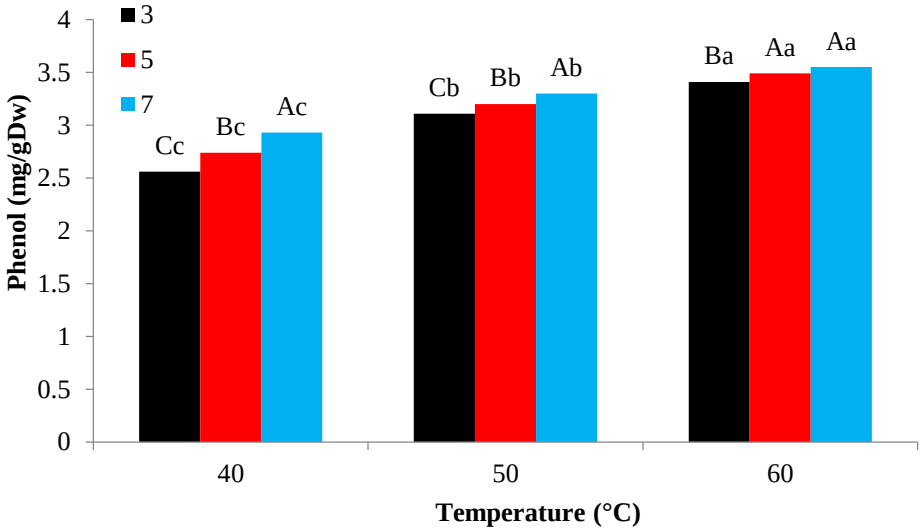

Fig. 8. The effect of temperature and air velocity on total phenol content in the state of drying with microwave pre-treatment

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Conclusion

The results revealed that the suitable method for drying artichoke medicinal plant leaves by using a fluidized bed dryer is the state of using microwave pre-treatment. Compared to the state of drying without pre-treatment, this method preserve the active ingredients significantly due to reduced drying time. According to the results, the best treatment for drying in terms of maximum quality of active components were 60°C and air velocity of 7 m/s and microwave pre-treatment. The lowest percentage of free radical scavenging and total phenol content were obtained at 40°C and an air velocity of 3 m/s in the drying state without using pre-treatment with19.36% and 0.25 mg/g of dry matter, respectively,

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جلد ۱۷، شماره ۶، بهمن- اسفند ۱۴۰۰، ص. ۸۳-۷۳

بررسی اثرات پیش تیمارهای بلانچینگ و مایکروویو در تغییرات بعضی از عوامل فیزیولوژیکی برگ گیاه کنگر فرنگی در خشک کن بستر سیال

محسن آزادبخت[1*]- بهاره اسحاقی[1]- علی متولی[2]-عظیم قاسم‌نژاد[3]

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چکیده

به‌منظور حفظ بیشترین میزان توانمندی آنتی‌اکسیدانی و ترکیبات موثر در این توانمندی از جمله فنل کل برگ کنگر فرنگی در یک خشک‌کن بستر سیال، اثرات دما، سرعت هوا و همچنین استفاده از پیش‌تیمارهای بلانچینگ و مایکروویو و مقایسه آن با حالت خشک شدن بدون پیش‌تیمار، در سه دمای ۴۰، ۵۰ و ۶۰ درجه سانتی‌گراد و سه سطح سرعت هوا ۳، ۵ و ۷ متر بر ثانیه مورد بررسی قرار گرفت. نتایج این تحقیق نشان داد که تغییرات دما و سرعت هوای محفظه خشک‌کن و روش‌های مختلف پیش تیمار تاثیر معنی‌داری بر میزان فعالیت آنتی‌اکسیدانی و فنل کل موجود در این گیاه داشت. بر اساس نتایج به‌دست آمده می‌توان نتیجه‌گیری کرد که با افزایش دما و سرعت هوا و استفاده از پیش‌تیمار بلانچینگ و مایکروویو مقدار درصد مهار رادیکال و میزان فنل کل افزایش می‌یابد. بیشترین درصد مهار رادیکال در دمای ۶۰ درجه سانتی‌گراد و سرعت هوای ۷ متر بر ثانیه در حالت خشک کردن و با استفاده از پیش‌تیمار مایکروویو مقدار (۷۲/۰۸٪) به‌دست آمد. همچنین بیشترین میزان فنل کل مقدار ۳/۵۵ میلی‌گرم بر گرم ماده خشک در دمای ۶۰ درجه سانتی‌گراد و سرعت هوای ۷ متر بر ثانیه در حالت خشک کردن استفاده از پیش‌تیمار مایکروویو به‌دست آمد.

واژه‌های کلیدی: کنگر فرنگی، خشک‌کن بستر سیال، مایکروویو، بلانچینگ.

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