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Research Article

Effects of pretreatments and drying methods on physico-chemical, sensory properties, mineral contents and bioactive compounds of garlic powders

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Abstract

This study was performed to evaluate the effects of pretreatments and drying methods on the quality attributes and bioactivities of dried garlic powders (DGP). Fresh garlic was soaked, steamed, soaked and steamed together or left untreated before being the hot air drying or sun drying. Results indicated that there were significant differences ($P<0.05$) between the chemical composition constituents and physico-chemical properties of garlic powder samples except lipid component and browning index, respectively. Also data of the statistical analysis performed on the sensory evaluation values of garlic powders showed that there were a little significant difference for the most evaluation determinants and overall acceptability. The results revealed that the sun dried garlic powders had higher values for the most parameters regarding chemical composition, physico-chemical, sensory properties. Data showed that the most mineral contents of sun dried garlic powders were least affected compared to the oven dried garlic powders. For the bioactive compounds, e.g. total polyphenols and antioxidants DPPH had higher levels with the sun dried garlic powders.

Keywords: Dried garlic powder, Pretreatments, Physico-chemical properties, Overall acceptability, Mineral contents, TPC, DPPH

INTRODUCTION

Garlic (*Allium sativum L.*) is a species of bulbous flowering plant in the genus Allium and it is the most important genus of the Alliaceae family, which contains more than 700 species distributed around the world.

Garlic is native to Central Asia, southeast of Iran, it has been used as a seasoning, with a history of several thousand years of human consumption and use in different regions of the world (Block, 2010; Tape et al., 2005), also used in culinary purposes and medical sciences since ancient times, and it is one of the oldest known cultivated plants as an integral component of the human diet has been mentioned in documents obtained by the ancient Egyptians, Greeks, Indians and Chinese. For example, Egyptian fed garlic to pyramid crews to boost their immunity thereby rendering safe from various maladies and improve their performance (Rivlin, 2001; Shooriabi, 2021). Globally, China is the largest producer of garlic, with more than 74% of world production followed by India, Bangladesh, South Korea and Egypt (FAOSTAT, 2020).

The height of the garlic plant reaches 4 feet, but varies in different species. The product of it is a tuber or bulb that is composed of several small tubers called cloves. Each garlic tuber contains about 12 cloves. The nutrient components of garlic bulbs mainly contain 61% water, 30% carbohydrates, 2% protein, 1% fat, whereas ash content is between 0.6% to 1.0% and energy content is around 140 kcal/100 g (Sethi et al., 2014; Nidhish et al., 2014; Brewster, 2008). Garlic has a high content of non-volatile compounds with well-

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known medicinal and therapeutic characteristics, like amides, nitrogen oxides, phenolic compounds specifically; flavonoids, proteins, saponins and sapogenins (Lanzotti et al., 2014; Lu *et al.*, 2011), in addition to its content from antioxidants, minerals and vitamins (Rekowska & Skupie, 2009).

Garlic is of major importance because of its beneficial components using in nutrition and medicine, therefore it is used for disease prevention and treatment around the word, since it has an antioxidant properties, also can be used as anti-bacterial, anti-virus, anti-fungal, anti-cancer, anti-diabetic and anti-inflammatory (Rizwani Ghazala & Shareef, 2011; Kimura et al., 2017). The biologically active substances in garlic are divided into two groups: (a) sulfur substances (b) sulfur-free active substances (Ma et al., 2011), Organosulfur compounds in garlic are thought to be responsible for its flavor and aroma, also its potential health benefits (Block, 1985), as well as garlic is a source of prebiotic fiber, which makes it useful for dental health and proper digestion (Migliorati & Madrid, 2007).

Drying is one of the most widely used methods of preserving vegetables and fruits because it leads to extend shelf life, product diversity and substantial size reduction of dried fruits and vegetables, this can be further extended improvements in product quality and process applications (Akpinar et al., 2003). The methods of drying limit the growth and a toxin produced by microorganisms, also improves quality of the product in terms of color, texture and flavor (Bondre et al., 2017).

Pandey & Bhonde (2003) reported that the garlic is consumed throughout the year in one or other preparations. Being a highly perishable crop, its storage is a serious problem. In India garlic is harvested in the month of March-April and stored throughout the year. Due to the fluctuations in daily environmental conditions, it is very difficult to maintain the quality and quantity of garlic during storage period. For these reasons, there is inadequate availability of garlic bulbs in the market as compared to demand. Thus, garlic should made available in different forms (dehydrated cloves, garlic paste, minimally processed garlic, dehydrated powder) etc. Garlic powder has chemical properties similar to those of fresh; powder of it is widely used in the flavor industry because of its stability in flavor, aroma, color and satisfactory in rehydration properties (Singh et al., 2014).

New drying techniques such as hot air drying have been developed due to economic and hygienic considerations (Motevali et al., 2010). Hot air drying of food has advantages, like controlling product quality, achieving hygienic conditions and reducing product loss (Corzo et al., 2008). Open sun drying is a simple and the seasoned drying method that does not require many costs, requires less technology and a familiar food preservation method and reducing the moisture content of most agricultural commodities, it is considered the most widespread to preserve the agricultural products in developing countries (El-Sebaii & Shalaby, 2012; Durance & Wang, 2002). The aim of the present study is to select a drying method and its pretreatments that achieving the quality characteristics of the obtained garlic powder.

MATERIALS AND METHODS

Garlic material

The garlic used in this study was purchased from the El-Baroudia Market, Fayoum, Egypt, which was the harvested in the month of March-April, season 2021-2022 .The moisture content of fresh garlic slices was 66.54%.

Drying of garlic

Fresh garlic bulbs selected by considering on the basis the absence of damage or infections, then cleaned, peeling, cut into slices with the uniformity of size.

The pretreatments were carried out as follows: T1, T5=control (untreated), T2, T6=soaking in citric acid solution 0.5% for 30 min., T3, T7=blanching by steam for 3 min., T4, T8=steaming and soaking together as previously.

After that the garlic slices were dried using two methods by the following; the treatments of garlic were placed on trays of stainless steel, then dried by using an oven drying (A) at 55ºC ± 2 until the weight is constant. Other garlic treatments were exposed to open sun drying (B) at ambient temperature with average 30 ± 5ºC and relative humidity at 40% ± 5 during the day and for 5 days (11 hr., daily). Dried garlic slices were ground and sifted to pass through 80 mesh sieve to obtain dried garlic powder (DGP). The powders were stored packed in a refrigerator at 4ºC until analysis.

Chemical analysis

The moisture content of fresh garlic was estimated through the method described by (Akgun & Doymaz, 2005). Chemical composition components (moisture, protein, ash, lipids and crude fibers) of garlic powders were determined by AOAC (2012). Total carbohydrate contents were calculated by difference.

Physico-chemical properties

Powders of garlic were estimated the physico-chemical characteristics, namely; yield, browning index and swelling index as follows. The percent of garlic powders yield was estimated according to Negi (2003). For the browning index values carried out through a five g of garlic powder sample was determined as optical density (OD) using a digital spectrophotometer at 440 nm (Srivastava & Kumar, 2000). Swelling index of DGP samples was determined according to (Nollet & Leo, 2004).

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Sensory evaluation

Sensory evaluation of dried garlic powders was done with 9 trained panelists of Food Science and Technology Department, Faculty of Agriculture, Fayoum University, Fayoum, Egypt. The quality attributes of DGP included items; appearance, color, taste, odor, texture and overall acceptability. The evaluation was carried out according to the method described by (Johanson, 1990). The score values were statistically analyzed by L.S.D. value.

Mineral contents

Calcium content of garlic powder samples was estimated by Inductively Coupled Plasma, APHA. (2005). Other minerals (Mg, K, Fe, Mn and Zn) were determined by using an atomic absorption spectrometer (Perkin-Elmer, 1982), these analyzes were estimated in the Environmental and Food Pollutants Laboratory, Faculty of Agriculture, Fayoum University, Egypt.

Determination of bioactive compounds

The total phenolic compounds of dried garlic powders were determined through Folin–Ciocalteu reagent according to (Singleton & Rossi, 1965), as described by (Woldegiorgis et al., 2014). The antioxidant capacity of DGP was estimated by radical scavenging ability using stable DPPH radical according to the method described with Akowuah et al. (2005). In Brief, 200 µL of methanolic solution of tested samples (50, 100, 150 and 200 µg/mL) was added to 2 mL of methanolic solution of DPPH radical and complete the total volume to 3mL with methanol. The absorbance was measured at 515 nm against methanol as blank in an UV spectrophotometer after 30 min of incubation at 30°C in the dark. The percent inhibition of the tested samples was evaluated by comparison with a control (2 mL of DPPH solution and 1mL of methanol). Each sample was measured in triplicate, and an average value was calculated. Antioxidant activity was expressed as a percentage of inhibition compared to control as follows:

% inhibition=[(A control–A sample)/A control]×100

Where A is the absorbance at 517 nm.

Data analysis

The collected data were statistically analyzed using analysis of variance (ANOVA) through used to the least significant differences LSD (at the 5 % level) according to (McClave & Benson,1991).

RESULTS AND DISCUSSION

The chemical composition of dried garlic powders

(Table 1 shows the effect of different pretreatments and drying methods on chemical composition of garlic powders. The results mentioned that there were significant differences ($P<0.05$) between all chemical composition constituents of DGP samples except lipid component. The moisture contents ranged from 7.23 to 8.50%, the sun dried garlic powder treated with steaming and soaking together (T8) has a higher value, whereas the oven dried garlic powder treated with soaked in citric acid (T2) recorded the lowest value. These results are in agreement with (Bisnoi et al., 2008; Abano et al., 2011).

For the protein contents found to be in the range 19.45 to 25.74%. The sun dried garlic treated with soaked in citric acid (T6) achieved the highest value, while the oven dried garlic powder treated with steaming and soaking together (T4) has a lower value. The sun-dried garlic powder had a higher protein content compared to other drying methods because of it's a low ambient temperature (25-40 ºC) (Maray et al., 2018). Steaming reduced the protein content; the reason for this decrease is due to the presence of water soluble- medium molecular weight protein and amino acids, which may have been affected during the evaporation process (Unlusayin et al., 2010).

The ash contents of garlic powders ranged between 2.15 to 3.78%. Powders of T4, T5 showed the lowest and highest values, respectively. The decrease of ash content, especially in the pretreatments of blanching with steam may be due to minerals leaching out during the blanching process (Chandra & Samsher, 2006). These results are in agreement with those reported by Anju et al. (2010) they found that the ash content of dried garlic powder, which obtained from oven drying was 3.62%.

For the fat contents of DGP samples were between 0.34 to 0.63%. These results similar with (Mariam & Devi, 2016; Yusuf et al., 2018). Data indicated that crude fiber contents of garlic powder samples ranged from 3.76 to 5.93%. Powders of T3 and T5 showed the lowest and highest values, respectively. Steaming using high temperature leads to rupture of the cell wall, thus resulted in a decrease in fiber contents of powders (Ekanem & Ubengama, 2002).

The total carbohydrate contents of DGP varied from 56.58 to 66.17%. The highest value obtained by the oven dried garlic powder treated with steaming (T3), while the sun dried garlic powder treated with soaked in citric acid (T6) scored the lowest value. These results similar to those reported by (Eshak & Nareman, 2018; Yusuf et al., 2018).

Physico-chemical properties of DGP

Results are shown in **(Table 2)** refers to the physico-chemical properties of DGP included items; yield, browning index and swelling index. Yield garlic powders ranged between 30.0 to 33.0%, the highest value obtained with the sun dried garlic powder treated by soaked in citric acid (T6), whereas the

Table 1. Chemical composition of garlic powders.

Treatments and drying methods		Components (%)					
		Moisture	Protein	Ash	Lipids	Fibers	Total carbohydrates
A	T1	7.60cd	21.94b	3.69a	0.52a	5.76ab	60.49b
	T2	7.23d	22.61b	3.43a	0.50a	5.52ab	60.71b
	T3	7.71bcd	19.45c	2.57b	0.34a	3.76c	66.17a
	T4	7.87abcd	19.86c	2.15b	0.48a	4.48abc	65.16a
B	T5	8.00abc	24.83a	3.78a	0.63a	5.93a	56.83c
	T6	7.84bcd	25.74a	3.54a	0.59a	5.71ab	56.58c
	T7	8.25ab	22.33b	2.68b	0.40a	4.19bc	62.15b
	T8	8.50a	22.77b	2.31b	0.55a	5.17abc	60.70b

Values in the same column with different superscript letters indicate presence a significant differences (P<0.05).

Table 2. Physico-chemical characteristics of garlic powders.

Treatments and drying methods		Items		
		Yield (%)	Browning index *OD	Swelling index (ml/g)
A	T1	31.5c	0.115a	0.46a
	T2	32.0bc	0.106a	0.43a
	T3	31.2c	0.082a	0.11c
	T4	30.0d	0.101a	0.51bc
B	T5	32.6ab	0.127a	0.32abc
	T6	33.0a	0.112a	0.34abc
	T7	32.5ab	0.093a	0.15bc
	T8	31.8bc	0.109a	0.57ab

Values in the same column with different superscript letters indicate presence a significant differences (P<0.05).
***OD:** Optical density.*

lowest value obtained by the oven garlic powder treated with steaming and soaking together (T4). These results are paralleled with Chang & Kimc (2011) they found that blanching garlic by boiling reduces the yield of powder compared to other treatments.

For the browning index values of garlic powders were between 0.082 to 0.127 (OD), but no significant differences between all powders samples. A decrease in the values of browning index were observed with blanching by steam treatments (T3 and T7), irrespective of drying methods. These results are agreed with Bisnoi et al. (2008) they found that the sun dried garlic powders had a higher values of browning index compared to powders were dried by other methods.

Results indicated that the swelling index of garlic powders ranged from 0.11 to 0.57 ml/g. T4 and T8 powders exhibited significantly higher values, while the lowest values were obtained by T3 and T7. From the results, it was a low significant difference between the most samples. In this regard, The swelling capacity of dry flour samples depends on the temperature, available water, the size of the particles, species of starch and the extent of the starch damage due to thermal and mechanical processes and other proteins and carbohydrates (Yellavila et al., 2015; Suresh & Samsher, 2013). Proteins and carbohydrates were associated to water molecules by forming hydrophilic bonds. The high swelling forces of the drying samples can be attributed to the relatively high carbohydrate and crude fiber contents which have ability to absorb water molecules and swell. The presence of strong, attractive forces within the structures of these molecules causes swelling as water is absorbed, which leads to an increase in the viscosity of the medium (Dossou et al., 2014). In a parallel direction (Dunkwal et al., 2007; Maray et al., 2018) they concluded that the mushroom samples soaked in citric acid solution and dried showed better physicochemical properties.

Sensory evaluation of powders

The organoleptic properties of garlic powders are shown in **(Table 3).** Results indicated that a significant differences (P<0.05) between most of the determinants evaluated with regard to appearance, odor, color, texture and overall acceptability. Data showed that the sun dried garlic powder has a higher score of overall acceptability. Soaking in 0.2% citric acid before drying, improved the color, odor, texture and properties of reconstitution (Pruthi et al., 1978).These results are similar with Eshak,Nareman (2018) and

Maray et al. (2018) who reported that the dried mushroom powders obtained by sun drying were the best in the sensory attributes compared to other drying method.

Mineral composition of garlic powders

The mineral contents of Ca, Mg, K, Fe, Mn and Zn of garlic powders were indicated in **(Table 4)**.The results showed that Ca content was between 13.07 to 26.28 mg/100g, the highest value achieved with the sun dried garlic powder (T5), while the lowest value recorded with the oven dried garlic powder treated with steaming and soaking together (T4). For Mg content ranged from 39.84 to 64.33 mg/100g, for K content ranged between 451.1 to 907.3 mg/100g, the same trend for the highest and the lowest values of Mg and K were T5 and T4 respectively. For Fe content varied from 4.70 to 8.67 mg/100g, the highest value obtained with T6, while the lowest value obtained with T4. A significant differences ($P<0.05$) between of the most DGP samples for mineral contents of Ca, Mg, K and Fe. On the other hand, no significant differences of Mn and Zn values, the contents ranged between 0.62 to 0.94 and 1.66 to 2.45 mg/100g of Mn and Zn, respectively. These data are in agreements with Kang (2016) and Eshak, Nareman (2018).

Total Phenolic compounds of DGP

The values of total phenolic compounds (TPC) of garlic powders are shown in **(Figure 1)**. Polyphenol contents varied from 38.0 to 124.0 expressed as mg gallic acid/100 g d.m. The chart showed that the highest value of TPC content achieved by the sun dried garlic powder (T5), while the oven dried garlic powder treated with steaming (T3) has a lower value of TPC. Also, there are significant differences between the most garlic powder samples for TPC values. These results are similar with the studying obtained by Chang & Kim (2011) they found that the oven dried untreated garlic powder scored the highest value of total phenolic compounds compared to other pretreatments Rababah et al. (2015) found that TPC values of dried species had higher amounts using the sun drying compared to the oven drying method.

Antioxidant activity of garlic powders

Figure 2 shows the antioxidant activity of garlic powder samples, which carried out based on estimated the radical scavenging ability through DPPH levels (2, 2-diphenyl-1-picrylhydrazyl). Percentage of DPPH radical scavenging capacity of dried garlic samples were in the range from 48.84 to 67.11%. From the results shown in the chart, there are a little significant difference between all garlic powder samples. The highest levels of DPPH activities obtained with the sun dried garlic powders (T5 and T6), while the oven dried garlic powders (T3 and T4) scored the lowest levels. These results are paralleled with Inchuen et al. (2010) they reported an improvement in the antioxidant activity of red curry powder obtained by drying process, Oboh & Akindahunsi (2004) found that the sun drying causes

Table 3. Sensory evaluation of garlic powders.

Treatments and drying methods		Appearance(20)	Odor(20)	Color(20)	Texture(20)	Overall acceptability
A	T1	17.14abcd	14.86e	16.68b	17.29bc	66.14bc
	T2	16.00cd	18.00a	14.80c	18.00ab	66.85b
	T3	17.41ab	16.00cde	17.45b	16.70cd	67.29b
	T4	15.85d	15.29de	15.34c	16.15d	63.00d
B	T5	17.18abc	16.20cd	16.90b	16.87cd	66.91b
	T6	15.28d	17.43ab	15.00c	16.55cd	64.28cd
	T7	18.40a	16.35bcd	18.71a	18.27a	71.15a
	T8	16.57bcd	16.86abc	17.14b	16.92cd	67.13b
LSD at 5%		1.3	1.2	1.0	0.9	2.2

Values in the same column with different superscript letters indicate presence a significant differences (P<0.05).

Table 4. Mineral contents of dried garlic powders.

Treatments anddrying methods		Mineral contents (mg/100g)					
		Ca	Mg	Fe	K	Mn	Zn
A	T1	19.16b	58.17ab	4.98bc	661.2cd	0.83a	2.05a
	T2	17.19b	57.08ab	5.16bc	593.4d	0.90a	2.30a
	T3	16.67b	44.67bc	6.69bc	575.2d	0.79a	1.93a
	T4	13.07c	39.84c	4.70c	451.1e	0.73a	1.66a
B	T5	26.28a	64.33a	6.12bc	907.3a	0.65a	2.14a
	T6	24.09a	63.50a	8.67a	830.5ab	0.94a	2.45a
	T7	23.54a	49.83abc	8.02a	811.5b	0.67a	2.05a
	T8	19.83b	45.17bc	6.40bc	684.2c	0.62a	1.76a

Values in the same column with different superscript letters indicate presence a significant differences (P<0.05).

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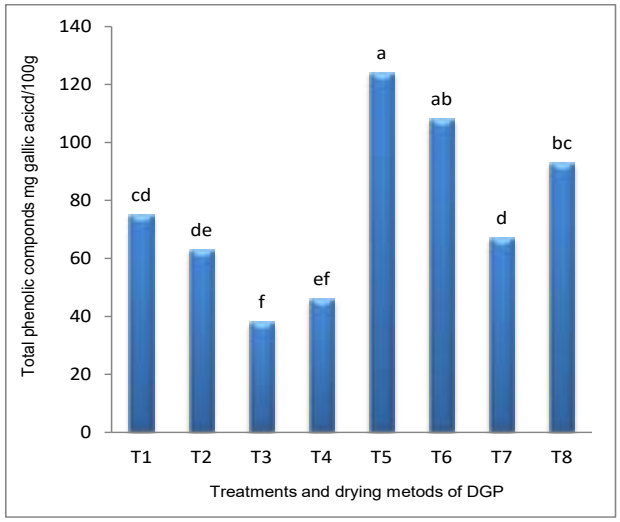

Figure 1: The total phenolic compound values of garlic powders.

Values on top of columns with different superscript letters indicate presence a significant differences (P<0.05).

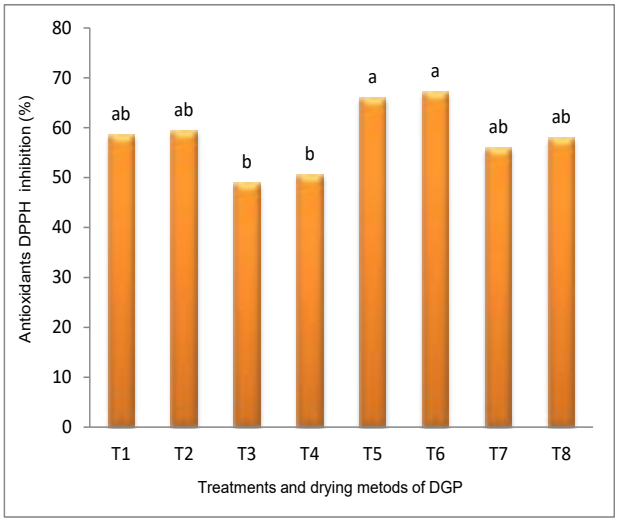

Figure 2: Antioxidant activity as (DPPH) levels of garlic powders.

Values on top of columns with different superscript letters indicate presence a significant differences (P<0.05).

significant increases in the antioxidant properties of green leafy vegetables. Rababah et al. (2015) found that DPPH levels of dried spices were the highest using the sun drying compared to the oven drying method.

CONCLUSION

In the current research, there are some points that can be summarized as follows: fresh garlic done on it pretreatments and using two drying methods (hot air drying and sun drying) to obtain the best dried garlic powder (DGP). It has been noticed that the sun dried garlic powders had a higher values for the most parameters that have been studied, namely; chemical composition, physico-chemical characteristics, sensory properties, mineral contents and finally bioactive compounds, like the total polyphenols and antioxidants (DPPH radical scavenging activities).

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