



Variation in Chemicals and Growth Parameters of Taşköprü Garlic

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ABSTRACT

Main goals of the present study were (1) to initially investigate the nutrient contents and bioactive compounds in the bulb and cloves of garlic, and (2) to study the growth parameter after planting. Garlic bulbs were firstly separated into three categories as pickled, big and small, while the big garlic cloves were also classified into three categories as big, small and central. Secondly, the garlic samples were analyzed before planting for their element profile, proline, soluble protein, free amino acid, β -carotene, lycopene, total phenolic, soluble sugars, SOD and α -amylase activities. Finally, the growth parameters were measured using the cultivated cloves and the pickled bulbs. According to the result, the highest soluble protein, N, phenolic, lycopene and α amylase activity (97.06 mg, 2.58%, 971 mg, 0.368 mg and 38.13 EU, respectively) were recorded in the biggest cloves. The highest proline, amino acid, glucose content (93.84 μ mol, 23.54 mg, 230.89 mg, respectively) and K, P, S, Mg, Mn, Fe and Zn (21940 ppm, 7577 ppm, 12200 ppm, 504 ppm, 38.1ppm, 377.7ppm and 44.5 ppm, respectively) were found in the pickled bulb. The maximum level of β -carotene (0.282 mg), Ca, Cl and Sr (11260ppm, 818.7ppm and 47.9 ppm) were determined in the small bulbs. Based on the growth parameters of seedlings, the highest value of shoot and root length (39.12 cm and 24.11 cm respectively), the fresh weight of shoot and root (5.29 g and 4.54 g respectively) and dry weight of shoot and root (1.70 g and 1.24 g respectively) were noted with the big cloves. The results of the current study have indicated that the pickled cloves have higher macro and micro nutrients, proline, amino acid and glucose, while the big cloves of garlic have higher proline, phenolic, N%, lycopene and amylase activity. It can be said that the big cloves showed good value for the five bioactive compounds, but the pickled exhibited good value for the macro and micro element and glucose.

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Introduction

Garlic (*Allium sativum* L.) contains many bioactive substances, mainly organ osulphur derivatives (allicin, alliin and allyl sulfides), flavonoids and isoflavonoids. In addition, garlic is very rich in various compounds such as carbohydrates, nitrogenous compounds, minerals (especially K, P and Se), vitamins, polyphenols and carotenoids (Chung, 2006; Asdaq and Inamdar, 2010). It has been consumed in the kitchen as raw and cooked because of its high nutrient value throughout the world (Azzini et al., 2014). However, it has been used in the treatment and preventing of several diseases for many years due to its high antioxidant capacity (Qidwai and Ashfaq, 2013). Garlic can be propagated vegetatively by sowing the cloves as well as sexual. Vegetative reproduction is preferred for cultivation purposes because it does not produce true seed. Therefore, researchers have reported that the genetic multiplication level is very low in

vegetative grown garlic (Jenderek and Zewdie, 2005). The growth period of garlic include clove sprouting, shoot growth, bulb growth and maturation. The mature, dry garlic bulb is a storage structure particularly well adapted to vegetative reproduction. There are some 10 to 20 cloves in average bulb as big, small and central teeth. Some authors have stated that the larger outer cloves produce the best garlic, higher emergence, heavier clove and bulb with larger clove (Kotagariwar et al., 1997; Nasir et al, 2017). And also, the larger and heavy cloves are able to more uniform bulbs than smaller and light types (Del Pozo and González, 2005). Growth and development, bulb quality, nutrient value and clove sprouting and decaying of garlic have been reported to be associated with environmental conditions as well as clove size (Bhandari et al., 2012). Several workers have reported that techniques applied during growth and development in field, pre- and post-

harvest conditions, bulb/clove type and size may affect yield quantity and quality of bulbs or cloves as colour, taste, favour, weight, sprouting, decaying as a result of increased respiration (Castellanos et al., 2004; Hughes et al., 2006). Hence, there is a great requirement to standardize the size of garlic cloves used for storage time and cultivation bulbs in order to increase effective garlic production. And well-defined healthy clove will contribute to increase quality, yield and extending of shelf life. Taşköprü garlic is the most widely grown garlic clone in Turkey due to its high soluble solid content, strong flavour, and long storage capability without the necessity of cold, and known as white gold, is unique to the district with its smell and taste (Ipek et al., 2008). Several studies have shown the differences in chemical composition, nutritional value and importance of Taşköprü garlic (Haciseferoğulları et al., 2005; Turfan et al., 2016). There are many investigations on the antioxidant and antimicrobial effects, chemical compounds, and nutritional value of Taşköprü garlic depends on environmental factors, but limited studies were made about bulb size and clove types. Therefore, main aim of this current study was to investigate the effects of bulb size and clove types on mineral content, nitrogenous compound as proline, amino acid, soluble protein, beta carotene, soluble carbohydrates as sucrose, glucose and total soluble carbohydrate and also secondary metabolites as flavones and total phenolic in Taşköprü garlic.

Material and Methods

Sample Preparation

Garlic samples were taken from the local producers and were firstly classified into three categories as big, small and pickled. Secondly, the big garlic samples were separated into the cloves as big, small and central. Fresh weight, length and width of all garlic categories were noted. All measurements were carried out 15 times.

Growth Experiment of the Garlic Samples

The separated cloves as big, small and center and pickled bulbs were planted in some pots filled with mixture of peat and sand (1:1 rate). The big cloves and the pickled bulb were sown in the pots with a spacing of $4 \times 4.5 \text{ cm}^2$ accommodating 10 cloves per pot, while the small and the centre cloves were sown in the pots with a spacing of $3 \times 4 \text{ cm}^2$ accommodating 15 cloves in each pot. The larger cloves and pickled bulbs were planted at 2 cm soil depth, while the small and centre cloves were dibbled at 1 cm soil depth. All samples were planted into soil mixture so that the ends of the cloves and bulbs were visible on the soil surface (Vural et al., 2000). The planting of the samples was completely performed using randomized design (CRD) with three replications. The planted pots were placed in a garden. All samples were irrigated according to soil capacity at 3 to 5 days' interval. Germination of the garlic samples was measured as success of garlic tip appearance above soil surface. Seedlings were collected at 28 days after emergence of new leaves from the cloves. The seedlings were cleaned from the soil and washed with tap water and rinsed with distilled water. The seedlings were taken on dehydrated paper and the root and plant height and root and shoot length and dry weights were

determined. Measurements of fresh weight, dry weight, length of shoot and root in seedlings were carried out with seven weeks old plant. The length of the seedling was estimated as cm by measuring the area of the seedling from the root throat to the growth tip with a millimetre ruler, while the root length was determined by measuring the distance from the root throat to the end of the root. The fresh weight was weighed with digital scales with the accuracy of $\pm 0.01 \text{ g}$ of the above and below ground parts of the seedlings. Dry weight was measured by weighing the subsoil and subsoil sections at a temperature of 65°C for 24 hours with a digital scale.

Chemical Analysis

All samples were then dried in an oven at 60°C for 48 hours. The dried samples were powdered under the laboratory conditions and used in chemical analysis. Total soluble protein contents of garlic samples were analysed according to the method of Bradford (1976) using the Bio-RadR assay kit with bovine serum albumin as a calibration standard. For free amino acid content, the garlic samples (0.5 g) were boiled in 10 ml of 80% ethanol. The extract obtained was centrifuged at 800 g for 15 min. The supernatant was completed to 10 ml with 80% ethanol. Then, 1 ml of extract was transferred into test tube (25 ml) and 0.1 N NaOH was added using methyl red. A 1 ml of ninhydrin reagent was added and the mixture was boiled for 20 min. Afterwards, 5 ml of ninhydrin reagent was added and it was cooled. The mixture was completed to 25 ml with distilled water. The standard was prepared by glycine and the absorbance was read at 570 nm (Moore and Stein, 1948). The amount of proline was determined by the method of Bates et al. (1973). Total phenolic content (TPC) was determined using the Folin-Ciocalteu assay (Singleton et al., 1999). 1 g of the samples were diluted to 1 ml with methanol and extracted. A 2.5 ml Folin-Ciocalteu reagent (10%) was added to extract (0.5 ml) and mixed. Following, 2.5 ml of 7.5% saturated sodium carbonate solution was put into this mixture. The mixture was incubated at 45°C for 45 min in the dark and formation of blue colour of samples were observed. At the end of, absorbance of blue colour in the samples was measured at 765 nm. For total phenolic analysis, a calibration curve was obtained by using 5 different concentrations of gallic acid ranged from 0.007813 to 0.125 mg ml^{-1} as standard ($R^2=0.9993$).

The total phenolic content was calculated using regression equation of the curve obtained and the results were expressed as mg of gallic acid equivalents per g of dry samples. The α -amylase activity in the samples was measured according to Bernfeld (1955) method by 3,5-dinitro salicylic acid colour indicator and starch substrate of 1%, spectrophotometry at 540 nm. Determination of the total soluble carbohydrate was performed according to the Antron Method by spectrophotometry at 620 nm (McCready et al., 1950). Sucrose and glucose content was estimated according to the Antron Method by spectrophotometry at 620 nm for sucrose and at 630 nm for glucose (Handel, 1968). Bernfeld, P. (1955) Amylases, alpha and beta. Methods in enzymology I: 149-158.

For enzyme activity, nearly 0.5-gram sample was homogenized with 50 mM (pH 7.6) phosphate buffer solution (10 mL) ground in liquid nitrogen and containing 0.1 mM Na-EDTA. The homogenized samples were

centrifuged for 15 min at 15000 g and +4°C, and then the enzyme activities in the resulting supernatant were determined according to the methods of Cakmak (1994). Superoxide dismutase (SOD) activities were measured according to the methods under nitro blue tetrazolium chloride (NBT) light by O₂ reduction. β-carotene and lycopene content of the garlic samples were determined using methods given in Nagata and Yamashita (1992). Garlic samples were extracted with acetone-hexane (4:6) at once, then optical density of the supernatant at 663 nm, 645 nm, 505 nm and 453 nm were measured by spectrophotometer at the same time. The concentration of β-carotene (βc) and lycopene (L) in garlic sample extracts (in mg per 100 ml) were estimated spectrophotometrically using the following equations:

$$\beta c = 0.216 \times A_{663} - 1.22 \times A_{645} - 0.304 \times A_{505} + 0.452 \times A_{453} \quad (1)$$

$$L = -0.0458 \times A_{663} + 0.204 \times A_{645} + 0.372 \times A_{505} - 0.0806 \times A_{453} \quad (2)$$

Mineral Element Contents

The elemental analysis was performed by using energy dispersive X-ray fluorescence spectrometry (Spectro, Xepos, Ametek, Germany) (Carvalho et al., 2005). 2.0 g dried garlic samples were digested in solution of HNO₃. The solutions obtained after digestion were used for direct spectrophotometric analysis. Calibration was done using metal/mineral standard solutions. Content of the elements was expressed as mg kg⁻¹ dry weight.

Statistical Analysis

Analysis of variance (ANOVA) was applied for analysing the differences in the chemical composition of Taşkoprü garlic samples using the SPSS program ver. 11.0 for Windows. Following the results of ANOVAs, Tukey's

honestly significance difference (HSD) test ($\alpha = 0.05$) was used for testing differences between group means.

Results and Discussions

Variation in germination rates and growth parameter as fresh and dry weight and length of the shoot and root were measured in fully ripe seedling, and result are given in Table 1. According to the results, a significant difference was observed between all parameters ($P < 0.05$).

As seen in the Table 1, mean fresh weight of garlic bulbs ranged from 6.14 g to 32.07 g in bulb, while mean weight of the big garlic cloves ranged from 1.53 g to 3.83 g. The big garlic bulbs had the highest length (3.36 cm) and width (4 cm), while the pickled garlic bulbs had the lowest (2.78 cm and 2.35 cm, respectively). As for the cloves, mean length of the cloves ranged from 3.23 cm for the big cloves to 1.65 cm for the centre cloves, while mean width of the cloves ranged from 2.18 cm for the big cloves to 0.81 cm for the centre cloves. As shown in Table 1, the highest germination was obtained with the big clove as 96.67%, and the lowest germination was obtained with 75.56% with the central cloves (Table 1). On the other hand, the highest shoot and root length, fresh weight of shoot and root, and dry weight of shoot and root was obtained with the big cloves, while the lowest values of them was noted with the small and the centre cloves. The second highest values in seedlings were from the seedling originated from the pickled bulb (Table 1). Our findings regarding shoot/root length and weight were coincided with the results of similar studies. Kotagariwar et al. (1997), Castellanos et al. (2004) and Nasir et al. (2017) have stated that clove size is effective in the vegetative growth and development. The largest cloves or bulbs contain more reserve nutrients and induce growth rate in initial stage of the development.

Table 1. Mean fresh weight, length and width; length of shoot and root, fresh and dry weight of shoot and root; and emergence rate of garlic bulbs and cloves.

Size	Fresh weight (g)	Length (cm)	Width (cm)	Emergence rate (%)	Shoot length (cm)	
Clove	Big	3.83 ^c ±0.14	3.23 ^c ±0.09	2.18 ^c ±0.10	96.67 ^c ±0.34	39.12 ^d ±0.88
	Small	2.31 ^b ±0.12	2.88 ^b ±0.10	1.36 ^b ±0.04	82.22 ^b ±0.22	21.41 ^a ±0.76
	Centre	1.53 ^a ±0.05	1.65 ^a ±0.08	0.81 ^a ±0.04	75.56 ^a ±0.22	26.11 ^b ±0.66
Bulb	Pickled	6.14 ^d ±0.37	2.78 ^b ±0.08	2.35 ^c ±0.08	80 ^b ±0.37	29.62 ^c ±0.64
	Big	32.07 ^f ±0.09	3.36 ^c ±0.04	4.00 ^d ±0.04	-	-
	Small	16.30 ^e ±0.37	2.91 ^b ±0.08	3.98 ^d ±0.09	-	-
F	625.04	59.34	249.94	8.45	12.80	
Sig.	0.000	0.000	0.000	0.007	0.000	
Size	Root length (cm)	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry Weight (g)	
Clove	Big	24.11 ^d ±0.78	5.29 ^d ±0.36	4.54 ^d ±0.23	1.70 ^c ±0.11	1.24 ^d ±0.23
	Small	15.51 ^b ±0.89	1.26 ^b ±0.21	1.01 ^a ±0.11	0.34 ^a ±0.09	0.11 ^a ±0.02
	Centre	15.32 ^a ±1.35	0.83 ^a ±0.18	1.19 ^b ±0.24	0.21 ^a ±0.06	0.26 ^b ±0.08
Bulb	Pickled	19.31 ^c ±1.33	2.87 ^c ±0.38	2.07 ^c ±0.31	1.23 ^b ±0.21	0.47 ^c ±0.11
	Big	-	-	-	-	-
	Small	-	-	-	-	-
F	13.67	47.83	49.53	30.91	14.23	
Sig.	0.000	0.000	0.000	0.000	0.000	

^{a-f} Mean values with different superscript symbols along the columns are significantly ($P < 0.05$) different.

The chemical composition of bulbs and cloves were measured in fully ripe Taşköprü garlics to determine the effect of clove and bulb size on proline, total soluble protein, total free amino acid, total nitrogen (N%), α -amylase and SOD activities, total phenolic, β -caroten, lycopene, glucose, sucrose, total soluble carbohydrate, total carbon (C%) levels and mineral profile. According to the results, a significant difference was determined between the bulbs and the cloves ($P < 0.05$) (Table 2).

Vegetables are an important component of the human diet and considered to be a high source of nitrogen compounds such as proline, free amino acid, soluble protein and antioxidant enzymes as superoxide dismutase (SOD), catalase (CAT), guaiacol peroxidase (GPOX) and play an important role during nutrition, growth and development of plants (Caverzan et al., 2012; Liu, 2013). Some leafy vegetables have higher nitrogen compound accounting for 72-94% of the total nitrogen intake of humans (Gilchrist et al., 2010; Jones, 2014). According to the results, the highest total soluble protein content, 97.96 mg/g was determined in the big cloves, while the lowest total soluble protein content (70.61 mg/g) was noted in the big bulb samples (Table 2). As seen in Table 2, while the amount of proline ranged from 11.68 to 31.92 $\mu\text{mol/g}$ in the cloves, it ranged from 29.38 to 93.84 $\mu\text{mol/g}$ in the bulb samples. When we evaluated the total free amino acid of the bulbs and the cloves, the lowest amino acid level (7.75 mg/g) was obtained from the small size cloves; the highest amino acid was obtained from the pickling bulbs with 23.54 mg/g (Table 2). There were no significant differences in the total N (%) level between the cloves and the bulbs, and mean N content ranged from 2.10% to 2.58% (Table 2). The results of protein were similar with the studies of many researchers. Petropoulos et al. (2018) found that the amount of protein ranged 4.62 g/100 g to 7.45 g/100 g. Azoom et al. (2014) showed that the amount of soluble protein ranged from 1.37% and 3.78% in garlic genotypes. Khan et al. (2016) noted that garlic samples were rich in crude protein as 13.83%.

When the activity of superoxide dismutase (SOD) enzyme was considered, it was seen that the highest activity as 147.49 EU/mg was obtained from the pickled bulb while the lowest activity as 49.38 EU/mg was in the small bulb (Table 2). SOD activity results are consistent with other studies, Martin et al. (2016); Stajner et al. (2004) found that Alliaceae member, especially *Allium* genus had high antioxidant activity. Turfan et al. (2016) showed that the SOD values of the garlic were 23.35 EU/mg. Belhadj et al. (2015) investigated antioxidant and antimicrobial activities of *Allium sativum* L. leaves, bulbs and roots. Their result indicated that the highest SOD activity was highest level in garlic bulb (50 EU). However, leaf and roots had lower SOD activity (48 EU and 43 EU). In a study conducted by Alici and Arabacı (2016), activity of SOD was found to be 11.6 EU in *Rumex obtusifolius* L. Ran et al (2004) noted that, SOD activity was 21.02 EU in goose berry, 6.58 EU in grapes, 30.45 EU in orange and 6.91 EU in tomato. Alves et al. (2008) and Krishnamurthy et al. (2010) have stated that antioxidant enzyme such as SOD, CAT, POD and GPOX are abundant in fruits and vegetables and they are effective protecting of several diseases. It was reported that rising the intake of antioxidant enzyme rich foods may have helped

overcoming free radicals related health problems due to stabilizing or deactivating free radicals with enzymes (Sudipta et al., 2014). Circu and Aw (2010) and Le Quere et al. (2014) showed that liposomal antioxidants containing SOD had at least 40 times more activity in the cell treatment within two hours than the others.

When the activity of α -amylase activity was evaluated, it was seen that the amylase activity was influenced by the clove and bulb types. The highest activity of amylase was found with the big clove as 38.31 EU, but it was lowest with the small bulbs as 5.31 EU (Table 3). α -amylase are the most important enzymes which break starch into metabolizable soluble sugars that used during the initial seedling growth and development as energy sources (Bernfeld, 1991; McCarty, 1995). The findings of germination and growth parameters confirmed this result in the present study. Germination rate, shoot and root length, fresh weight of shoot and root and dry weight shoot and root were higher as amylase activity was higher in the big cloves (Table 1 and 3). And also, when activity of enzyme was lowered the germinated rate and growth parameters were reduced in the central, small cloves and pickled bulbs (Table 1 and 3). The researchers have stated that amylase can degrade starch molecules into sugars as glucose, fructose and sucrose and after that germination they are mobilized to the embryonic axes (Gupta, 2003; Agić et al., 2009). *Allium* species are rich in sugars such as glucose, sucrose, fructose and fructo-oligosaccharides (Koruri et al., 2014). Several researchers have reported that sugars have an important role in plant and the amount of them may change depends on genetic, age, organs competitiveness and environmental factors (Ciereszko, 2018). Sugar profile of the garlic cloves and bulbs for this present study was given in Table 3. Glucose level ranged from 180.38 to 230.89 mg/g. The amount of sucrose was highest in the smaller cloves (75.42 mg/g), whereas it was lowest (48.14 mg) in the central cloves (Table 3). Total soluble carbohydrate content of garlic segments varied between 82.63 and 100.33%, while total carbon level (C%) ranged from 37.55 to 43.55% (Table 3). Azoom et al. (2014) investigated total soluble sugar content in bulbs of eight varieties of onion, and found that total soluble sugar level ranged from 2.62 to 4.72%. Lisciani et al. (2017) analysed the amount of sugar variation in the four commonly consumed "Italian local landraces" and their result showed that fructan contents were to be the most representative component in all the garlic samples, comprising about 78% of the total carbohydrates, and varying from 45.8 to 54.4 g/100 g. And also the amount of total sugars ranged between 2.12 and 3.27 g/100 g with higher levels of sucrose.

Koruri et al. (2014) noted that the concentration (on dry weight basis) of inulin in natural prebiotic sources was 16.60% for garlic. Petropoulos et al. (2018) studied the chemical composition and quality (total soluble solids, dry matter content, nutritional value, mineral composition, organic acids, fatty acids content and free sugars content), and also bulb morphology of garlic. Their results showed that total soluble carbohydrate level of garlic genotypes changed between 23.13 and 36.03 g/100 g and also protein level of them ranged from 4.62 to 7.45 g/100g. Ritota et al. (2012) found that sucrose as the main carbohydrate in Italian garlics. Rekowski and Skupień (2009) observed

that total carbohydrate of bulb ranged from 16.15 to 18.00%, while it varied between 3.80 and 4.84% in green leaf sample. Khan et al. (2016) found that the amount of carbohydrates of garlic was 72.01%.

β -carotene and lycopene are belonging to a group of pigments molecules called carotenoids, which are abundantly present in part of plant tissue like fruits, leaf, root and seeds. They are known to be very efficient physical and chemical quenchers of reactive oxygen species. They have important role protecting several diseases such as cancer, heart disease, macular degeneration and ageing, with their highly reactive conjugated bounds and antioxidant properties (Fiedor and Burda, 2014). It was reported that the recommended dose for β -carotene for adults was 700 μ g for females and 900 μ g for males. The common dose for lycopene supplements was 2 to 30 mg daily (Story et al., 2010). In this present study, β -carotene level varied in garlic samples, the smaller bulb had the highest value (0.282 mg/g) compared to all samples, whereas the big clove had the lowest carotene (0.164 mg/g) (Table 2). As seen in the Table 1, the amount of lycopene was lowest (0.271 mg) in the central clove and 0.279 mg in the small bulb (Table 2). However, the big bulb and the big clove had the highest lycopene (0.382 and 0.368 mg/g, respectively) (Table 2). Many researchers have stated that vegetables and fruits are a source of carotenoids. Chandra-Hioe et al. (2017) studied some vegetables in order to determine the range of β -

carotene and found that the amount of β -carotene ranged from 1974 to 6604 μ g/100 g. Hanson et al. (2011) showed that the carotenoids contents varied depended on cultivar, stage of maturity, analysed part of the plants, environmental conditions, treatments of preharvest and postharvest, storage conditions and time and also seasonally. For example, flowering cabbage collected in dry season had higher β -carotene (96000 μ g/100 g) than those harvested in wet season. Tuan et al. (2011) showed that green leaf of garlic contained very high carotene (73.44 b μ g/g), but it was significantly lower in the bulbs (2.85 μ g/g). Azzini et al. (2014) found that β -carotene level ranged from 5.68 to 7.41 μ g/100 g and 6.36 to 7.46 μ g/100 g for two garlic variety bulbs.

Phenolic compounds synthesized by plants as secondary metabolites to function as a chemical defense against abiotic and biotic stress conditions (Kim et al., 2013; Beato et al., 2011). However, epidemiological studies have showed that high dietary intake of them is thought to be responsible for preventing of some chronic diseases (Rein et al., 2013; Sharma, 2014). Total phenolic content in the samples of garlic ranged from 7.06 to 9.1 μ g/g. and the highest value was seen in the big clove. The lowest value of phenolic was found in the big size bulb (Table 2). Garlic has been shown by different studied to be rich in phenolic compounds.

Table 2. Variation in total soluble protein, proline, free amino acid, nitrogen (N%), SOD activity and total phenolic content among different tissues of Taşköprü garlic.

Size	TSP	P	TFAC	N%	SOD	TP	
Clove	Big	97.06 ^f ±0.14	15.70 ^b ±0.07	21.81 ^d ±0.04	2.58 ^c ±0.041	40.87 ^a ±0.14	9.71 ^c ±0.14
	Small	88.72 ^d ±0.11	31.92 ^d ±0.11	7.75 ^a ±0.06	2.44 ^c ±0.006	47.78 ^b ±0.11	8.88 ^b ±0.11
	Central	77.60 ^b ±0.16	11.78 ^a ±0.14	12.67 ^b ±0.09	2.10 ^b ±0.010	53.43 ^c ±0.35	7.76 ^a ±0.16
Bulb	Pickled	93.35 ^e ±0.11	93.84 ^f ±0.11	23.54 ^e ±0.23	2.19 ^b ±0.010	65.57 ^e ±0.06	9.34 ^c ±0.11
	Big	70.61 ^a ±0.18	29.38 ^c ±0.15	15.20 ^c ±0.03	2.52 ^c ±0.008	74.48 ^f ±0.21	7.06 ^a ±0.18
	Small	80.34 ^c ±0.19	59.69 ^e ±0.26	14.71 ^c ±0.05	1.96 ^a ±0.068	62.45 ^d ±0.21	8.04 ^b ±0.19
F	4691.75	43144.71	2986.76	56.85	10556.43	4691.75	
Sig	0.000	0.000	0.000	0.000	0.000	0.000	

TSP: Total soluble protein mg/g, P: Proline μ mol/g, TFAC: Total free amino acid mg/g, SOD: SOD EU/mg protein, TP: Total phenolic mg/g, ^{a-f} Mean values with different superscript symbols along the columns are significantly (P<0.05) different.

Table 3 Variation in β -caroten, lycopene, α -amylase activity, glucose, sucrose, total soluble carbohydrate, total C (%) and H (%) content among different tissues of Taşköprü garlic.

Size	β -caroten mg/g	Lycopene mg/g	α -Amylase EU/mg protein	Glucose mg/g	
Clove	Big	0.164 ^a ±0.001	0.368 ^d ±0.002	38.31 ^e ±0.16e	190.26 ^b ±0.11
	Small	0.218 ^c ±0.003	0.306 ^c ±0.003	13.87 ^c ±0.20c	224.35 ^d ±0.17
	Central	0.226 ^d ±0.002	0.271 ^a ±0.003	7.70 ^a ±0.10b	180.38 ^a ±0.09
Bulb	Pickled	0.213 ^b ±0.002	0.285 ^c ±0.001	8.86 ^b ±0.07b	230.89 ^f ±0.20
	Big	0.217 ^c ±0.002	0.382 ^e ±0.004	17.47 ^d ±0.17d	212.77 ^e ±0.14
	Small	0.282 ^e ±0.003	0.279 ^b ±0.002	5.31 ^a ±0.11a	228.81 ^e ±0.12
F	283.75	336.92	10556.43	22441.2	
Sig	0.000	0.000	0.000	0.000	
Size	Sucrose mg/g	Total soluble carbohydrate (%)	C (%)	H (%)	
Clove	Big	53.85 ^b ±0.08	87.63 ^b ±0.0	38.90 ^b ±0.07	6.49 ^d ±0.02
	Small	75.42 ^e ±0.10	100.33 ^f ±0.04f	41.83 ^c ±0.02	6.44 ^c ±0.01
	Central	48.14 ^a ±0.06	82.63 ^a ±0.05	37.55 ^a ±0.06	6.36 ^c ±0.03
Bulb	Pickled	55.78 ^c ±0.08	93.75 ^c ±0.11	42.35 ^d ±0.08	6.01 ^a ±0.05
	Big	62.08 ^d ±0.07	95.65 ^d ±0.06	43.55 ^e ±0.07	6.31 ^c ±0.03
	Small	63.78 ^d ±0.15	97.48 ^e ±0.17	42.91 ^d ±0.02	6.16 ^b ±0.02
F	10421.38	5101.20	1737.23	52.39	
Sig	0.000	0.000	0.000	0.000	

^{a-f} Mean values with different superscript symbols along the columns are significantly (P<0.05) different.

Table 4. Variation in macro elements among different tissues of Taşköprü garlic.

Size		Macro element (ppm)				
		Ca	K	P	S	Mg
Clove	Big	2648±10	20430±30	4065±6	8067±7	19.55±0
	Small	3617±10	21190±30	5561±6	9014±7	144.7±4.9
	Central	5883±14	23740±30	4701±6	7293±6	74.3±2.8
Bulb	Pickled	6379±14	21940±30	7577±8	12200±10	504±12
	Big	2998±9	19440±20	4962±6	10100±10	157.6±4.8
	Small	11260±20	18490±20	4641±6	6373±5	33.78±0

Table 5 Variation in micro elements among different tissues of Taşköprü garlic.

Size		Micro element (ppm)							
		Na	Mn	Cl	Si	Al	Cu	Fe	Zn
Clove	Big	99.95±0	25.9±0.3	543.6±1.1	103.6±2.6	19.23±0	9±0.3	26.5±0.3	32.2±0.3
	Small	100.76±0	26.1±0.3	575.9±1	156±2.6	154.8±2.2	10.4±0.3	28.9±0.4	34±0.3
	Central	100.82±0	29.1±0.3	643.9±1.1	2007±6	5166±15	8.5±0.3	64.8±0.6	37.8±0.3
Bulb	Pickled	100.55±0	38.1±0.3	284.4±0.7	1326±5	392.2±4.4	9.1±0.3	377.7±1.7	44.5±0.3
	Big	100.47±0	30.6±0.3	701.7±1	186.3±2.7	88.05±1.4	9.2±0.3	35.1±0.4	33.3±0.3
	Small	100.34±0	34.4±0.3	818.7±1.2	1792±6	650.4±5.2	10.7±0.3	267.6±1.4	34.9±0.3
Size		Micro element (ppm)							
		Ag	I	Sr	Se	Ba	Ti	Te	
Clove	Big	7.5±0.6	7.9±0.7	11.9±0.1	0.3±0.1	44±3.9	7.1±0.4	16.8±0.8	
	Small	5.5±0.6	6.2±0.8	16.3±0.1	0.45±0	1.87±0	9.6±0.4	11.6±0.7	
	Central	5.9±0.6	7.5±0.8	16.5±0.1	0.47±0	1.92±0	24.1±0.6	10.3±0.6	
Bulb	Pickled	8.1±0.6	25.3±0.9	18.2±0.1	0.48±0	54.4±4.4	31.4±0.8	20.6±0.9	
	Big	11±0.6	14.1±0.8	16.2±0.1	0.44±0	56.3±4.6	2.7±0.4	29.1±1	
	Small	6.7±0.6	8.1±0.8	47.9±0.1	0.46±0	58.8±4.4	30.6±0.9	14.7±0.8	

Belhadj et al. (2015) found that the total phenolic content was 42.92 ± 3.15 mg in leaves, 32.31 ± 2.3 mg in bulbs and 22.2 ± 3.81 mg in roots. Queiroz et al. (2009) found that fried garlic content varied between 4.78 and 8.32 $\mu\text{g}/\text{mg}$, and also it was lower than the fresh garlic samples (from 6.99 to 8.32 $\mu\text{g}/\text{mg}$). Kim et al. (2013) expressed that the total phenolic acid content of a local garlic cultivar was 17.86 mg/kg. Beato et al. (2011) showed that the amount of total phenolic ranged from 3.4 mg/g to 10.8 mg/g in different garlic cultivars. Nagella et al. (2014) measured phenolic profiles and screened antioxidant activities of some garlic bulbs collected from different locations of Korea. According to their results, the amount of total phenolic varied widely from the different locations and ranged from 33.50 to 49.89 mg.

Minerals are essential for optimal growth, development and maintenance of all living thing including plant and animal. They are categorized as macronutrients and micronutrients. In addition, they are nutritionally important components in food and enhance tolerance to many chronic and some infectious diseases (Elliot et al. 2008; Żurawik et al., 2013). It is reported that garlic is an important source of minerals (Turfan et al., 2016; Mardoni, 2017). The mineral profile as macro and micronutrients of the three cloves and bulbs of garlic in this present study are given in Table 4 and Table 5. It was seen from the Table 4 that mean potassium (K) concentration in the garlic cloves and bulbs were highest compared to all the other elements. The central cloves showed the highest K content (23740 ppm), whereas the small bulb had the lowest concentration (18490 ppm).

Calcium (Ca) was the second highest element determined in the garlic samples and ranged from 2648 ppm to 11260 ppm. The highest amount of Ca (11260 ppm) was noted in the small bulb, whereas the lowest level (2648 ppm) was determined in the big cloves. The highest level

for phosphorus (P), sulfur (S) and magnesium (Mg) were found in the pickled bulb (7577 ppm, 12200 ppm and 504 ppm, respectively) (Table 3). Whereas, the lowest P and Mg were seen in the big cloves (4065 ppm and 19.55 ppm), the lowest S was estimated in the big bulb (6373 ppm) (Table 4). The sodium (Na) level of the garlic samples was 99.95 ppm for the big clove to 100.82 ppm for the central clove (Table 5). Aluminum (Al) and silisyum (Si) contents were found to be highest (5166 ppm and 2007 ppm respectively) in the central cloves, whereas they were lowest (19.23 ppm and 103.6 ppm respectively) in the big cloves. Similarly, iron (Fe) and zinc (Zn) contents were lowest in the big cloves (26.5 ppm and 32.2 ppm respectively), whereas they were highest in the pickled cloves (377.7 ppm and 44.5 ppm respectively) (Table 4).

The concentrations of manganese (Mn) in the different samples of garlic were 38.1 ppm in the pickled, 34.4 ppm in the big bulb as the highest value, and 25.9 ppm in the big cloves as the lowest level. Chlorine (Cl) content of garlic tissues varied between 284.4 ppm for the pickled bulb to 818.7 ppm for the small bulb. Copper (Cu) amount ranged from 8.5 ppm for the central clove to 10.7 ppm for the small bulb, while iodine (I) varied from 6.2 ppm for the small bulb to 25.3 ppm for the pickled bulb (Table 5). According to element values, there was an important variation between the bulbs and the cloves. It was reported that elemental profile of garlic variations depended on cultivars, part of garlic as root, leaf and bulb (Azooz et al., 2014; Petropoulos et al., 2018). Khalid et al. (2014) determined that *Allium tuberosum* contained high contents of calcium (28.66 mg/100 g), potassium (10.62 mg/100 g) and zinc (59.00 mg/100 g). Khan et al. (2016) stated that the mineral analysis of garlic showed higher concentration of potassium (48.75) followed by calcium (24.79 mg/100 g). And also, as trace minerals were Na, Fe, P, Zn, Cu, Mn and Mg with concentration of 4.06 mg/100g, 3.93, and 9.86, 0.53, 0.010, 0.010 and 2.63 mg/100g, respectively.

According to Żurawik et al. (2013), the most abundant minerals in garlic were Ca (12.9 g kg⁻¹), K (48.4 g kg⁻¹), Na (0.2 g kg⁻¹), P (3.6 g kg⁻¹), Mg (2.6 g kg⁻¹), and S (9.1 g kg⁻¹). Haciseferoğulları et al. (2005), Akinwande and Olatunde (2015) and Petropoulos et al. (2018), found also similar result and they showed that K and Ca were the most abundant element in garlic samples. Mg, Na and Ca were also detected in considerable amounts.

Conclusion

The results obtained from this study have indicated that there are significant differences ($P \leq 0.05$) in the element profile, some chemical constituents and growth parameters between the bulbs and the clove categories. According to the growth parameters, the highest values as the shoot and root length, the fresh and dry weight and also germination were obtained from the seedlings germinated from the big cloves. Based on the results from mean macro and micro element values, the big cloves contained the lowest Mn, Si, Al, Fe, Zn and Sr compared to other tissues. In addition, mean sodium content was similar for all samples of garlic. Selenium was found to be the lowest micronutrient in all parts of garlic. Mean content of proline and free amino acid was highest in the big cloves, whereas the small bulb had the lowest contents. Mean β -carotene level was higher in the small bulb of garlic, while the highest value of total phenolic content found in the big cloves of garlic.

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