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Selenium Concentration of Garlic Bulbs Grown in Different Parts of Turkey

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The aim of this study is to evaluate the selenium concentration of garlic bulbs, which are widely grown in different parts of Turkey. For this purpose, 88 samples of garlic bulbs were collected from eight intensive garlic growing areas of Turkey, namely, Kastamonu (23), Balikesir (18), Kirklareli (11), Mugla (9), Kahramanmaras (8), Karaman (6), Hatay (8) and Antalya (5). The selenium concentrations of the garlic bulbs were determined using ICP-OES techniques. The selenium concentrations in the dry and fresh weight of garlic bulbs were determined as being in the ranges 1.85-9.33 mg/kg and 0.46-2.33 mg/kg, respectively. The overall average of the 88 samples was found to be 3.87 mg/kg in dry weight and 0.97 mg/kg in fresh weight. As a result, the garlic bulbs from Kastamonu showed the highest selenium concentration, which indicates that the recommended dietary allowance of selenium, 70 micrograms, could be supplied by these garlic bulbs.

Key Words: Garlic, Selenium, ICP-OES.

INTRODUCTION

Garlic (*Allium sativum* L.) is a common food spice which is widely used in many parts of the world. It is predominantly grown in Mediterranean countries, India, China, Far East countries, the USA and EU countries. Turkey, one of the primary growers of garlic, is the 12th most significant garlic grower worldwide, with a garlic cultivation area, yield and production at 15000 ha, 6546 kg/ha and 98190 tons, respectively[1].

Aside from its use in food, garlic has been used as a medicinal plant for over 4000 years for a variety of purposes such as increasing gastric fluids, stimulating cardiac muscles, regulating the bloodstream, blood pressure, cardiac outflow and the nervous system, cleaning up the blood, inhibiting oxidation, cancer and high cholesterol and performing antimicrobial and toxicological actions[2,3]. Garlic has also been known as a tension regulator and a strong antiseptic for a long time and it continues to be used for medical purpose. The antimicrobial effect of garlic is broad-spectrum much like very strong antibiotics[4].

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Selenium is recognized as an essential trace element for animals and human beings and has received considerable attention for its possible role as an effective, naturally occurring anticarcinogenic agent[5-7]. However, it is not very crucial for plant development. In the case of selenium deficiency, the symptoms for animals, especially young ones, are white muscle disease, nutritional muscular dystrophy or reproductive disorders[5,8,9]. Plants do have an effectual role in supporting the selenium cycle from soil to organisms[10]. On the other hand, symptoms of selenium toxicity vary among individuals and are dependent on a number of factors such as the dose, type and form of selenium ingested, as well as the length of time the product was used and they can include significant hair loss, muscle cramps, nausea, vomiting, diarrhea, joint pain, fatigue, fingernail changes and blistering skin[11]. Plants are capable of directly accumulating Se depending on the Se amount in the soil, which is generally between 0.1 and 2 mg/kg. In seleniferous soils, the Se content is considerably higher, at 2-10 mg/kg[12]. There are several reports available on garlic as being a Se hyperaccumulator plant that is known to accumulate selenium at levels up to 1000 mg/kg or over[13,14].

Epidemiological studies support the protective role of garlic against the development of certain cancer types due to its sulfur- and selenium-containing compounds, such as diallyl disulfide, Se-methyl selenosystein and y-glutamyl-Se-methyl selenosystein[15,16]. Selenium-enriched garlic is more effective in cancer prevention in comparison with other garlic types[17], aside from having the ability to inhibit the toxic effects of heavy metals such as arsenic, cadmium, mercury and tin[18].

Studies are focused mainly on the antioxidant and antimicrobial properties of garlic and its derivatives. However, there is no research on the selenium contents of garlic based on geographical origin. Therefore, this study was planned to determine the selenium concentration of garlic bulbs according to geographical regions.

EXPERIMENTAL

Samples collection: Samples of garlic bulbs were collected at eight different garlic grown regions, which have been the most important places for the cultivation and growing of garlic in Turkey. These places are the Kastamonu (n = 23), Balikesir (n = 18), Kirklareli (n = 11), Mugla (n = 9), Kahramanmaras (n = 8), Karaman (n = 6), Hatay (n = 8) and Antalya (n = 6) regions.

Standard preparation: All working standard solutions were made from stock solutions (1000 mg/L) of selenium, which were supplied by Inorganic Ventures Crop, USA. High-quality water, obtained using a Human UP 900 system, was used exclusively.

Sample preparation: The garlic bulb samples were kept in cooled bags for transport to the laboratory. On arrival the bulbs were cleaned from foreign material such as dust, soil particles *etc.* and their fresh weight was determined. The bulbs were dried at 65 ºC and ground.

The samples were prepared for ICP-OES analysis using a method based on that of Boss and Fredeen[19]. Approximately 0.1 g of ground garlic bulb samples were accurately weighed and transferred into an acid-washed Teflon digestion tube containing 4 mL of 65 % HNO_3. The tube was heated in a microwave oven (Berghof-MWS-2, Germany). The heating program is shown in Table-1. After the microwave digestion cycle, high-purity deionized water was added to the digested solutions to adjust the final volume to 14 mL. Three water blanks were run with each batch of samples.

TABLE-1
HEATING PROGRAM IN MICROWAVE DIGESTION SYSTEM

Step	1	2	3
Temperature (ºC)	145	190	100
Power (%)	75	90	40
Time (min)	5	10	10

Determination of total selenium concentrations of garlic bulbs: Wet digested garlic-bulb-sample solutions containing $NaBH_4$ was reacted with acid in the continuous generation mode. The sample solutions and the HCl reacting solution were fed into the hydride generator with a peristaltic pump. The generated H_2Se was carried by an argon flow to the ICP-OES torch. The intensities of Se were measured at 196 nm by using ICP-OES (Inductively Coupled Plasma-Optical Emission spectrometry, Perkin-Elmer Model DV 2100)[19]. The instrument operating conditions are listed in Table-2.

TABLE-2
OPERATING CONDITIONS FOR ICP-OES

Settings	ICP-OES
Argon plasma/coolant gas flow (L/min)	17
Argon nebulizer gas flow (L/min)	0.50
Argon auxiliary gas flow (L/min)	0.2
Power (watt)	1450
Plasma aerosol type	Dry
Nebulizer type	Meinhard
Nebulizer set up	Gradual
Sprey chember	Perkin Elmer
Sample flow rate (mL/min)	1.5
Replicates	3

RESULTS AND DISCUSSION

The selenium concentrations of garlic bulb samples taken from the eight geographical regions varied between 0.968 and 9.330 mg Se/kg in dry weight and 0.345 and 2.333 mg/kg in fresh weight, respectively (Table-3). Izgi *et al.*[20] report the selenium content of garlic from the Kastamonu Tasköprü region of Turkey as being 0.359 mg/kg. Choi *et al.*[21] find 0.021 mg/kg Se in garlic from Korea. A large range of Se concentrations was previously reported in Slovakian garlic 1.4-129.0 ng/g[22].

TABLE-3
TOTAL SELENIUM CONCENTRATIONS OF GARLIC BULB SAMPLES COLLECTED FROM DIFFERENT REGIONS IN TURKEY

	Se, mg/kg dry weight	Se, mg/kg fresh weight
Kastamonu (n = 23)		
Minimum	3.535	0.884
Maximum	9.330	2.333
Avarage	6.488 ± 1.74	1.622 ± 0.43
Balikesir (n = 18)		
Minimum	3.563	0.891
Maximum	4.392	1.098
Avarage	3.953 ± 0.32	0.988 ± 0.08
Kirklareli (n = 11)		
Minimum	2.219	0.555
Maximum	4.521	1.600
Avarage	3.152 ± 0.97	0.810 ± 0.24
Mugla (n = 9)		
Minimum	2.210	0.553
Maximum	3.221	0.805
Avarage	2.763 ± 0.29	0.691 ± 0.07
Kahramanmaras (n = 8)		
Minimum	1.848	0.462
Maximum	4.848	1.212
Avarage	2.822 ± 0.45	0.705 ± 0.16
Karaman (n = 6)		
Minimum	2.434	0.608
Maximum	4.313	1.078
Avarage	3.526 ± 0.82	0.881 ± 0.20
Hatay (n = 8)		
Minimum	0.968	0.345
Maximum	2.785	0.912
Avarage	1.574 ± 0.58	0.641 ± 0.17
Antalya (n = 5)		
Avarage	3.526	0.881
Maximum	3.491	0.873
Avarage	2.937 ± 0.48	0.734 ± 0.12
General (n = 88)		
Minimum	0.968	0.345
Maximum	9.330	2.333
Avarage	3.665	0.943

According to geographical regions, the garlic bulb samples from Kastamonu had the highest selenium content (6.488 mg/kg in dry weight, 1.622 mg/kg in fresh weight), which was followed by the garlic samples grown in Balikesir, Karaman, Kirklareli, Antalya, Kahramanmaras, Hatay and Mugla (Fig. 1).

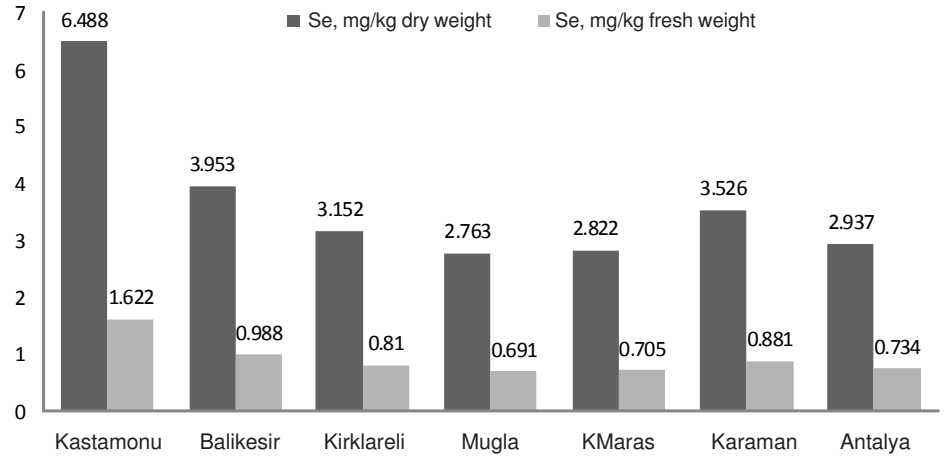

Fig. 1. Average selenium concentrations of garlic samples of different geographical origin

The differences in Se concentrations among the garlic bulb samples could be due to the soil type, the kind of applied fertilizers and pesticides and climatic conditions. Parcerisa *et al.*[23] reported that the mineral composition of plants varies mainly by the soil type, the mineral composition of the soil, the use of fertilizers and the use of irrigation. It could also be stated that the mineral composition as well as the genetic properties of garlic bulb itself might have an effect on the Se concentration.

Recent studies have revealed that the selenium content of plants is dependent upon the amount of selenium in the soil[22,24,25]. Although it is a prominent nutrient found in fresh garlic, the level of selenium is very low; however, it is high enough for garlic to be considered adequate for daily uptake. A recommended dietary allowance (RDA) of 70 μg selenium per day for men and 55 μg for women has been determined on the basis of the maximization of glutathione (GSH-Px) enzyme activity[18].

Conclusion

Recent reports on the anti-carcinogenic activity of selenium have resulted in many people seeking to increase their daily selenium intake. However, the selenium content of a particular food is dependent on the geographic origin of the raw agricultural product with regard to the soil in which the agricultural crop is grown. Though Se is an essential nutrient, high levels of the mineral can be toxic due to its chemical forms. The present study reveals the differences in the Se content of garlic bulb samples from different geographical regions in Turkey. The garlic bulbs from the Kastamonu region had the highest selenium concentrations. It is considered that the important part of the recommended intake of selenium can be fulfilled by the consumption of garlic, especially that which is grown in Kastamonu region. Because garlic is a widely used ingredient and spice in Turkish food culture, Se-enriched garlic obtained by bioenrichment is a good source for supplying the recommended

daily Se intake effective in the prevention of cancer. For the bioenrichment of Se-deficient regions, soil fertilization with Se-enriched fertilizers can be applied to increase the selenium content of garlic.

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