Garlic (Allium sativum L.)

Subjects: Nutrition & Dietetics

Contributor: Silvia Lisciani

Garlic (Allium sativum L.) is one of the most important food products in the world and an ancient and widespread medicinal herb. It is rich in minerals and vitamins, which are both essential nutrients for human health.

Keywords: Italian garlic ; minerals ; vitamins

1. Introduction

Garlic (*Allium sativum* L.) belongs to the plant family Amaryllidaceae and it is one of the most important bulb crops [1]. Native to Central Asia, it is now cultivated worldwide. Garlic has been appreciated since ancient times for its aroma and flavor, which make it suitable for consumption in numerous recipes around the world [2][3]. The first mention of garlic can be traced back to an Egyptian papyrus, the Codex Ebers, dating from 1550 BC, containing hundreds of recipes used, for instance, as a therapeutic cure for headaches and insect bites, and as a painkiller [4]. In fact, in addition to the use of garlic as a food product, it is also known as a medicinal plant; garlic has been used for healing a wide variety of disorders, including leprosy, diarrhea, constipation, asthma, fever, and infection [5][6]. The benefits associated with its consumption are attributed to the presence of different functional compounds in it. The synergistic interactions between all the components, vitamins, saponins, and moderate levels of carotenoids contribute to provide the observed health benefits of garlic [2][7]. The advantages attributed to garlic consumption should also include the high fructooligo-/polysaccharide (FOS) content, responsible for its prebiotic activity, together with dietary fiber [8]. In recent years, many researchers have demonstrated various significant biological functions of garlic, including anticancer, cardiovascular protective, anti-inflammatory, and immune modulatory [9][10][11][12][13]. In particular, the wide variety of dietary and medicinal functions of garlic can be attributed to its oil-soluble organosulfur compounds, which are also the main factors responsible for its characteristic flavor and taste [2][12]. The organosulfur compounds of garlic bulbs are a major source of sulfur in the human diet [14][15][16]. Garlic also contains a decent percentage of sodium, potassium, and magnesium, as well as vitamins, such as C and B [17][18]. Most of the studies present in the literature addressed “commercial” garlic samples, but its particular type of reproduction (agamic) has favored the development and diffusion of numerous local ecotypes that were adapted to different climates and soils [19]. Despite the fact that garlic has been propagated asexually with cloves in many areas of the world by farmers, there is a great diversity in its morphological and agronomic characteristics, mostly due to the existence of various ecotypes that have been cultivated in the same areas for a long time, resulting in the accumulation of natural mutations [20][21][22].

The genotype significantly affects the chemical composition of garlic bulbs, as well as their growing conditions [15][16][17][18][19][20][21][22]. The quality and fertility of the soil have a direct influence on the levels of nutrients in food crops, in particular on micronutrients. Many factors, such as rainfall, sunshine, temperature [23][24][25], species, and soil characteristics, including mineral composition and bioavailability, crop systems, and fertilization practices, play critical roles in plant mineral uptake, affecting the morphology, physiology, and nutritional quality [14][24][25][26][27]. Therefore, cultivation in selected areas can be used to optimize the content of compounds and, consequently, the quality of the final product [15].

Accordingly, differences in geography and farming conditions may determine variations in mineral content for certain plant species. In addition, fertilizer application rates and soil properties may have a significant effect on the mineral composition of garlic bulbs [22]. In this regard, as reported by Naruka and Dhaka [28], nitrogen fertilization has a positive influence on the N, P, K, and S contents of the bulb, due to the improved nutritional environment both in the root zone and the plant system. An increased availability of nutrients in the root zone, coupled with increased metabolic activity at the cellular level, might increase the nutrient uptake and accumulation in the vegetative plant parts [27][29][30][31][32].

Despite the importance of knowledge of close linkage between the nutritional profile of local products and territory and cultivation practices [33], food composition data on Italian-specific landraces are still scarce, and studies are incomplete, especially regarding information on the amounts of vitamins. The identification and highlighting of the chemical properties of the landraces compared with “commercial” varieties may represent an added value of the product to better address the consumer preference [8][34] and stimulate cultivation, thus contributing to the protection of this biodiversity by promoting its conservation [34]. The valorization of the typical products by identifying and evaluating nutritional quality and safety characteristics represents an important goal for the preservation of local ecosystems [33][34].

2. Four Italian Garlic Landraces

Four traditional ecotypes of *Allium sativum L.*: Bianco Piacentino, Rosso di Castelliri, Rosso di Sulmona, and Rosso di Proceno were selected and analyse for their content of minerals and vitamins (**Table 1 and Table 2**). All four varieties, well characterized as regards their morphological and organoleptic properties, are widespread in Italy and grown in many geo-graphic areas. The samples studied were produced in the Lazio region, in two differentgeographical areas (Viterbo and Alvito), using the same trail conditions.

The content of essential minerals and oligo-elements in the four landraces of garlic were reported in **Table 1**. The data showed that potassium (K) was the highest mineral detected, ranging from 645 mg/100 g d.w. of Bianco Piacentino produced in Alvito, to 1057 mg/100 g d.w. of Rosso di Sulmona grown in the same area. These values were comparable to those reported by Bonasia [34], but lower than those reported by Hacıseferoğulları, et al. [35], on a Turkish garlic variety (21,378.84 mg/Kg). The statistical analysis (**Table 1**) revealed that the cultivar, the geographical area, and the interaction between these variables affected the K content, probably reflecting the high exchangeable K value in Viterbo soil.

Table 1. Levels of minerals and oligo-elements (mg/100 g d.w.) in four garlic landraces from the Viterbo and Alvito areas.

	Area	Bianco Piacentino		Rosso di Sulmona		Rosso di Castelliri		Rosso di Proceno		ANOVA		
										Cultivar	Area	C × A
	Viterbo	5 ± 0.3		18 ± 0.1		4 ± 0.4		4 ± 0.4				
Na	Alvito	13 ± 0.4	§	6 ± 0.6	§	22 ± 5.2		23 ± 0.5	§	*	***	***
	Mean	9 ± 5.0 ^{a}		12 ± 6.4 ^{ab}		13 ± 13.7 ^{ab}		14 ± 10.7 ^{b}				
	Viterbo	866 ± 18.7		723 ± 9.9		1016 ± 35.4		1049 ± 143.1				
K	Alvito	645 ± 20.7	§	1057 ± 130.4		710 ± 19.6	§	694 ± 6.5		n.s.	**	***
	Mean	755 ± 128.2		890 ± 207.3		863 ± 178.5		871 ± 221.1				
	Viterbo	27 ± 0.7		46 ± 0.8		40 ± 0.0		40 ± 1.0				
Ca	Alvito	23 ± 0.4	§	38 ± 1.8		50 ± 2.5		50 ± 0.2	§	***	*	***
	Mean	25 ± 2.1 ^{a}		42 ± 4.74 ^{b}		45 ± 6.0 ^{c}		45 ± 5.8 ^{c}				
	Viterbo	47 ± 0.0		48 ± 0.6		54 ± 0.2		50 ± 6.4				
Mg	Alvito	37 ± 0.9	§	49 ± 3.4		45 ± 1.9		42 ± 0.1		*	**	n.s.
	Mean	42 ± 5.5 ^{a}		49 ± 2.0 ^{b}		50 ± 5.2 ^{bc}		46 ± 5.5 ^{abc}				
	Viterbo	296 ± 1.2		293 ± 4.7		347 ± 0.2		301 ± 24.5				
P	Alvito	219 ± 32.4		303 ± 20.3		263 ± 6.7		261 ± 0.5		*	**	*
	Mean	257 ± 48.1 ^{a}		298 ± 13.5 ^{a}		305 ± 50.1 ^{b}		281 ± 27.3 ^{a}				
	Viterbo	1.54 ± 0.136		3.48 ± 1.178		2.56 ± 0.039		3.21 ± 1.446				
Fe	Alvito	1.54 ± 0.132		3.05 ± 1.366		2.77 ± 0.190		2.98 ± 0.103		n.s.	n.s.	n.s.
	Mean	1.54 ± 0.109		3.26 ± 1.070		2.67 ± 0.165		3.10 ± 0.848				
	Viterbo	0.60 ± 0.096		0.53 ± 0.006		0.61 ± 0.002		0.52 ± 0.000				
Cu	Alvito	0.46 ± 0.027		0.66 ± 0.020		0.55 ± 0.015		0.46 ± 0.009		n.s.	n.s.	n.s.
	Mean	0.53 ± 0.102		0.60 ± 0.075		0.58 ± 0.040		0.49 ± 0.034				

	Area	Bianco Piacentino		Rosso di Sulmona	Rosso di Castelliri	Rosso di Proceno	ANOVA Cultivar	Area	C × A
Zn	Viterbo	1.84 ± 0.016	§	1.54 ± 0.017	1.85 ± 0.009	1.49 ± 0.106	*	*	*
	Alvito	1.51 ± 0.041		1.68 ± 0.100	1.60 ± 0.084	1.43 ± 0.004			
	Mean	1.67 ± 0.192 ^{a}		1.61 ± 0.101 ^{ab}	1.73 ± 0.155 ^{a}	1.46 ± 0.071 ^{b}			
Mn	Viterbo	0.53 ± 0.005	§	0.64 ± 0.003	0.60 ± 0.002	0.63 ± 0.088	**	n.s.	n.s.
	Alvito	0.44 ± 0.001		0.58 ± 0.065	0.61 ± 0.043	0.65 ± 0.009			
	Mean	0.49 ± 0.054 ^{a}		0.61 ± 0.050 ^{b}	0.61 ± 0.025 ^{a}	0.64 ± 0.053 ^{b}			

Data are expressed as Mean ± S.D.; Student's *t*-test between two areas of each cultivar: § is statistically significant ($p < 0.05$). Two-way ANOVA effect: * statistically significant differences at p below 0.05; ** statistically significant differences at p-value below 0.01; *** statistically significant differences at p-value below 0.001. Tukey's honestly significant difference (HSD) test: by row, means of each cultivar followed by different superscript (a,b,c) are significantly different ($p < 0.05$).

Table 2 shows the content of some water-soluble vitamins in the studied samples. The values pointed out that, among the B-group vitamins, vitamin B6 was the most represented, followed by niacin, thiamine and finally riboflavin. Vitamin C was contained in greater quantities than all other vitamins detected.

Vitamin C content ranged from a minimum value of 9.7 mg/100 g found in Rosso di Proceno from Viterbo, to a maximum value of 15.6 mg/100 g in Rosso di Sulmona grown in Alvito and were not influenced by soil, cultivar or cultivar–soil interaction (**Table 2**). These results may be due to the fact that the vitamin C content depends on many factors, not least its sensitivity to pre- and post-harvest condition.

Table 2. Levels of vitamins (mg/100 g f.w.) in four garlic landraces from the Viterbo and Alvito areas.

	Area	Bianco Piacentino	Rosso di Sulmona		Rosso di Castelliri		Rosso di Proceno	ANOVA Cultivar	Area
Thiamine	Viterbo	0.27 ± 0.077	0.20 ± 0.005		0.26 ± 0.005		0.21 ± 0.036	n.s.	n.s.
	Alvito	0.25 ± 0.073	0.19 ± 0.017		0.22 ± 0.020		0.24 ± 0.010		
	Mean	0.26 ± 0.062	0.19 ± 0.011		0.24 ± 0.025		0.22 ± 0.025		
Riboflavin	Viterbo	0.02 ± 0.001	0.01 ± 0.001	§	0.04 ± 0.002	§	0.02 ± 0.001	***	*
	Alvito	0.02 ± 0.002	0.02 ± 0.000		0.02 ± 0.002		0.02 ± 0.001		
	Mean	0.02 ± 0.002 ^{a}	0.02 ± 0.004 ^{a}		0.03 ± 0.011 ^{b}		0.02 ± 0.001 ^{a}		
Niacin	Viterbo	0.91 ± 0.000	0.80 ± 0.060		0.66 ±0.040		0.62 ± 0.020	***	n.s
	Alvito	0.77 ± 0.030	0.91 ± 0.030		0.60 ±0.040		0.56 ± 0.030		
	Mean	0.84 ± 0.084 ^{a}	0.86 ± 0.075 ^{a}		0.63 ± 0.047 ^{b}		0.59 ± 0.039 ^{b}		
Vitamin B6	Viterbo	1.60 ± 0.010	1.37 ± 0.090		2.04 ± 0.230	§	1.03 ± 0.052	***	n.s.
	Alvito	0.98 ± 0.097	1.37 ± 0.026		0.99 ± 0.056		0.88 ± 0.072		
	Mean	1.29 ± 0.357 ^{a}	1.37 ± 0.054 ^{a}		1.52 ± 0.609 ^{b}		0.96 ± 0.099 ^{c}		
Vitamin C	Viterbo	11.4 ± 2.23	12.6 ± 3.61		13.0 ± 3.97		9.7 ± 1.85	n.s.	n.s.
	Alvito	12.4 ± 2.93	15.6 ± 8.48		14.6 ± 6.16		10.5 ± 6.03		
	Mean	11.9 ± 2.21	14.1 ± 5.60		13.8 ± 4.32		10.1 ± 3.66		

Data are expressed as Mean ± S.D.; Student's *t*-test between two areas of each cultivar: § is statistically significant ($p < 0.05$). Two-way ANOVA effect: * statistically significant differences at p below 0.05; *** statistically significant differences at p-value below 0.001. Tukey's honestly significant difference (HSD) test: by row, means of each cultivar followed by different superscript (a,b,c) are significantly different ($p < 0.05$).

3. Conclusions

Our results indicated that the four Italian garlic landraces studied were a good source of minerals and vitamins, and their content was differently affected by the genotype and the growing area. The most represented mineral was K, followed by P, Mg and Ca. These concentrations were influenced by the cultivation area and therefore by the characteristics of the soil, since the agronomic trails were the same for Viterbo and Alvito areas.

As concerns the vitamins, the results showed that vitamin C was the most represented, and its values were independent from the area and cultivar.

The values of the B vitamins showed a greater cultivar effect for riboflavin, niacin and vitamin B6. Furthermore, many of the micronutrients were influenced by the interaction between cultivar and growing area, suggesting that the effect of the soil on their content is expressed in the presence of some characteristics related to the genotype.

Therefore, the study of the chemical composition of traditional foodstuffs and their nutritional characteristics, in relation to biodiversity, is important for the definition of their total quality and to enhances and preserves the identity of local products. Furthermore, knowledge about the properties of these garlic varieties could also promote their cultivation and consumption as food. Nowadays, garlic is used mainly in the formulation of food supplements, for its beneficial effects on blood pressure and on the functionality of the cardiovascular system.

References

1. Block, E. Garlic and Other Alliums: The Lore and the Science; Royal Society of Chemistry, RSC Publishing: Cambridge, UK, 2010; p. 759.
2. Amagase, H.; Petesch, B.L. Garlic. Encyclopedia of Food Sciences and Nutrition, 2nd ed.; Caballero, B., Ed.; Academic Press: London, UK, 2003; pp. 2861–2864. ISBN 9780122270550.
3. Petrovska, B.B.; Cekovska, S. Extracts from the history and medical properties of garlic. Pharmacogn. Rev. 2010, 4, 106–110.
4. Rivlin, R.S. Historical perspective on the use of garlic. J. Nutr. 2001, 131, 951S–954S.
5. Charu, K.; Yogita, S.; Sonali, S. Neutraceutical potential of organosulfur compounds in fresh garlic and garlic preparations. Int. J. Pharm. Bio. Sci. 2014, 5, 978–982.
6. Botas, J.; Fernandes, Â.; Barros, L.; Alves, M.J.; Carvalho, A.M.; Ferreira, I.C.F.R. A Comparative Study of Black and White Allium sativum L.: Nutritional Composition and Bioactive Properties. Molecules 2019, 24, 2194.
7. Durazzo, A. Study Approach of Antioxidant Properties in Foods: Update and Considerations. Foods 2017, 6, 17.
8. Lisciani, S.; Gambelli, L.; Durazzo, A.; Marconi, S.; Camilli, E.; Rossetti, C.; Gabrielli, P.; Aguzzi, A.; Temperini, O.; Marletta, L. Carbohydrates Components of Some Italian Local Landraces: Garlic (Allium sativum L.). Sustainability 2017, 9, 1922.
9. Patumraj, S.; Tewit, S.; Amatyakul, S.; Jariyapongskul, A.; Maneesri, S.; Kasantikul, V.; Shepro, D. Comparative Effects of Garlicand Aspirin on Diabetic Cardiovascular Complications. Drug Deliv. 2000, 7, 91–96.
10. Zeng, T.; Guo, F.F.; Zhang, C.L.; Song, F.Y.; Zhao, X.L.; Xie, K.Q. A meta-analysis of randomized, double-blind, placebo-controlled trials for the effects of garlic on serum lipid profiles. J. Sci. Food Agric. 2012, 92, 1892–1902.
11. Raman, P.; Dewitt, D.L.; Nair, M.G. Lipid peroxidation and cyclooxygenase enzyme inhibitory activities of acidic aqueous extracts of some dietary supplements. Phytother. Res. PTR 2008, 22, 204–212.
12. Zhang, Y.; Liu, X.; Ruan, J.; Zhuang, X.; Zhang, X.; Li, Z. Phytochemicals of garlic: Promising candidates for cancer therapy. Biomed. Pharm. 2020, 123, 109730.
13. Devi, A.; Chaurasia, H.; Chandel, S.R.; Kaushik, S.; Bhatt, B. A Review: Impact of garlic on human health. Int. J. Pharm. Biol. Sci. 2021, 10, 935–947.
14. Põldma, P.; Moor, U.; Tõnutare, T.; Herodes, K.; Rebane, R. Selenium treatment under field conditions affects mineral nutrition, yield and antioxidant properties of bulb onion (Allium cepa L.). Acta Sci. Pol. Hortorum Cultus 2013, 12, 167–181.
15. Martins, N.; Petropoulos, S.; Ferreira, I.C. Chemical composition and bioactive compounds of garlic (Allium sativum L.) as affected by pre- and post-harvest conditions: A review. Food Chem. 2016, 211, 41–50.
16. Tocmo, R.; Liang, D.; Lin, Y.; Huang, D. Chemical and biochemical mechanisms underlying the cardioprotective roles of dietary organopolysulfides. Front. Nutr. 2015, 2, 1.
17. Prianshu, A.; Singh, M.; Kumar, M.; Malik, S.; Sahahi, U.; Lodhi, S. Effect of integrated nutrient management on yield and quality of Garlic cv. Yamuna Safed-3. J. AgriSearch 2020, 7, 251–254.
18. Evrendilek, G.A. Nutritional Composition and Antioxidant Properties of Fruits and Vegetables; Jaiswal, A., Ed.; Academic Press: London, UK, 2020; pp. 89–105.

19. González, R.E.; Soto, V.C.; Sance, M.M.; Camargo, A.B.; Galmarini, C.R. Variability of solids, organosulfur compounds, pungency and health-enhancing traits in garlic (Allium sativum L.) cultivars belonging to different ecophysiological grou ps. J. Agric. Food Chem. 2009, 57, 10282–10288.
20. Figliuolo, G.; Candido, V.; Logozzo, G.; Miccolis, V.; Zeuli, P.L.S. Genetic evaluation of cultivated garlic germplasm (Alli um sativum L. and A. ampeloprasum L.). Euphytica 2001, 121, 325–334.
21. Mohammadi, B.; Khodadadi, M.; Karami, E.; Shaaf, S. Variation in agro-morphological characters in Iranian garlic landr aces. Int. J. Veg. Sci. 2014, 20, 202–215.
22. Petropoulos, S.; Fernandes, Â.; Ntatsi, G.; Petrotos, K.; Barros, L.; Ferreira, I.C.F.R. Nutritional Value, Chemical Chara cterization and Bulb Morphology of Greek Garlic Landraces. Molecules 2018, 23, 319.
23. Kibar, B.; Temel, S. Evaluation of mineral composition of some wild edible plants growing in the Eastern Anatolia region grasslands of Turkey and consumed as vegetable. J. Food Process. Preserv. 2016, 1, 56–66.
24. Atif, M.J.; Amin, B.; Ghani, M.I.; Hayat, S.; Ali, M.; Zhang, Y.; Cheng, Z. Influence of Different Photoperiod and Tempera ture Regimes on Growth and Bulb Quality of Garlic (Allium sativum L.) Cultivars. Agronomy 2019, 9, 879.
25. Atif, M.J.; Amin, B.; Ghani, M.I.; Ali, M.; Cheng, Z. Variation in Morphological and Quality Parameters in Garlic (Allium s ativum L.) Bulb Influenced by Different Photoperiod, Temperature, Sowing and Harvesting Time. Plants 2020, 9, 155.
26. Smith, R. Determination of the country of origin of garlic (Allium sativum) using trace metal profiling. J. Agric. Food Che m. 2005, 53, 4041–4045.
27. Diriba-Shiferaw, G. Review of Management Strategies of Constraints in Garlic (Allium sativum L.) Production. J. Agric. Sci. 2016, 11, 186–207.
28. Naruka, I.S.; Dhaka, R.S. Effect of row spacing and nitrogen fertilization on growth, yield and composition of bulb in gar lic (Allium sativum L.) cultivars. J. Spices Aromat. Crop. 2001, 10, 111–117.
29. Panda, S.C.; Panda, P.C.P.; Nanda, S.S. Nitrogen and phosphorus uptake from Tithonia diversifolia and inorganic fertili zers and their effect on maize yield in Malawi. In Proceedings of the Symposium on Maize Production Technology for th e Future: Challenge and Opportunities, Addis Ababa, Ethiopia, 21–25 September 1998; pp. 264–266.
30. Surendra, S. Effect of sulphur on yields and S uptake by onion and garlic grown in acid alfisol of Ranchi. Agric. Sci. Dig est. 2008, 28, 189–191.
31. Diriba-Shiferaw, G.; Nigussie-Dechassa, R.; Kebede, W.; Getachew, T.; Sharma, J.J. Growth and nutrients content and uptake of garlic (Allium sativum L.) as influenced by different types of fertilizers and soils. Sci. Technol. Arts Res. J. 201 3, 2, 35–50.
32. Shedeed, S.I.; El-Sayed, S.A.A.; Bash, D.A. Effectiveness of bio-fertilizers with organic matter on the growth, yield and nutrient content of onion (Allium cepa L.) plants. Eur. Inter. J. Sci. Tech. 2014, 3, 115–122.
33. Durazzo, A. The Close Linkage between Nutrition and Environment through Biodiversity and Sustainability: Local Food s, Traditional Recipes, and Sustainable Diets. Sustainability 2019, 11, 2876.
34. Bonasia, A.; Conversa, G.; Lazzizera, C.; Loizzo, P.; Gambacorta, G.; Elia, A. Evaluation of Garlic Landraces from Fog gia Province (Puglia Region; Italy). Foods 2020, 9, 850.
35. Hacıseferoğulları, H.; Özcan, M.; Demir, F.; Çalışır, S. Some nutritional and technological properties of garlic (Allium sat ivum L.). J. Food Eng. 2005, 68, 463–469.