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Original Article

# Evaluation of some mineral composition and biochemical among different ecotypes of Iranian Shallot

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ABSTRACT

**Abstract**
Shallot bulbs are a rich source of vitamins, mineral elements, and essential fatty acids. This study evaluated the biochemical and nutritional properties of five Iranian shallot populations to identify suitable varieties for specific applications in the food industry. Five shallot populations, collected from the provinces of Isfahan, Chaharmahal and Bakhtiari, Kurdistan, Lorestan, and Hamadan, were cultivated under rain-fed conditions at the Chahmakhani Research Station in Yasouj. The experiment was arranged in a randomized complete block design with three replications. The bulbs were analyzed for dry matter, total phenol content, mineral elements (K, Na), fatty acid profile, and DPPH radical scavenging activity. Significant differences ($p < 0.05$) were observed among populations for most traits. The Lorestan ecotype exhibited the highest total phenol content (0.729 mg) and potassium (K) content (4602 mg), while the Kurdistan ecotype recorded the lowest values for these traits. Dry matter percentage ranged from 22.7% (Chaharmahal and Bakhtiari) to 27.2% (Hamadan), though differences were not statistically significant. Significant variation was also found in palmitoleic acid content and sodium (Na) levels. The significant biochemical variation among the studied populations allows for the selection of specific ecotypes based on desired traits. The Lorestan ecotype, with its high phenol and potassium content, is particularly promising for applications emphasizing antioxidant and mineral enrichment.


## 1. Introduction

### Introduction

Persian shallot (*Allium hirtifolium* Boiss.), a perennial herb belonging to the Amaryllidaceae family, is a valuable endemic species native to the mountainous regions of Iran. This plant occupies a unique position in Iranian culture, serving not only as a traditional culinary ingredient often consumed fresh, dried, or mixed with dairy products like yogurt but also as a significant component of ethnomedicine. Its longstanding medicinal use, which includes applications for reducing blood pressure, alleviating inflammation, and treating infections (Khezri, 2003), has prompted extensive scientific investigation into its therapeutic properties. Research has now confirmed a wide range of pharmacological activities for *A. hirtifolium*, including potent antioxidant, antimicrobial, anti-inflammatory, and antidiabetic effects (Ebrahimi et al., 2009). The remarkable therapeutic and nutritional value of Persian shallot is directly attributed to its rich and complex phytochemical composition. The edible bulbs are a significant source of essential vitamins (A, B, C, D), beta-carotene, and essential amino acids (Brewster and Rabinowitch, 1990), as well as crucial minerals such as iron, copper, zinc, manganese (Rubatzky and Yamaguchi, 1997), potassium, phosphorus, calcium, sodium, and magnesium. Furthermore, like many Allium species, it contains essential fatty acids, with linoleic, oleic, and palmitic acid often comprising more than three-quarters of the total fatty acid content (Fenwick and Hanley, 1985). The key bioactive constituents responsible for its medicinal properties, however, are the organosulfur compounds. The most notable of these is allicin (diallyl thiosulfinate), which is widely recognized as the primary antibacterial compound in the genus Allium (Pizzino et al., 2017). Other important organosulfur compounds present include ajoene, diallyl disulfide, diallyl trisulfide, and S-allyl cysteine (Tony et al., 2015). In addition to sulfur compounds, Persian shallot is rich in phenolic compounds, particularly flavonoids, and saponins. These phenolic compounds are major contributors to the plant's high antioxidant capacity, playing a vital role in neutralizing free radicals, reducing oxidative stress, and inhibiting lipid oxidation, thereby enhancing the body's resistance to cellular damage (Manuel et al., 2010; Askari et al., 2025). A critical factor in understanding the nutritional and medicinal potential of Persian shallot is the significant influence of the growing environment. While the genetic makeup of the plant dictates its capacity to produce these beneficial compounds, the ultimate levels that accumulate in the bulb are profoundly shaped by the interplay of climatic, edaphic (soil), and other environmental factors. Therefore, the quality of the final horticultural product is a complex function of these interacting genetic and environmental components (Jafari et al., 2019). Numerous studies have emphasized that the growing region can have a significant impact on the nutritional composition and phytochemical profile of various plants (Saeidi et al., 2021). This means that shallot populations collected from different geographical locations within Iran may exhibit substantial variation in their biochemical properties. Despite the recognized potential of Persian shallot as a valuable nutritional and medicinal resource, it remains largely underutilized and inadequately characterized. Systematic studies that explore the full extent of phytochemical diversity among its various Iranian ecotypes are surprisingly scarce. A recent investigation by Salavati and Kakaei (2024) provided important preliminary data by analyzing shallot bulbs from five ecotypes in the western provinces of Hamedan and Kermanshah. Their findings revealed significant differences among populations for key traits such as bulb dry matter percentage, protein content, and total polyphenol content. For instance, they identified the Bahar ecotype as having the highest dry matter and total polyphenols, suggesting it is particularly well-suited for the pharmaceutical industry. This study clearly demonstrates that valuable chemotypic variation exists even within a relatively limited geographic area.

However, a significant research gap remains. A comprehensive evaluation of Persian shallot diversity across a broader geographic range specifically concerning a wider array of nutritional and biochemical traits is lacking. Most critically, there is insufficient information on the variability of mineral element composition (such as potassium and sodium) and the detailed fatty acid profile of different ecotypes. These components are essential for a complete understanding of the plant's nutritional value and its potential applications in functional foods and nutraceuticals. To address this gap, the present study was designed with the following objective: to evaluate and compare the total phenolic content, fatty acid composition, and the concentrations of key mineral elements (potassium and sodium) in five Iranian shallot ecotypes collected from the provinces of Isfahan, Chaharmahal and Bakhtiari, Kurdistan, Lorestan, and Hamadan.

## 2. Materials and Methods

### *2.1 Experimental site*

This study was conducted to evaluate five ecotypes of Persian shallot collected from the provinces of Isfahan, Chaharmahal and Bakhtiari, Kurdistan, Lorestan, and Hamadan (Figure 1). The bulbs were cultivated as a rain-fed crop during the 2023-2024 agricultural year at the Chahmakhani Research Station.

**Fig1**.Shallot samples from the Lorestan (left side) and Isfahan (right side) ecotypes.

The station is a research facility affiliated with the Agricultural and Natural Resources Research and Education Center of Kohgiluyeh and Boyer-Ahmad Province. It is situated 20 kilometers from Yasouj, the provincial capital, adjacent to the Imamzadeh Shah Mokhtar shrine. The station covers approximately 130 hectares, comprising 70 hectares of agricultural and orchard land and 60 hectares of forested area. Geographically, it is located at a longitude of 51° 31' E and a latitude of 30° 41' N, at an average altitude of 1800 meters above sea level. The region has a cold mountain climate, with an average annual temperature of 15.7°C. During the 2023-2024 cultivation year, the average rainfall at the site was 699 mm, and the average temperature was 16.1°C.

### *2.2 Laboratory Analysis of Mineral and Nutritional Elements*

All analyses of mineral and nutritional elements were conducted at the Central Laboratory of the Islamic Azad University, Yasouj Branch. The following procedures were employed for each measured trait:

### *2.3 Dry Matter Percentage*

To determine dry matter content, five bulbs from each population were selected and initially weighed to record their fresh weight. The samples were then placed in a forced-air oven set at 100°C and dried for 24 hours. After this period, the bulbs were weighed again to obtain their dry weight. The dry matter percentage was calculated using the following formula (Argyropoulos and Muller, 2014):

MCdb=WdWm×100*MCdb*=*WmWd*×100

Where:

MCdb*MCdb* = Dry matter percentage of the bulb (%)

Wm*Wm* = Initial fresh weight of the sample before drying (g)

Wd*Wd* = Weight of the sample after 24 hours of drying (g)

### *2.4 Total Phenol Content*

Total phenolic content was measured using the Folin-Ciocalteu reagent, following the method of Slinkard and Singleton (1977). The same methanolic extract prepared for the DPPH assay was used for this analysis.

**Extraction Preparation:** The extract was centrifuged at 12,000 g for 10 minutes at 4°C.

**Reaction Mixture:** An aliquot of 200 µl of the resulting supernatant was diluted with 300 µl of distilled water. To this mixture, 2.5 ml of freshly prepared 50% Folin-Ciocalteu reagent was added.

**Incubation:** The solution was incubated in darkness at room temperature for 3 minutes. Following this, 2 ml of a 7.5% sodium carbonate ($Na_2CO_3$) solution was added.

**Measurement:** The mixture was incubated again in darkness at room temperature for 30 minutes. After incubation, the absorbance was measured at 760 nm using a UV-Vis spectrophotometer.

**Quantification:** A calibration curve was prepared using gallic acid standards at different concentrations. The total phenol content of the samples was expressed as milligrams of gallic acid equivalent per gram of fresh weight (mg GAE/g FW).

### *2.5 Mineral Element (Sodium and Potassium) Content*

The concentrations of sodium (Na) and potassium (K) in the dried shallot samples were determined using flame photometry (Jenway PFP-7, UK).

**Digestion:** A 0.5 g sample of powdered, dried shallot was weighed and digested with 10 mL of nitric acid ($HNO_3$, 65%) and 2 mL of perchloric acid ($HClO_4$, 70%) on a hot plate at 180°C. Digestion continued until a clear solution was obtained, indicating complete mineralization.

**Filtration and Dilution:** The resulting digestate was allowed to cool, then filtered through appropriate filter paper. The filtered solution was diluted to a final volume of 50 mL with deionized water.

**Measurement:** The concentrations of Na and K in the prepared solution were measured using a flame photometer. Standard calibration curves were prepared using certified NaCl and KCl standard solutions.

**Expression of Results:** All measurements were performed in triplicate. The results were calculated and expressed as milligrams per kilogram of dry weight (mg/kg DW).

### *2.6 DPPH Radical Scavenging Activity*

The radical scavenging activity of the shallot extracts was determined using the stable DPPH (2,2-diphenyl-1-picrylhydrazyl) radical, according to the method described by Brand-Williams et al. (1995).

**Extraction:** A 0.5 g sample of powdered shallot was extracted with 5 mL of 85% methanol at room temperature.

**Assay:** An aliquot of 25 µl of the methanolic extract was rapidly mixed with 1975 µl of a methanolic DPPH solution (40 mg $L^{-1}$, Sigma) directly in a cuvette placed in the spectrophotometer.

**Measurement:** The decrease in absorbance, corresponding to the scavenging of the DPPH radical by the extract, was measured at the characteristic wavelength (typically 515-517 nm) after a defined incubation period. The percentage of inhibition was then calculated.

## 3. Results

**Results**

The physicochemical characteristics of the soil from the experimental field at the Chahmakhani Research Station were analyzed prior to cultivation, and the results are presented in Table 1. The analysis revealed that the soil had an available phosphorus content of 21.85 mg/kg, an available potassium (K) concentration of 471 mg/kg, and an organic carbon content of 0.897%. These baseline soil properties provide context for the growing conditions experienced by the five shallot ecotypes during the 2023-2024 cultivation year.

**Table 1.** The chemical composition of soil of experimental site

| | |
|---|---|
| Texture | Si-Cl |
| Sand% | 15 |
| Silt% | 44 |
| Clay% | 41 |
| Available K | 471 |
| Available P | 21.85 |
| Total N | 0.093 |
| TNV | 13.12 |
| OC | 0.897 |
| pH | 7.4 |
| EC | 0.492 |

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**Fig2**. Total phenol content in different ecotypes of shallot

The antioxidant activity of the shallot ecotypes, measured as DPPH radical scavenging percentage, showed a statistically significant difference ($p < 0.05$) among the populations. As illustrated in Figure 3, the Hamadan ecotype exhibited the highest antioxidant activity, with a mean DPPH inhibition of 56.6%. In contrast, the Chaharmahal and Bakhtiari ecotype recorded the lowest activity, with a mean value of 27.7%. These findings indicate substantial variation in antioxidant capacity among the five shallot populations studied.

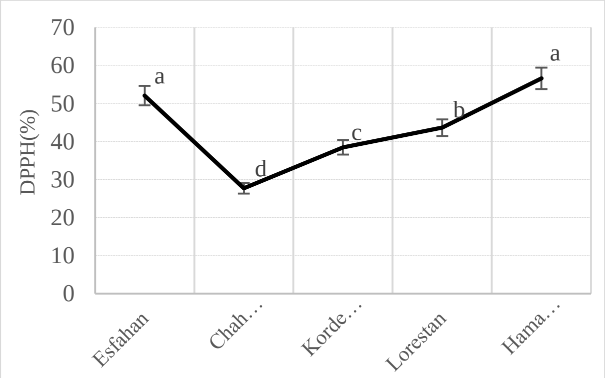


**Fig3**. The results of the test regarding the DPPH among the various shallot ecotypes.

Analysis of potassium concentration revealed a statistically significant difference ($p < 0.05$) among the shallot ecotypes. As presented in Figure 4, the Lorestan ecotype accumulated the highest potassium content, with a mean value of 4602 mg/kg DW. In contrast, the Kurdistan ecotype exhibited the lowest potassium concentration, measuring 3503 mg/kg DW. These results demonstrate considerable variability in potassium uptake and accumulation among the five studied populations.

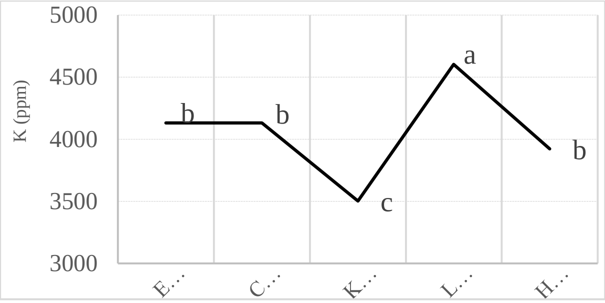


**Fig4**. The results of the K content among the various shallot ecotypes

The analysis of sodium concentration revealed a statistically significant difference ($p < 0.05$) among the shallot ecotypes.

As shown in Figure 5, the Hamadan ecotype accumulated the highest sodium content, with a mean value of 289 mg/kg DW. In contrast, the Isfahan ecotype exhibited the lowest sodium concentration, measuring 168 mg/kg DW. These findings indicate significant genetic or environmentally-induced variation in sodium accumulation among the five shallot populations studied.

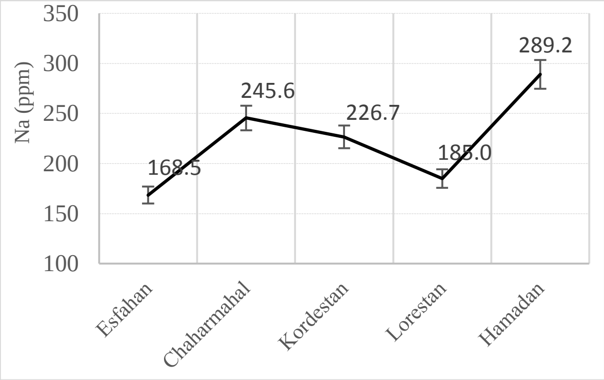


**Fig5**. The results of the Na content among the various shallot ecotypes

According to the obtained results, the palmitoleic acid content in different shallot ecotypes showed a statistically significant difference, such that the Chaharmahal ecotype had the highest amount at 1.9%, while the Lorestan ecotype had the lowest amount at 0.45% (Figure 6).

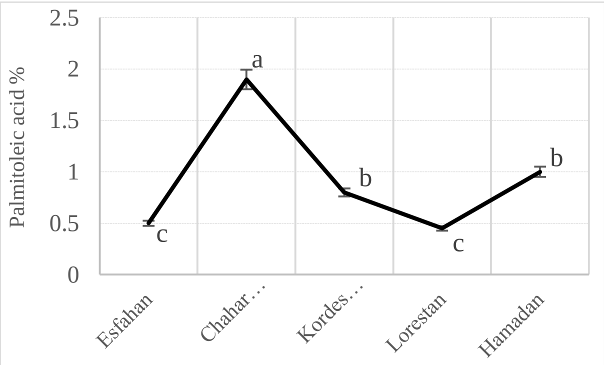


**Fig6**. The results of the palmitoleic acid among the various shallot ecotypes

The dry matter percentage of the five shallot populations is presented in Figure 7. Although the Hamadan ecotype exhibited the highest numerical value (27.2%) and the Chaharmahal and Bakhtiari ecotype the lowest (22.7%), analysis of variance revealed no statistically significant difference among the populations for this trait. These results suggest that dry matter accumulation was relatively consistent across all studied ecotypes under the rain-fed conditions of the experiment.

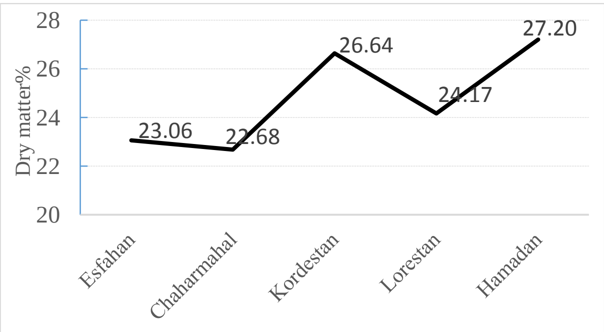


**Fig7**. Dry matter percentage of different shallot ecotypes

## 4. Discussion

Ecological factors, including climate, soil physicochemical properties, topography, and geology, play a decisive role in shaping the distribution and phytochemical composition of Iranian shallot (*Allium hirtifolium*). Research by Allahmoradi et al. (2013) demonstrated that shallot preferentially grows in soils with high organic matter content, which consequently leads to enhanced accumulation of trace elements in the bulbs. The mineral content of the soil from sampling areas directly influences plant composition, with plant access to nutrients being particularly dependent on soil pH (Mkhabela and Warman, 2005). The observed differences among ecotypes in the present study can therefore be partially attributed to the distinct environmental conditions of their original habitats.

In the present study, dry matter percentage varied among populations, with the Hamadan ecotype exhibiting the highest value (27.2%) and the Chaharmahal and Bakhtiari ecotype the lowest (22.7%), although these differences were not statistically significant. This range is consistent with previous investigations of Iranian shallot populations. Salavati and Kakaei (2024) reported dry matter percentages ranging from 26.22% (Asadabad) to 29.12% (Bahar) among ecotypes from western Iran. Similarly, Ebrahimi et al. (2009) found that the Harsin population had the highest dry matter (36.71%), while the Doshman-Ziari population had the lowest (29.15%). The variation in bulb dry matter across studies reflects differences in environmental conditions, including climate and soil (Shimeles, 2014), as well as genetic variation among populations, growth location, growing season (Yeshiwas et al., 2023), and pre- and post-harvest management practices (Getachew and Asfaw, 2004). Given that over 90% of the weight of most vegetables is water (Salunkhe and Kadam, 1998), the shallot bulb, with an average dry matter of approximately 25-30%, represents a valuable vegetable for producing dried products such as shallot powder. The dry matter content of shallot is slightly lower than that of garlic (36%), which has the highest dry matter among vegetables, but it is higher than most other bulb vegetables (Rubatzky and Yamaguchi, 1997). For dry matter-based applications, populations such as Harsin (Ebrahimi et al., 2009) or Bahar (Salavati and Kakaei, 2024) may be superior; however, adaptation studies under uniform conditions are recommended before large-scale cultivation (Ebrahimi et al., 2009).

Total phenol content differed significantly among ecotypes, with the Lorestan population exhibiting the highest value (0.729 mg GAE/g FW) and the Kurdistan population the lowest (0.562 mg GAE/g FW). These findings contrast with those of Salavati and Kakaei (2024), who reported the highest total polyphenol content (0.15%) in Bahar and Asadabad ecotypes and the lowest (0.12%) in the Hamadan ecotype. Such discrepancies may arise from differences in extraction methods, analytical protocols, or environmental conditions at the collection sites. Ghahremani and Dashti (2014) evaluated 11 shallot populations and reported the highest total phenolic compounds in the Sahneh (Kermanshah) population and the lowest in the Nahavand and Hamadan populations, further confirming substantial chemotypic diversity among Iranian shallot germplasm.

Phenolic compounds are secondary metabolites positively correlated with antioxidant capacity. Plants of the Amaryllidaceae family are particularly valued for their content of polyphenols, flavonoids, terpenoids, alkaloids, and other bioactive compounds (Hosseini Shekarabi et al., 2021). In the present study, DPPH radical scavenging activity varied significantly among ecotypes, with the Hamadan population showing the highest activity (56.6%) and the Chaharmahal and Bakhtiari population the lowest (27.7%). The DPPH assay is widely used for rapid evaluation of antioxidant activity due to its stability and reproducibility (Nuutila et al., 2003). The observed variation in antioxidant capacity reflects inherent genetic differences among ecotypes and aligns with previous reports of variability in *A. hirtifolium* populations (Ghasemi Pirbalouti et al., 2015).

Sodium (Na) and potassium (K) concentrations also exhibited significant variation among ecotypes. The Hamadan ecotype accumulated the highest Na content (289 mg/kg DW), while the Isfahan ecotype had the lowest (168 mg/kg DW). For potassium, the Lorestan ecotype recorded the highest value (4602 mg/kg DW) and the Kurdistan ecotype the lowest (3503 mg/kg DW). These findings are consistent with Ebrahimi et al. (2008), who reported that the Sahneh population ranked first in potassium content, while the Divandareh population had the lowest. The potassium content of shallot in the present study is approximately 1.2 times higher than values reported for edible onions but lower than those for garlic (Salunkhe and Kadam, 1998). Regarding sodium, Ebrahimi et al. (2008) found that the Harsin population had the highest concentration (0.46 mg/100g) and the Khansar population the lowest (0.06 mg/100g). The sodium levels observed in this study are lower than those reported for edible onions, leeks, and scallions (Rubatzky and Yamaguchi, 1997), confirming that Persian shallot can be considered a low-sodium dietary component.

The concentration of palmitoleic acid, a minor fatty acid in shallot, was highest in the Chaharmahal and Bakhtiari ecotype (1.9%) and lowest in the Lorestan ecotype (0.45%). These values are consistent with previous reports indicating that shallot is not a significant dietary source of this particular fatty acid.

Iran possesses a rich diversity of native vegetables, yet the nutritional value of many species remains inadequately characterized. Persian shallot (*Allium hirtifolium*) is one such underutilized genetic resource.

The present study demonstrates that Iranian shallot populations contain essential fatty acids, including linolenic acid (Omega-3) and linoleic acid (Omega-6), along with important mineral elements such as potassium and sodium. The variation observed among ecotypes underscores the importance of comprehensively characterizing native germplasm to identify populations with superior nutritional traits.

## 5. Conclusion

The results of this study reveal substantial variation in dry matter, phenolic content, antioxidant activity, and mineral composition among five Iranian shallot ecotypes grown under uniform rain-fed conditions. The Lorestan ecotype demonstrated superior total phenol and potassium content, while the Hamadan ecotype exhibited the highest antioxidant activity and sodium content. These findings support the potential of Persian shallot as a valuable dietary source of bioactive compounds and essential minerals.

However, to fully elucidate the genetic potential of each population and eliminate the confounding influence of environmental conditions, further research should evaluate these ecotypes under controlled, uniform conditions across multiple locations and years. Such multi-environment trials would enable confident recommendations for the cultivation of specific genotypes tailored to particular nutritional or industrial applications, whether for dried product manufacturing, antioxidant-rich extracts, or mineral supplementation.

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