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Effects of planting times on the chemical compositions, antioxidant activity, and nutritional properties of *Allium jesdianum* Boiss. & Buhse leaves in Lorestan Province

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ABSTRACT

Aims: This study aimed to investigate the nutritional and phytochemical changes of *A. jesdianum* leaves on different planting dates.
Materials & Methods: The same wild bulbs were cultivated in October/January 2017 and harvested on April 25, 2018. Essential oils were analyzed by Gas Chromatography (GC) and Gas chromatography-mass spectrometry (GC-MS). Also, total protein, vitamin C, non-structural sugars, antioxidant activity, and nutritional elements of the shoots were measured.
Findings: The main compounds of the leaf essential oil in October, November, December and January were Dimethyl trisulfide (12.11%, 15.1%, 12.4% and 10.2%), dipropyl trisulfide (5.13%, 4.10%, 12% and 6.11%), D-2 Propenyl (1.15%, 2.14%, 13.7% and 9.12%) and hexadecanoic acid (11%, 8.10%, 9.8% and 3.5%), respectively. The results showed that the morphological traits of *A. jesdianum* in different planting dates have a significant difference($P > 0.05$). The highest germination (68.33%), shoot height (31.33 cm), root length (16.33 cm), aerial dry weight (3.50 g), bulb diameter (3.76 cm), bulb fresh weight (12.66 g), bulb dry weight (6.40 g), leaf length (24.4 cm) and leaf width (1.43 cm) were recorded in November plants. As well as bulbs cultivated in November had the highest amount of Potassium (13.7 $mg.g^{-1}$ DW), Iron (2.5 $\mu g.g^{-1}$ DW), Copper (0.43 $\mu g.g^{-1}$ DW), Zinc (2.1 $\mu g.g^{-1}$ DW), and Manganese (2 $\mu g.g^{-1}$ DW) compared to other planting dates. The highest amount of sugar (46.00 $mg.g^{-1}$ DW) and protein (8.96 $mg.g^{-1}$ DW) were obtained in January. The highest level of starch (54.33 $mg.g^{-1}$ DW) was obtained in December, and Vitamin C (86.33 $mg.100g^{-1}$ FW), Antioxidant potency (IC_{50}=37.00 $\mu g.mL^{-1}$), Phenolic (77.00 mg gallic acid.100 mg^{-1} DW), Flavonol (66.66 mg rutin.100 mg^{-1} DW), and Flavonoid (136.33 mg rutin.100 mg^{-1} DW) were obtained in the planted samples in November.
Conclusion: Although this study requires further research, the results indicated that planting this plant in November will be the most appropriate for the highest qualitative and quantitative yield of *A. jesdianum.*

Keywords: *Allium jesdianum*; Morphology; Nutritional elements; Planting date; Gas Chromatography-Mass Spectrometry.

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Introduction

Many people have recently been interested in using natural plant compounds. Consequently, different researchers have isolated these compounds from plants to eliminate pathogens and microorganisms. Moreover, plant crops are potentially suitable for the preservation of foods. As a result of changes in nutrition patterns and lifestyle, oxidized lipids negatively impact human organs, leading to increasing usage of synthetic antioxidants, like BHA and BHT given the adverse impacts of these materials on human health [1]. Therefore, the attention was increased to MAPs conservation, cultivation, and domestication [2].

With increasing diversity and the growth of human needs, the global demand for various aromatic and medicinal wild species has also increased. Subsequently, people still collect a large amount of aromatic and medicinal species from nature. Hence, when the demand for these species is increased, they will be destroyed and overexploited. Also, many of these plants have been vulnerable to extinction and destruction due to unsustainable and careless harvest [3]. The existence of few habitats, limited distribution, very low density, large and traditional use, and the role of these plants in the economy of the rural households, have led to unprocessed consumption and overexploitation of medicinal plants, and therefore, cultivation and domestication of these plants with high performance and preservation of their quality seem to be necessary [4]. The growth and development of medicinal plants and the production of active substances on them are influenced by genetic and environmental factors, and the maximum quantitative and qualitative yield is usually obtained when an appropriate combination of environmental factors for the plant is provided. Determining the appropriate planting date is one of the most important factors affecting the growth and yield of plants [5]. There is a suitable planting date for each plant, and its delay results in yield reduction [6]. Changing the planting date is associated with changing the day length, maximum and minimum temperature, relative humidity, and other environmental conditions during plant growth and growth. Phenological stages ultimately affect the quantitative and qualitative yield of the plant [5]. The aim of determining the planting date is to find the optimum planting time of a plant, so that the set of environmental factors at that time would be appropriate for the germination, establishment, and survival of the plant, and the plant will not encounter adverse conditions. The best sowing date results in higher yields than other planting dates [6]. The planting date is one of the critical factors influencing the length of vegetative and reproductive growth and their balance, as well as other factors of production, harvesting quality, and, finally, the yield. Different studies have been conducted on the *Allium* species to determine the appropriate planting date. Bulb yield, bulb diameter, bulb weight, and number of cloves in *Allium sativum* L. and *Allium cepa* L. were higher at November planting [7, 8].

Allium jesdianum Boiss. & Buhse belongs to the Alliaceae family, which grows in the Middle East, especially in the mountainous regions of Iran and Iraq. This plant is perennial and bulbous, usually consumed for its edible leaves in spring or as a dried vegetable in other seasons. Traditionally, the leaves of this plant are used to cook soup for the common cold and also for treating abdominal pain, rheumatism, and kidney stones [9, 10]. The antifungal effects of *A. jesdianum* extract have been reported [11]. Amiri, 2007 reported that trisulfide dimethyl (22.34%), Hexadecanoic acid (19.03%), Phytol (12.82%), Disulfide methyl-1-(methylthio) ethyl (9.25%), Pentacosane (8.03%), and Curzerene (7.62%) are the main compounds of *A. jesdianum* leaves [9].

The high medicinal and nutritional value

of *A. jesdianum* and its high profitability for indigenous farmers have resulted in the overexploitation of this plant in natural habitats and threatened its life. Hence, *A. jesdianum* is among the endangered species [12]. Therefore, due to the limited harvesting of this plant from natural habitats and the reduction of its species in recent years, basic studies should be carried out to cultivate this valuable plant in large areas. A literature review indicated that research has yet to be conducted on planting techniques of *A. jesdianum* as a medicinal plant, including determining the optimal planting date for this species. Hence, the present study, for the first time, investigates the impact of culture date on some morphological characteristics, physiological traits, nutrients, and active substances in the essential oil of this plant. Therefore, this study aimed to investigate the changes in essential oil composition, morphological characteristics, and medicinal-nutritional metabolites of *the A. jesdianum* plant on different planting dates.

Materials & Methods

A. jesdianum onions were harvested from the Kakareza habitat in the spring of 2017. Kakareza habitat is located in Aleshtar city, Lorestan Province, Iran, at a longitude of 48°19' 42'' and latitude of 33°44' 40'' an altitude of 2417 meters above sea level. The average annual rainfall in this habitat is 421 mm, the average annual temperature is 15.7, and its minimum and maximum temperatures are -7.4 and 43.4, respectively. The area from which the onions were harvested had a loamy soil with an acidity of 7.24, possessing 3.3% organic matter. Table 1 presents other soil characteristics. The collected onions were stored in a cool and dry place and planted in October/January

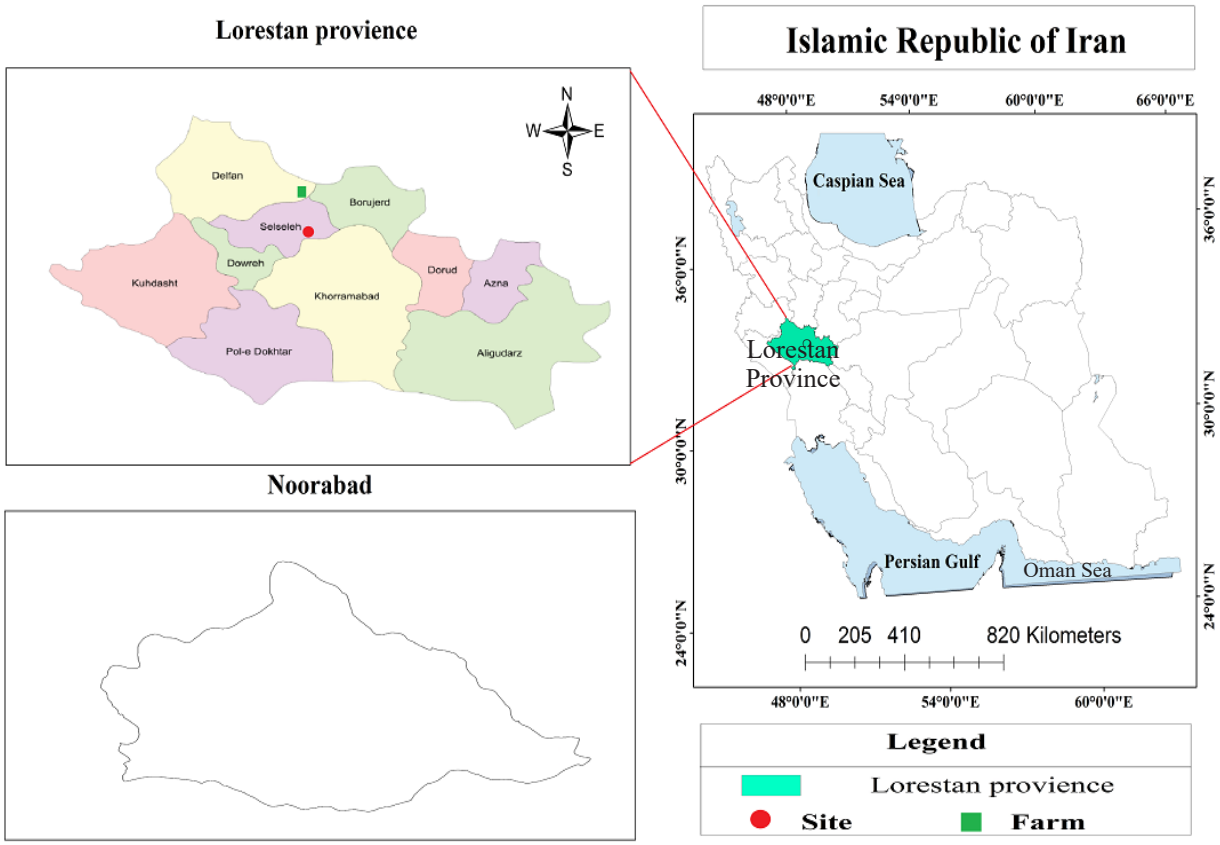

Figure 1) The geographical location of the A. jesdianum farm and habitat.

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2017 in Noorabad farm. The farm is located in Noorabad city, Lorestan province, at a longitude of 48°15' 19'', latitude of 34°00' 32'', and altitude of 2943 meters above sea level. The average annual rainfall in this region is 393 mm, the average annual temperature is 11.5, and the minimum and maximum temperatures are -18.8 and 11.5, respectively.

The experiments were done as a complete randomized design (CRD) with four replications. Planting was done in a row with a distance of 35 cm and the space of bulbs on the row was 20 cm in 2×1 m plots. In the following spring, sampling was done from the cultivated plants, and the samples were transferred to the laboratory for analysis objectives.

Morphological characteristics

The harvest time of *A. jesdianum* is early spring and at the beginning of blossoming. Considering that the vegetative organs of this plant have food and medicinal usages, so for evaluating the yield, we measured some morphological traits that affect the yield, including length and diameter of leaf, plant height, depth of root, fresh and dry weight of onion, and shoot fresh weight and dry weight in habitat and farm in spring at harvest time.

Physiological characteristics

Soluble protein in dry matter was extracted by the Bradford method. In order to measure the protein concentrations of study samples, the standard curve was plotted using different concentrations of BSA. Then 20 microliters of the extracted protein were mixed with 2 ml of 20% Bradford reagent, and after 5 minutes, the absorption of samples at the wavelength of 595 nm was read in a spectrophometer. The protein content of all samples was calculated in mg/g of dry weight [13].

The extract of samples was extracted by metaphosphonic acid from the fresh tissue and vitamin C of fresh tissue was measured by titration method with the reagent of 2,6- dichlorophenol indophenol. After calculating, the amount of vitamin C was obtained in ml per 100 g of fresh weight [14]. Using the Kochert method (1978) [15], non-structural sugars (starch and soluble sugars) contained in the dry matter of aerial organs of *A. jesdianum* were extracted, and a spectrophotometer measured the absorption of the resulting solution at 485 nm. The sugar values were calculated in $mg.g^{-1}$ of dry weight using a standard glucose curve.

Nutritional elements

Standard laboratory methods were used to measure macronutrient and micronutrient elements in the tissue of aerial organs of *A. jesdianum* so that Nitrogen was measured by Kjeldahl method and digestion in sulfuric acid; Potassium and phosphorous were measured by flame photometer, and micro-elements including iron, Manganese, copper and zinc were extracted from dry matter by Lindsay and Norvell (1978) method and their amount was measured by atomic absorption spectrometry [16].

Antioxidant capacity

The antioxidant capacity of the methanolic extract of the aerial part of *A. jesdianum* was measured based on neutralizing free radicals (2, 2-diphenyl-1-picrylhydrazyl). The absorption of samples against the sample of Blanc methanol and positive control of BHT, at 515 nm wavelength, was read using a spectrophotometer. The calculations were carried out using Eq. (1) [17].

$$\%\text{DPPH Scavenging} = [(A0 - A1)/A0] \times 100 \quad \text{Eq. (1)}$$

where A_0 is the control absorption number, and A_1 is the absorption of the solution included in the sample.

Then, results were reported based on IC_{50}; some antioxidants were required to reach a concentration of DPPH of 50% of the initial value.

Extraction and analysis of essential oils

After washing briefly with distilled water, the

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Table 1) Comparison of Physical and chemical characteristics of soil in habitat and farm.

Characteristic	Farm soil	Habitat
Texture	Loamy	Loamy
Clay (%)	13[a]	11[b]
Silt (%)	42[a]	40[d]
Sand (%)	45[b]	49[a]
EC ($dS.m^{-1}$)	0.62[a]	0.44[b]
pH	7.22[a]	7.24[a]
Organic Carbon (%)	3.18[b]	3.30[a]
Total Nitrogen (%)	0.62[a]	0.42[b]
Phosphorus (ppm)	29.67[b]	32.30[a]
Potassium (ppm)	625[b]	664[a]
Manganese (ppm)	5.94[a]	3.97[b]
Iron (ppm)	1.63[a]	1.60[b]
Copper (ppm)	1.60[a]	1.30[b]
Zinc (ppm)	6.60[a]	5.50[b]

Note: Different letters indicate statistically significant differences (Duncan's test, $p<0.05$).

Table 2) Analysis of variance (ANOVA) for the effect of planting dates on vegetative growth traits.

Vegetative Growth Traits	Sum of Square	df	Mean Square	F
Germination	2436.917	3	812.306	57.004**
Height	106.916	3	35.639	23.759**
Root Depth	17.538	3	5.861	5.410*
Shoot Fresh Weight	1.749	3	0.583	7.365*
Shoot Dry Weight	0.967	3	0.332	3.515*
Bulb Diameter	6.853	3	2.282	28.856**
Bulb Fresh Weight	41.000	3	13.667	6.074*
Bulb Dry Weight	13.816	3	4.605	8.502**
Leaf Length	89.000	3	29.667	10.788**
Leaf Width	0.417	3	0.139	9.804**

Note:* and ** are significant at 5% and 1% probability, respectively.

plants were dried in shade for 3 days. Then, 100 g of the dried sample was powdered by hand and poured into a 300 L flask connected to the Clevenger. Approximately 1000 ml of distilled water was added to the plant powder, and the essential oil operation was continued from the boiling time of water in the flask for 4 hours. The essential oil was collected in a small glass and was hydrated by sodium sulfate. The obtained essential oil was kept in darkness and the refrigerator at 4°c until the test time [9].

Identification of the extracted essential oil compounds was carried out by 0.5 µl injection of cyclohexane diluted essential oil to Agilent 6890A gas chromatography

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Table 3) Comparison of vegetative traits in different planting dates.

planting dates	Germination (%)	Height (cm)	Root Depth (cm)	Shoot Fresh Weight (g)	Shoot Dry Weight (g)	Bulb Diameter (cm)	Bulb Fresh Weight (g)	Bulb Dry Weight (g)	Leaf Length (cm)	Leaf Width (cm)
October	28.66^{c}	28.66^{b}	13.66^{b}	3.83^{b}	2.93^{a}	1.70^{c}	8.00^{b}	3.76^{b}	18.66^{b}	0.96^{b}
November	68.33^{a}	31.33^{a}	16.33^{a}	4.50^{a}	3.50^{a}	3.76^{a}	12.66^{a}	6.40^{a}	24.00^{a}	1.43^{a}
December	47.00^{b}	28.33^{b}	13.66^{b}	3.86^{b}	2.90^{a}	2.30^{b}	8.66^{b}	4.16^{b}	18.66^{b}	1.20^{b}
January	42.33^{b}	23.00^{c}	13.33^{b}	4.70^{a}	3.46^{a}	2.76^{b}	8.66^{b}	3.90^{b}	16.66^{b}	1.00^{b}

Note: Different letters indicate statistically significant differences (Duncan's test, $p<0.05$).

Table 4) The composition of the essential oils of A. jesdianum in different planting dates.

			(%)			
No	**Chemical Composition**	**RI**	**October**	**November**	**December**	**January**
1	Dimethyl Trisulfide	1178	12.11	15.1	12.4	10.2
2	Dimethyl Tetrasulfide	1215	7.6	8.5	6.7	8.8
3	Dipropyl Trisulfide	1299	13.5	10.4	12	11.16
4	Di-2-Propenyl Tetrasulfide	1376	15.1	14.2	13.7	12.9
5	Curzerene	1512	6.6	7.6	6.5	6.7
6	Methyl Tetradecanoate	1727	2.1	2.2	2.3	3.1
7	Tetradecanoic Acid	1770	6.5	5.4	5.3	7.5
8	Hexahydrofarnesyl Acetone	1844	2.1	3.2	-	2
9	Pentadecanoic Acid	1868	3.3	4.4	5.3	6.4
10	Methyl Hexadecanoate	1928	3.2	3.6	-	-
11	Hexadecanoic Acid	1963	11	10.8	9.8	5.3
12	Pentacosane	2011	6.8	8.7	6.7	4.4

Table 5) Analysis of variance (ANOVA) for the effect of planting dates on nutrients.

nutrients	Sum of Square	df	Mean Square	F
Nitrogen	14.489	3	4.830	103.494**
Phosphorus	3.803	3	1.268	38.025**
Potassium	16.060	3	5.353	79.309**
Iron	1.176	3	0.392	33.595**
Copper	0.018	3	0.006	29.375**
Zinc	0.183	3	0.061	4.056*
Manganese	1.506	3	0.502	33.257**

Note: * and ** are significant at 5% and 1% probability, respectively.

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machine containing HP-5 columns (length of 30 m, internal diameter of 250 µm and 25 µm thickness of stationary phase) connected to mass spectroscopy of Agilent 5973 [18].

Statistical analysis

The effect of different planting months on characteristics of *A. Jesdianum* was studied. In order to investigate the data normality, the normality test was performed using the Kolmogorov-Smirnov test. The variance was decomposed, and finally, in cases with significant variance decomposition, Duncan's test was conducted. All statistical analysis was done in SPSS version 21. All statistical analysis was done in SPSS version 21.

Findings

Morphological traits

Our findings showed that morphological traits, including the percentage of germination, plant height, the diameter of the bulb, bulb dry weight, and length and width of the leaf, had a significant difference at a 1% level. Traits of total root depth, fresh weight of the aerial organ, dry weight of the aerial organ, and fresh weight of bulb had a significant difference at 5% (Table 2).

Our findings showed a significant difference in the morphological traits of *A. jesdianum* plant in different planting dates (Table 3). According to the traits of germination of bulbs (68.33%), plant height (31.33 cm), root depth (16.33 cm), dry weight of aerial organ (3.50 g), bulb diameter (3.76 cm), fresh weigh of bulb (12.66 g), dry weight of bulb (6.40 g), leaf length (24.4 cm) and leaf width (1.43 cm) of cultivated bases in November were in favorable conditions than other months. Only the fresh weight of aerial organs (4.70 g) in cultivated bases in January was higher than in other months (Table 3).

Chemical compounds

Twelve chemical compounds were identified in the essential oils of the samples planted in October and November, and 10 and 11 chemical compounds were identified in the plants planted in December and January, respectively (Table 4). Samples of November have 5 compounds more than other months. The sum of identified compounds in the studied essential oil at the planting dates of October, November, December, and January were 89.91%, 94.1%, 80.7%, and 78.46%, respectively. The amount of the compounds in the essential oil of the plant during different planting dates of October, November, December, and January was dimethyl trisulfide (12.11%, 15.1%, 12.4%, and 10.2%), dipropyl trisulfide (5.13%, 4.10%, 12% and 6.11%), di-2-propenyl (1.15%, 2.14%, 13.7%, and 9.12%) and hexadecanoic acid (11%, 8.10%, 9.8% and 3.5%), respectively.

Nutritional elements

The results of the variance analysis of *A. jesdianum* nutrients at different planting dates (September, November, December, and October) are presented in Table 5. According to the results, nutrient elements of Nitrogen, Phosphorus, Potassium, Iron, Copper, and Manganese at 1% level and zinc at 5% level significantly differ in different planting dates (Table 5).

The comparison of the mean of nutrients of cultivated samples of *A. jesdianum* at different times (October, November, December, and January) is presented in Table 6. According to the results, all studied nutrients, except phosphorus, in the cultivated sample of November were more than in other months. In the cultivated samples of this month, the amount of Nitrogen (8.1 $mg.g^{-1}$ DW), Potassium (13.70 $mg.g^{-1}$ DW), Iron (2.5 $\mu g.g^{-1}$ DW), Copper (0.43 $\mu g.g^{-1}$ DW), Zinc (2.10 $\mu g.g^{-1}$ DW), and Manganese (2.00 $\mu g.g^{-1}$ DW). The highest amount of phosphorus (3.83 $mg.g^{-1}$ DW) was obtained in the cultivated sample in October (Table 6).

Physiological characteristics

The results of variance analysis showed that all of the investigated plant metabolites in the lead of cultivated *A. jesdianum* at different planting dates have a significant difference (Table 7).

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Table 6) Comparison of nutrients in different planting dates.

Planting Dates	Nitrogen (mg.g^{-1} DW)	Phosphorus (mg.g^{-1} DW)	Potassium (mg.g^{-1} DW)	Iron (µg.g^{-1} DW)	Copper (µg.g^{-1} DW)	Zinc (µg.g^{-1} DW)	Manganese (µg.g^{-1} DW)
October	5.83^{b}	3.83^{a}	11.13^{b}	1.93^{b}	0.36^{b}	1.76^{b}	1.56^{b}
November	8.16^{a}	3.53^{ab}	13.70^{a}	2.50^{a}	0.43^{a}	2.10^{a}	2.00^{a}
December	5.60^{b}	2.33^{c}	11.03^{b}	1.63^{c}	0.34^{b}	1.86^{ab}	1.03^{d}
January	5.50^{b}	3.33^{b}	10.93^{b}	2.10^{b}	0.34^{b}	1.96^{ab}	1.33^{c}

Note: Different letters indicate statistically significant differences (Duncan's, $p<0.05$).

Table 7) Analysis of variance (ANOVA) for the effect of planting dates on some metabolites and antioxidant activity.

Metabolites and Antioxidant Activity	Sum of Square	df	Mean Square	F
Soluble Sugar	359.583	3	119.861	55.321**
Starch	1166.667	3	388.889	133.333**
Total Protein	58.089	3	19.363	704.111**
Vitamin C	3004.667	3	1001.556	600.933**
DPPH	3235.667	3	1078.556	258.853**
Total Phenole	398.333	3	132.778	38.562**
Flavenol	88.667	3	29.556	4.926*
Flavonoids	708.583	3	236.528	19.988**

Note: * and ** are significant at 5% and 1% probability, respectively.

Table 8) Comparison of some metabolites and antioxidant activity in different planting dates.

planting dates	Soluble sugar (mg.g^{-1} DW)	Starch (mg.g^{-1} DW)	Total protein (mg.g^{-1} DW)	Vitamin C (mg.100 g^{-1} FW)	DPPH (IC_{50}; µg.mL^{-1})	Total Phenole (mg gallic acid.100 mg^{-1} DW)	Flavenol (mg rutin.100 mg^{-1} DW)	Flavonoids (mg rutin.100 mg^{-1} DW)
October	34.66^{b}	31.66^{c}	4.63^{c}	81.00^{b}	41.66^{c}	65.00^{b}	63.66^{ab}	122.66^{b}
November	33.66^{b}	33.00^{c}	4.20^{d}	86.33^{a}	37.00^{d}	77.00^{a}	66.66^{a}	136.33^{a}
December	44.00^{a}	54.33^{a}	8.63^{b}	50.66^{d}	68.33^{b}	64.33^{b}	60.33^{b}	115.66^{c}
January	46.00^{a}	49.00^{b}	8.96^{a}	54.00^{c}	75.00^{a}	62.33^{b}	60.00^{b}	120.33^{bc}

Note: Different letters indicate statistically significant differences (Dunn's test, $p<0.05$).

The results of the comparison of the average of *A. jesdianum* metabolites in different planting dates are presented in Table 8. According to the results, the highest amount of sugar (46.00 mg.g^{-1} DW) and protein (8.96 mg.g^{-1} DW) was obtained in January. The highest level of starch (54.33 mg.g^{-1} DW) was obtained in December, and Vitamin C (86.33 mg.100g^{-1} FW), Antioxidant potency (IC_{50}= 37.00 µg.mL^{-1}), Phenolic (77.00 mg galic Acid.100 mg^{-1} DW), Flavonol (66.66 mg rutin.100 mg^{-1} DW), and Flavonoid (136.33 mg rutin.100 mg^{-1} DW) were obtained in the planted samples in November.

Discussion

The highest level of morphological characteristics of the cultivated *A. jesdianum* occurs in November, after which it is reduced. In other words, the delay in cultivation leads to this

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decrease. These results are consistent with the research on different plants [5, 7]. Adekpe et al. (2007) indicated that to achieve higher yield in the plant, the planting time should be such that most of the vegetative growth stage would be under short photoperiod conditions and cool air [7]. A delay in planting caused a decrease in bulb growth and reported a 40% reduction in garlic yield by delaying planting from November to December. This study indicated that dimethy1 trisulfide, dipropy1 trisulfide, di-2-propenyl tetrasulfide, and hexadecanoic acid are the significant components of *A. jesdianum* essential oil. In Amiri's study (2007), Hexadecanoic Acid, Pentacosane, and Curzerene were introduced as the significant components of *A. jesdianum* essential oil, consistent with this study's results [9]. Sakka Rouis-Soussi et al. (2014) introduced Hexadecanoic Acid as one of the major compounds of the species *A. nigrum* of the same species of *A. jesdianum* is similar to our research in the dominant combination of hexadecanoic acid [19]. The results of Lopes et al. (1997) on *A. tuberosum* leaf essential oils showed that 84% of the essential oil content was formed by sulfide compounds such as 1-(methylthio) alk (en)yl disulfide and allyl-1-(methylthio)ethyl disulfide [20]. This research and previous studies indicate a high percentage of sulfur compounds in *Allium* species. Regarding nutrients, the cultivated bases in November had more nutritional elements than other cultivations. It can be argued that the delay in planting *A. jesdianum* and delaying planting in the late autumn (December) and early winter (January) due to environmental conditions leads to decreased plant nutrient elements. On the other hand, cultivation sooner than the due date (October) also does not increase the nutritional parameters of the *A. jesdianum*. By studying the effects of planting date on the growth and performance of onion (*Allium cepa* L.), Ikeda et al. (2019) stated that delay in planting time reduced the quality indices of this plant, which is consistent with the results of this study [8]. Ikeda et al. (2019) believe that with the delayed planting time, the *A. cepa* performance drops sharply, which is consistent with the results of this research [8]. In the investigations in the present research, it was found that the shoot fresh weight and shoot dry weight in plants planted in November showed a higher yield compared to other months, and delay in planting resulted in a significant reduction in yield. According to Ikeda et al. (2019), the decline in this performance is the decrease in the length of the growth period and the lack of conformity of the climatic factors affecting the production, such as the correlation of flowering time with the temperature [8]. The results also indicate changes in metabolites at different times of planting. According to Oloyede et al. (2014), the effect of different planting times on the amount of active ingredient in *Cucurbita pepo* L. Gaerate showed that the cultivation date had a significant effect on phenol and flavonoid and antioxidant activity, which is consistent with the results of the present study [21]. Of the eight metabolites of *A. jesdianum* examined in the study, six were more frequent in the samples planted in November than in other times. In addition to genetic control, the biosynthesis of secondary metabolites is strongly influenced by environmental factors; in this regard, suitable planting dates lead to the maximum product. Therefore, it may be possible to change the cultivation date so that the different stages of plant development with suitable environmental conditions during the growing season are well adapted and achieve the desired quality and quantity performance. Considering the same conditions affecting the range of *A. jesdianum* cultivation, including soil characteristics and irrigation, in terms of environmental conditions such as day length, sunshine, and other climatic parameters in November, improved the

metabolites at that time. No research was found on the impact of planting date on the amount of secondary metabolites and active substances in *Allium* species. However, there are some reports on the impact of environmental conditions on the amount of active substances and medicinal properties in different plants. Studies have shown that changes in environmental conditions, including temperature, humidity, and soil's chemical and physical composition, are among the most important factors affecting changes in plants' secondary metabolites and active substances [22,23].

Most of the environmental factors primarily affect the plant's primary metabolism and secondary metabolism is also affected. The effect of different factors can be attributed to changes in the fitness of plant organs, functions of metabolites per unit of dry weight, and the ratio of the components of secondary metabolites in the plant [24].

Conclusions

Significant differences in chemical composition, antioxidant properties, nutrients, and some morphological and physiological characteristics of *A. jesdianum* were caused by the planting date. Despite the need for further surveys on this research in the future, the results obtained up to now suggest that the best time for planting *A. jesdianum* is November, and the plants planted in this month provide the highest quantitative and qualitative yield. The present research data are consistent with the development of cultivation and cultivation of *A. jesdianum*. They help protect this valuable species against the risk of extinction and reduce the pressure of its uncontrolled harvest from nature. They are also effective in improving the nutritional status and health of the community due to their different medicinal and food usage.

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