Romanian Biotechnological Letters *Vol. 20, No. 4, 2015*

ORIGINAL PAPER

Floral Fragrances of Daffodil under Salinity Stress

Received for publication, 20 December 2014
Accepted, 26 April 2015

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Abstract

Daffodil is a valuable plant for the cosmetic, pharmaceutical, therapeutical and industrial traits, and become an important in the Mediterranean region of Turkey. The volatile compounds of daffodil flowers were compared using HS/SPME-GC/MS (Headspace/Solid Phase Micro Extraction-Gas Chromatography Mass Spectrometry) techniques grown in different salinity stress (0, 10, 20, 30, 40 mM NaCl) conditions. In the study 38 volatiles compounds were detected depending on the salinity treatments. The detected compounds belong to aldehydes, alcohols and terpenes chemical classes. It was pointed out that the presence and concentrations of 14 terpenes were influenced by the used salt concentrations. Monoterpenes were major component among the terpenes. Ocimene, myrcene, δ-3-carene and α-pinene among the moneterpenes were detected in higher percentages. In conclusion, a decrease in the total aldehyde and alcohol content was determined in daffodil flowers; whereas, an increase was identified in terpenes (mostly monoterpenes) under salinity stress. The most remarkable decrease ratio was determined to be hexanal as aldehydes and 3-hexen-1-ol as alcohols. On the other hand, the most remarkable increase ratio was found to be ocimene content as monoterpenes under higher salinity stress condition. Ocimene content, with 80.91 %, in the 40 mM NaCl which is the highest salinity stress, was significantly found high at a remarkable rate.

Keywords: *Bulbous plants, Flower volatiles, HS/SPME-GC/MS, Narcissus pseudonarcissus, NaCl.*

Introduction

The ornamental plants production is increasing year by year worldwide, due to the having their aesthetics and odor characteristics. Today, even though they are odorless, most of the types of the roses, chrysanthemums and carnations have commercial value due to the long vase life. However, there are also such varieties as lilium and daffodil flowers whose vase lives are relatively long and which are fragrant (1). Aromatic volatile compounds emitted from the flowers have a very pleasant effect on human olfactive system (2). Daffodil flowers having a pleasant scent are used in the composition of some perfumes and cosmetics. On the other hand, scent of flowers is also significant in terms of the activities of pollinator insects and their behavior of visiting flowers (2, 3, 4).

Salinity is one of the most significant environmental stress factors limiting the growth and productivity of the plants (5). Salinity of soil or irrigation water leads to visual damage and

quality losses by adversely affecting plant growth (6, 7, 8). On the other hand, the world is facing a water shortage that brought in attention the use of alternative water sources with a high salt for the irrigation of ornamental plants (9, 10). The producers of ornamental plants avoid the use of poor quality water as they consider that the types of ornamental plants are sensitive to salt during the production process. Therefore, it is highly significant to identify the responses of the flowers to the salinity stress (11). The effect of the salinity damage on plants arises as a result of the interaction of morphological, physiological and biochemical processes available in the plant (5).

In previous studies, it was determined that essential oil content or the composition of odor-aromatic constituents has increased under salinity conditions in many different types of plants (12). It was determined that in such plants as basil (*Ocimum basilicum*) (13), sage (*Salvia officinalis*) (14) and rosemary (*Rosmarinus officinalis*) (15), there is an increase in the essential oil content and the main components under the increasing salinity stress. An increase in the essential oil concentration in the plants compared to the untreated control plants suggests that essential oil synthesis and/or degradation processes are not susceptible to salinity stress (16). Besides, variations occurring in the essential oil composition under salinity stress are thought to be associated with the plant defense mechanism against harmful effects of salt. It was reported that variation observed in oxygenated components are associated with defense mechanisms as opposed to active oxygen species (AOS) favorised by salinity stress (17). However, different types of plants can react differently under salinity stress. In the literature, it was mentioned that the amount of essential oil under salinity stress decreases in chamomile (*Matricaria chamomile*), (18), lemon balm (*Melissa officinalis* L.) (19), sage (*Salvia officinalis*) (12), and safflower (*Carthamus tinctorius* L.) (17).

About 35-70 varieties of daffodil are known (20). Many of these varieties are found in Mediterranean countries (4). *Narcissus pseudonarcissus* cv. 'Ice Follies' is typically included in 'Large cupped daffodil flowers' or 'Long cupped daffodil flowers' groups (21, 22). Daffodil flowers are used in perfumes (23), cosmetics and pharmaceuticals aspects (2) as they contain volatile components. So far, various chemical studies have been conducted for the determination of the volatile components available in daffodil flowers (24, 1). Nevertheless, these studies have been limited to only a few taxons and some varieties. However, there are no studies regarding the volatile components of many of the daffodil types (4). As far as we know, this study is considered as the first one related to the effect of the salinity in daffodil flowers on volatile components. The aim of the present study was to determine the volatile components through HS/SPME-GC/MS (Headspace/Solid Phase Micro Extraction-Gas Chromatography) method in the *Narcissus pseudonarcissus* cv. 'Ice Follies' flowers grown under salinity conditions.

Materials and Methods

2.1. Plant material, growth conditions and treatments This study was conducted in greenhouses at the University of Cukurova, Department of Horticulture in Adana/Turkey. In this study *Narcissus pseudonarcissus* cv. 'Ice Follies' bulbs were used. Daffodil bulbs were grown in black plastic pots which were 10x10x11 cm and had a volume of 0.8 l with peat medium. Salt treatments started at time close to the plants to blossom.

Five salinity treatments (0, 10, 20, 30, 40 mM of NaCl) were applied for two weeks with two days intervals as 20 ml for each treatment. The treatments have been carried out from the top of soil without being leak from the pots.

Flowers were collected from the potted plants when flower heads were fully opened. Fragrance samples were collected from flower petals, using headspace sorption techniques.

Flowers of daffodil volatile compounds, HP were determined using HS/SPME-GC/MS (Headspace/Solid Phase Micro Extraction-Gas Chromatography).

2.2. SPME analysis of volatile compounds A Supelco fiber holder (Bellefonte, PA-USA) and a 100 µm polydimethylsiloxane (PDMS) coated fused-silica fiber were used due to the most suitable fiber for adsorbing volatiles compound from the daffodil petals. Prior to first extraction, the fiber was conditioned in the GC injector port at 250 ºC for 1h according to manufacturer's recommendation. HS-SPME techniques were used in the extraction of the volatile compounds. Daffodil petals were homogenized with saturated sodium chloride (1g) for HS-SPME and 5g of sample for each extraction was placed into an 100 ml glass vial. In HS-SPME analysis, the PDMS fibre was inserted into the headspace of the glass vial and PDMS fibre was immersed into the sample during 30 min at 30ºC. During this time samples of daffodil petals were stirred with a magnetic stirrer. After equilibration the fibre was removed from the sample and the analytes were thermally desorbed in the injector port of the GC/MS instrument for analysis. Thermal desorption in the injector glass liner at 250ºC, for 10 min. The analyses were carried out in triplicate.

2.3. GC/MS analysis of volatile compounds Aroma compounds of the daffodil petals were analysed by GC-MS. A Perkin Elmer Clarus apparatus equipped with CPSil5CB (25 m x 0.25 mm i.d., 0.4 µm film thickness) fused-silica capillary column was used. The flow rate of helium as carrier gas was 1 ml/min. The injector temperature was 250ºC, set for splitless injection. The column temperature was 60ºC//5ºC/min//260ºC for 20min. Mass spectra were taken at 70eV. Mass range was between m/z 30-425. A library search was carried out using the Wiley GC-MS Library and Flavor Library of Essential Oil Constituents. The mass spectra were also compared with those of reference compounds and confirmed with the aid of retention indices from published sources. Relative percentage amounts of the separated compounds were calculated from total ion chromatograms by the computerized integrator.

Results and Discussions

Volatile components of *Narcissus pseudonarcissus cv.* 'Ice Follies' petal leaves which were determined through HS-SPME/GC/MS techniques are presented in table 1. In this study, 38 different volatile components were found in total, their detection varied among treatments. The number of volatile components detected in the petals of daffodil flowers 0 (control), 10, 20, 30, 40 mM NaCl treatments are 17, 20, 15, 15 and 16, respectively. In this study, the volatile compounds detected in daffodil flowers belonged to aldehydes, alcohols and terpenes groups. Besides, volatile components included in the other chemical groups were also presented in table 1 as minor compounds.

Volatile components identified in the aldehydes were determined to be hexanal, benzaldehyde and pentanal. The changes in the amount of these components under salinity stress were detected. The decrease in the amount of hexanal which is in the aldehyde group is worth considering. Compared to the control group, hexanal content was decreased at the respective rates of 99.7, 88.1 and 73.7 l % in 10, 20 and 30 mM NaCl treatments. Hexanal was not detected in 40 mM NaCl which was the highest salinity stress applied in this study.

Regarding the alcohol group, 6 different components (3-hexen-1-ol, linalool, lauryl alcohol, cyclopentanol, benzenemethanol and cyclobutanol) which vary according to the treatments were determined. Among alcohols, 3-hexen-1-ol was identified as the major component. The amount of 3-hexen-1-ol was significantly reduced by salinity stress. When

compared to the control group, 3-hexen-1-ol content decreased approximately 1.2, 1.7 and 33.9 times in 10, 20 and 30 mM NaCl treatments, respectively. However, 3-hexen-1-ol was not determined in 40 mM NaCl. Linalool which is one of the alcohols was not detected in the control and 40 mM NaCl treatments. However, in other NaCl concentrations (10, 20 and 30mM), the amount of linalool decreased in parallel to the stress level. While lauryl alcohol, cyclopentanol and benzenemethanol were determined under some salinity treatments, cyclobutanol was only identified in control treatments.

Table 1. The volatile compounds (%) of daffodil flowers under salinity stress.

Volatile Compounds	*NaCl Concentrations (mM)*				
	0	**10**	**20**	**30**	**40**
ALDEHYDES					
hexanal	9.42	0.03	1.12	2.48	nd
benzaldehyde	nd	1.63	nd	nd	2.43
pentanal	nd	nd	nd	0.45	nd
ALCOHOLS					
3-hexen-1-ol	9.35	8.16	5.68	0.28	nd
linalool	nd	0.77	0.49	0.18	nd
lauryl alcohol	nd	1.37	nd	0.33	nd
cyclopentanol	nd	nd	nd	0.57	nd
benzenemethanol	nd	nd	nd	nd	0.27
cyclobutanol	0.56	nd	nd	nd	nd
TERPENES					
Moneterpene					
ocimene	20.23	7.65	44.88	38.78	80.91
myrcene	5.61	14.99	4.94	6.32	1.83
δ-3-carene	7.12	22.82	2.52	nd	nd
α-pinene	6.93	7.56	4.55	6.57	nd
dI-limonene	2.71	2.6	nd	nd	nd
α-terpinene	0.43	nd	0.57	0.81	2.2
terpinolene	nd	3.03	nd	nd	0.74
sabinene	nd	1.66	nd	nd	1.47
p-cymene	nd	nd	nd	nd	0.41
Sesquiterpene					
α-farnesene	0.18	nd	0.55	0.22	0.26
β-selinene	0.31	nd	nd	nd	nd
Diterpene					
5,5-dimethyl-1,3-cyclopentadiene	0.37	nd	nd	nd	nd
Triterpene					
bergamotene	0.71	1.25	0.93	1.03	0.21
2,6-dimethyl-2,4,6-octatriene	nd	nd	9.35	14.50	nd
MINOR COMPOUNDS					
Acids					
benzoic acid	nd	0.55	nd	nd	nd
Alkane					
3-heptene	nd	3.23	nd	nd	nd
3-ethylidenecycloheptene	nd	0.61	nd	nd	nd
n-dodecane	nd	nd	nd	nd	0.24
Esters					
neryl acetate	0.57	nd	nd	nd	nd
Nitrogen compounds					
dimethyl pyrazine	nd	0.26	nd	nd	nd
2,6-dimethyl, pyrazine	nd	0.06	nd	nd	nd
phenols					
phenol	0.93	2.66	1.45	1.87	0.48
Keton					
3,3-dimethyl-4-methylamino-butan-2-one	nd	nd	0.89	nd	nd
2-(1-hydroxyethyl)-cyclohexanone	nd	nd	0.68	nd	nd
1-(2-methylphenyl)-ethanone	nd	nd	nd	nd	0.11

Alkyne					
2-ethyl-1-octen-3-yne	nd	nd	nd	nd	0.47
Hydrocarbon					
Benzene	3.96	3.14	13.38	18.6	3.16
1,5,5-trimethyl-6-methylene-cyclohexene	nd	nd	nd	nd	0.25
Heterocyclic organics					
4-ethyl-pyridine	3.92	nd	nd	nd	nd
Others	26.69	15.97	8.02	7.07	4.56

Values: volatile compounds detected from HS/SPME-GC/MS
nd: not detected

Depending on the treatments in the terpene group, 14 different volatile components (ocimene, myrcene, δ-3-carene, α-pinene, dI-limonene, α-terpinene, terpinnolene, sabienene, p-cymene, α-farnesene, β-selinene 5,5-dimethyl-1,3-cyclopentadiene, bergamotene, 2,6-dimethyl-2,4,6-octatriene) were detected. As seen in Table 1, it was observed that monoterpenes are the major components in terpene group. Nine volatile components within the monoterpene group, two volatile components in sesquiterpene and triterpene group, and just one volatile component in diterpene group were found.

Ocimene, myrcene, δ-3-carene and α-pinene were identified as major components within the monoterpenes. As a result of the study, it was found that the content of monoterpenes varies depending on salinity stress and, it has completely disappeared in some treatments. Ocimene and myrcene have been identified in all treatments. A change in ocimene content under salinity stress has been taken into account. When ocimene content is compared to the control group, it was found that it approximately decreased 2.6 times in 10 mM NaCl treatment; whereas it increased 2.2, 1.9 and 4.0 times in 20, 30 and 40 mM treatments, respectively. Ocimene content under the highest salinity stress (40 mM NaCl) was found to be higher at the remarkable rate of 80.91% compared to the control and other salinity treatments. The amount of myrcene which is the other major monoterpene changed under salinity stress. While the highest amount of myrcene (14.99%) was determined in 10mM NaCl treatment, the lowest amount of it (1.83%) was found in the 40 mM NaCl treatment. Compared to control group, 167% increase in the amount of myrcene under salinity stress was observed in 10 mM NaCl treatment. In contrast, 88% decrease was observed in 40 mM NaCl treatment compared to the control. In δ-3-carene content, the highest value was found in 10 mM NaCl treatment with the rate of 22.82%. When compared to the control, δ-3-carene content was found to be 3.2 times higher in 10 mM NaCl treatment. In addition, α-pinene was observed in all treatments except for 40 mM treatment which is the highest salinity stress condition. The other monoterpenes such as dI-limonene, α-terpinene, terpinolene and sabinene were determined in varied proportion depending on the treatments, and they were not found in some treatments. P-cymene was only observed in 40 mM NaCl treatment.

In sesquiterpene group, the α-farnesene was observed at low level under salinity conditions except for 10mM NaCl treatment. On the other, β-selinene was detected only in the control treatment. Likewise, 5,5-dimethyl-1,3-cyclopentadiene which is a diterpene was only found in the control group. In triterpene group, bergamotene was identified in all treatments. 2,6-Dimethyl-2,4,6-octatriene was detected with the respective rates of 9.35% and 14.5% in the 20 and 30 mM NaCl treatments while it was not determined in the other treatments (table 1).

In the present study, some minor components were determined as in acid, alkane, ester, nitrogen compound, phenol, ketone, alkyne, hydrocarbon and heterocyclic organic groups (table 1). Some changes in the composition and quantity of the minor components were determined under salinity stress. Some compounds were only detected in some NaCl concentrations. Neryl acetate and 4-ethyl-pyridine were only determined in the control group. Benzoic acid, 3-

heptene, 3-ethylidenecycloheptene, dimethyl pyrazine, 2,6-dimethyl, pyrazine which were not detected in the other treatments were determined under 10mM NaCl. On the other hand, as salinity stress is 20 mM NaCl, two compounds (3,3-dimethyl-4-methylamino-butan-2-one and 2-(1-hydroxyethyl)-cyclohexanone) which has not existed in the other treatments were determined. Under the highest salinity stress (40mMNaCl), four different compounds (n-dodecane, 1-(2-methylphenyl)-ethanone, 2-ethyl-1-oct-3-yne and 1,5,5- trimethyl-6-methylene-cyclohexane) which have not been observed in the other treatments were found. The phenol and benzene are defined as the common components of all NaCl treatments.

Among the minor components, 3-heptene available in the alkane group was found remarkable with 3.23% (only determined in 10 mM NaCl treatment). Besides, a significant increase was determined in the benzene content being in hydrocarbon group under salinity stress. Amount of benzene was found close to the control group in 10 and 40 mM NaCl treatments while it was determined to be 3.4 and 4.7 times higher compared to control in 20 and 30 mM NaCl treatments, respectively (table 1).

As a result of the research, total aldehyde content of daffodil flowers significantly decreased under salinity stress (figure 1). The total content of aldehyde was found to be the highest in the control group with 9.42%. Under the salinity stress, it was found at the respective rates of 1.66, 1.12, 2.93 and 2.43% in 10, 20, 30 and 40 mM NaCl treatments. When total aldehyde content is compared to the control group, 5.7, 8.4, 3.2 and 3.9 times decrease was determined in 10, 20, 30 and 40 mM NaCl treatments.

Based upon the obtained results, the total alcohol content in daffodil flowers had a significant decrease under salinity stress (figure 2). Accordingly, total alcohol content was respectively determined as 9.91, 10.30, 6.17, 1.36 and 0.27 in 0 (control), 10, 20, 30, and 40 mM NaCl treatments. When compared to the control group, it was determined that the total alcohol content increased 1.1 times in 10 mM NaCl treatment; whereas, it decreased approximately 1.6, 7.3 and 36.7 times in 20, 30 and 40 mM NaCl treatments, respectively.

Under salinity stress, a decrease in the total aldehyde and alcohol content was determined in daffodil flowers; whereas, an increase was identified in terpenes which are the most important components. Different trends (increase or decrease) in the volatile components of the terpene group were observed depending upon the level of NaCl. On the other hand, considering the total terpene content, the influence of the NaCl treatments is clearly seen (figure 3). Thus, total terpene content was identified as 44.6, 61.6, 68.3, 68.2 and 89.0%, respectively in the 0 (control), 10, 20, 30 and 40 mM NaCl treatments. Compared to the control treatment, an increase in the total terpene was determined to be 38, 53, 53 and 100% respectively in 10, 20, 30 and 40 mM NaCl treatments.

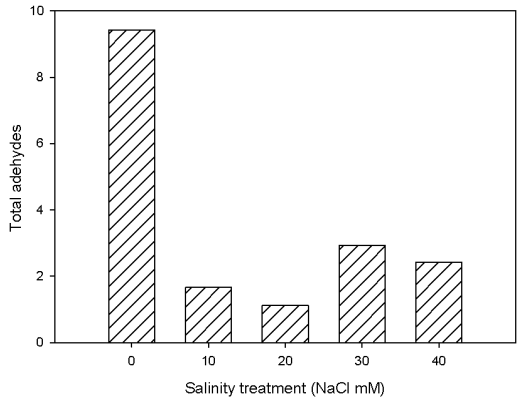

Figure 1. Changing of total aldehydes (%) of daffodil flowers under salinity

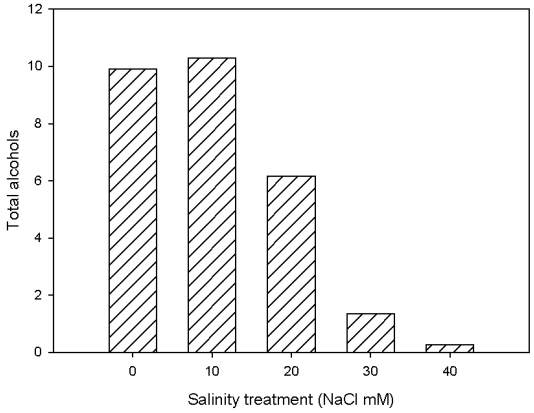

Figure 2. Changing of total alcohols (%) of daffodil flowers under salinity

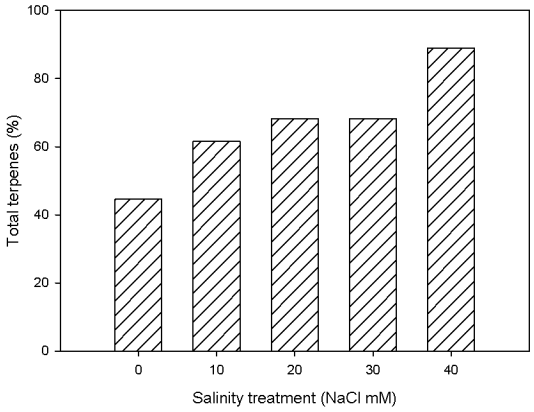

Figure 3. Changing of total terpenes (%) of daffodil flowers under salinity

Daffodil is a kind of flower used in the cosmetic industry as it has a strong fragrance (23). However, very limited previous studies carried out for the determination of the volatile compounds of daffodil flowers. There are some differences caused by various factors among volatile components which have been identified in daffodil flowers so far. In general, various factors such as geographic origin, environmental factors (25), genotype (4, 26, 27), phenological stage (28, 29) season, daily rhythms (30), the sampling method (12), and the extraction method have an effect on the amount and profiles of volatile components in the leaves or in the flowers of the plant.

DOBSON & al. (4) stated that trans-β-ocimene is the major component in 6 of 9 different daffodil flowers. Similarly, in our study, ocimene was identified as the major component. On the other hand, SURBURG & al. (31) reported that trans α-farnesene and various benzoyl ethers in *N. bugei* are dominant. HUANG & FENG (32) identified 55 aroma compounds such as benzaldehyde, limonene, linalool, benzyl acetate in fresh daffodil flowers. SONG & al. (2) presented 27 compounds in the fresh Chinese daffodil (*Narcissus tazetta* Chinensis) through HS-SPME/GC-MS technique. Among these components, acetic acid phenethyl ester, E-ocimene, acetic acid benzyl ester, neo-allo-ocimene, *allo*-ocimene, α-linalool, 1,8-cineole, benzenepropyl acetate, and 3-methyl-2-buten-1 ol acetate were identified as dominant compounds. MOOKHERJEE & al. (23) ascertained benzyl acetate, 3,4 and 3,5-dimethoxy toluene and indole as major components during the pre- and postharvest in daffodil flowers.

Parallel to the previous studies, various components such as benzaldehyde, limonene, linalool, ocimene, α-farnesene were found in our study. Nevertheless, in daffodil flowers in the control group, such compounds as hexanal, 3-hexen-1-ol, ocimene, myrcene, δ-3-carene, α-pinene, dI-limonene were determined as a major compound.

Soil and/or salinity in irrigation lead to serious problems in plant growth. When the effects of salinity are considered in terms of ornamentals its impact on the aesthetic and quality is becoming much more significant. One of the most important values of flowering and aromatic plants is essential components. However, as far as we know, it is the first study in which the effect of salinity stress on volatile components in daffodil flowers has been examined. Therefore, it is not possible to make a comparison of the effects of salinity stress upon volatile components of daffodil flowers. However, in many plants under saline conditions, changes in the aroma and volatile components were emphasized in many studies (14, 15, 16, 17, 33, 34).

In the previous studies, changes (increase or decrease) in major volatile components which are unique for those plants were primarily observed in the plants under salinity stress. TRAAIT & al. (33) reported that the effect of salinity stress on clary sage (*Salvia sclarea* L.) may occur in such major components as germacrene-D α-thujone and α-thujone. In another study, TRAAIT & al. (12) mentioned that in the oil obtained from the sage leaves (*Salvia officinalis* L.), salinity stress (75 mM) provides an increase in the major components (α and β-thujone, 1,8-cineole, camphor, α-humulene, viridiflorol and manool). It was reported by KARRAY-BOURAOUI & al. (35) that being the major component, menthone increased in *M. pulegium* under salinity stress. KHALID &TEIXEIRA da SILVA (16) determined thatsaline irrigation water in *Calendula officinalis* provides an increase in the rates of the main components (α-cadinol, γ-cadinene, Δ-cadinene) with the essential oil yield. In parallel to the previous studies, in our study, the most significant changes were observed in the major components.Accordingly, salinity stress in daffodil petals has led to a decrease in hexanal and 3-hexen-1-ol and, an increase in ocimene, myrcene, δ-3-carene and α-pinene. These results reveal that essential oil components are affected by environmental factors particularly by salinity stress. The most important change in the major components under salinity stress can be associated with the activation of the related enzymes. The activities of the enzymes responsible for the biosynthesis of the major components increase under salinity stress are known (12).

As a result of the study, it was determined that some of the components identified in the control treatment are increased or reduced by salinity stress. Besides, some of the components which are not specified in the control treatment were determined to be caused by salinity stress. The composition of the essential oil components of the plants can vary under environmental stress factors. The changes observed in oxygenated components compared to active oxygen species (AOS) encouraged by salinity stress are known to be associated with the plant defense mechanism (17). HARRATHI & al. (17) expressed that an increase was observed in oxygenated components such as linalool and Z-3-hexenol under salinity stress. In similarly, in this study the components like linalool, lauryl alcohol, cyclopentanol, benzenemethanol which were not determined in the control treatment were detected in different NaCl levels. In addition, despite a decrease in the level of 3-hexen-1-ol depending on the level of NaCl, It has been relatively preserved under 10mM salinity stress.

In the current study, it was determined that monoterpenes are dominant components in the daffodil flowers. Our study had similar results with those reported by DOBSON & al. (4). Researchers found out that monoterpene and benzenoid were found dominant in 9 different daffodil types collected from Southern Spain, except for one type (4). Our study suggests that salinity stress increases the amount of monoterpenes. Similarly, EL KELTAWI &CROTEAU

(36)stated that salinity stress has a positive effect on monoterpene composition in spearmint (*Mentha spicata*) and marjoram (*Majorana hortensis*). KARRAY-BOURAOUI & al. (35) determined that monoterpenes (such as pulegone and neomenthol) increased under salinity stress in *M. pulegium* plant. TRAAIT & al. (12) identified that depending upon NaCl concentrations, monoterpenes (ocimene, myrcene, δ-3-carene, α-pinene, α-terpinene, terpinolene, sabinene, p-cymene) increased in sage oil.

Conclusions

In the current study, 38 different volatile components were found in total in *Narcissus pseudonarcissus* cv. 'Ice Follies' flowers under salinity stress, which change depending on the treatments. Some changes in the number of the volatile components in daffodil flowers under salinity stress were observed. Some volatile components were reduced by the effect of salinity stress or completely destroyed. However, many components such as linalool, lauryl alcohol, cyclopentanol and benzenemethanol which were not identified in control treatment were determined under salinity stress.

In the study, it was determined that volatile components intensively specified in the daffodil flowers are in the aldehyde, alcohol and terpene groups. In addition, some volatile components included in the other chemical groups were determined. Despite the decrease in the total aldehyde and alcohol content, an increase in terpenes which are the most important volatile components was determined. The most remarkable volatile component among aldehydes was determined to be hexanal. Besides, among alcohols, 3-hexen-1-ol was found to be the major one and it was decreased with salinity stress. As a result of the study, the most significant changes were identified in terpene group. Total terpene content was respectively determined as 44.6, 61.6, 68.3, 68.2 and 89.0 % in 0 (control), 10, 20, 30 and 40 mM NaCl treatments, respectively. Compared to the control group, total terpene content has approximately 1.4, 1.5, 1.5 and 2.0 times increased in 10, 20, 30 and 40 mM NaCl treatments respectively. In parallel with the increase of salinity stress, it was observed that there was an increase in the content of some volatile components in the terpene group while it was decrease in some of them. Monoterpenes are the major group in terpenes. Ocimene, myrcene, δ-3-carene and α-pinene were identified as the major components. Ocimene content in the 40 mM NaCl, which is the highest salinity stress, (80.91 %) was significantly found high at a remarkable rate.

In the present study, it was determined that creating salinity stress in daffodil flowers has an effect upon volatile components. Salinity treatments were determined to have a positive effect on terpenes (especially monoterpenes) which are significant volatile components for the cosmetics industry. Accordingly, alternative water sources with a high salt could be used in the production of cosmetic industry. In addition, the new salinity studies using with different cultivars and genotypes of daffodil, will be useful for further essential oil research.

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