

Original Research Article**CODEN: PJZSAZ e-ISSN: 1331-7776****Forage quality and macroelement composition of selected wild *Alcea* species
from southeastern Türkiye**Mehmet Basbag¹, Erdal Cacan^{2*}¹Dicle University, Faculty of Agriculture, Department of Field Crops, Diyarbakır, Türkiye²Bingöl University, Vocational School of Food, Agriculture and Livestock, Department of Plant
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ABSTRACT

The study was carried out to investigate the possibilities of utilizing some *Alcea* species as an alternative forage source. Within the scope of the study, *Alcea* populations were collected from 15 distinct locations in the Southeastern Anatolia Region of Türkiye. Crude protein (CP), acid detergent insoluble protein (ADIP), acid detergent fiber (ADF), neutral detergent fiber (NDF), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV), calcium (Ca), magnesium (Mg), phosphorus (P), and potassium (K) contents were determined in dried herbage samples of *Alcea* species. On average, the samples were classified as prime quality for CP and first-class quality for ADF, NDF, DDM, DMI, and RFV, although notable variation occurred among individual species-locality samples. Specifically, *Alcea apterocarpa* from Şırnak-1 and *Alcea striata* from Gaziantep-2 exhibited the most favorable fiber fractions, digestibility, and RFV values. While P, K, and K:(Ca+Mg) ratios remained within desirable ranges, high Ca concentrations resulted in Ca:P ratios exceeding recommended dietary thresholds (>2). Hierarchical cluster analysis categorized the 18 species-locality samples into two distinct clusters. In conclusion, wild *Alcea* species show potential as an alternative roughage source; nonetheless, comprehensive feeding trials, palatability assessments, and antinutritional profiling are needed before practical dietary recommendations can be made.

Keywords: *Alcea* spp., quality characteristics, macroelements, cluster analysis

INTRODUCTION

The family Malvaceae is represented worldwide by approximately 80 genera and more than 1,000 species. Economically significant crop plants such as cotton (*Gossypium* spp.) and okra (*Hibiscus* spp.), as well as *Alcea rosea*, which is cultivated as an ornamental plant, are also members of this family. The genus *Alcea*, as a member of this family, is represented in Türkiye by 18 species (Uzunhisarcıklı and Vural, 2009).

Alcea species are predominantly perennial herbaceous plants that naturally occur in a variety of habitats, including steppes, rocky slopes, grasslands, agricultural fields, and roadsides. The species examined in this study (*Alcea acaulis*, *A. striata*, *A. apterocarpa*, and *A. setosa*) are perennial taxa with broad altitudinal and geographical distribution across Türkiye and neighboring Near Eastern regions (Uzunhisarcıklı and Vural, 2012), reflecting a high capacity for environmental adaptation.

Naturally occurring *Alcea* species are recognized not only for their botanical diversity but also for their extensive ethnobotanical applications and apicultural significance. Locally referred to as "Hiro", taxa such as *A. apterocarpa* and *A. setosa* are utilized in traditional medicine for wound healing, abscesses, and asthma (Baykan et al., 2023), while the roots, leaves, and flowers of *A. apterocarpa* are employed as decoctions for abdominal pain, cough, bronchitis, and anti-inflammatory remedies (Ezer and Arısan, 2006; Oğuz and Tepe, 2017). Similarly, preparations from the flowers of *A. striata* and *A. setosa* are traditionally consumed to alleviate respiratory ailments (Dağlı, 2015; Melikoğlu et al., 2015). In addition to their therapeutic relevance, these species serve as vital nectar and pollen resources for honeybees (*Apis mellifera* L.). Specifically, *A. apterocarpa* has been documented as a prominent melliferous plant (Bakoğlu et al., 2013; Demir et al., 2024), a value mirrored in other regional congeners such as *A. calvertii* (Öztürk and Görhan, 2021) and *A. setosa* (Sıralı and Deveci, 2002).

Beyond their medicinal and apicultural value, certain *Alcea* species are consumed as food or utilized in animal feeding. For example, *A. apterocarpa* is gathered as an edible wild vegetable (Demir et al., 2017), whereas the fresh aerial parts of *A. acaulis* (locally known as "Pıçek") are directly offered to livestock (Dağlı, 2015), and *A. pallida* has been reported to possess suitable characteristics for roughage (Acar and Güncan, 2002). Türkiye possesses a rich reservoir of plant genetic diversity, wherein wild taxa native to natural rangelands frequently display

superior adaptation to environmental stresses such as drought, cold, and disease compared with cultivated crops (Acar and Güncan, 2002). Consequently, non-legume and non-grass species naturally occurring in rangelands, including members of the genus *Alcea*, represent noteworthy alternative genetic resources for ruminant nutrition.

However, information regarding the forage quality characteristics of these naturally growing *Alcea* species remains considerably limited. We hypothesized that forage-quality and macroelement profiles would differ significantly among the sampled *Alcea* populations and that some populations would meet commonly accepted forage-quality thresholds. Therefore, the objectives of this study were to determine the forage quality characteristics and macroelement contents of selected *Alcea* taxa naturally growing in the Southeastern Anatolia Region of Türkiye, to evaluate their similarity relationships via cluster analysis, and to reveal their potential value in ruminant nutrition.

MATERIAL AND METHODS

Plant material and sampling sites

The plant material of this study consisted of *Alcea* populations collected from 15 distinct localities across seven provinces in the Southeastern Anatolia Region of Türkiye during the early flowering period in May 2024. The geographic distribution of the sampling localities is illustrated in Figure 1, detailed site descriptors (latitude, longitude, and altitude) are presented in Table 1, and representative photographs of the taxa are shown in Figure 2. Two taxa co-occurred at certain localities: *Alcea setosa* and *A. striata* at Adıyaman-1, and *A. setosa* and *A. apterocarpa* at Mardin-1 and Mardin-2, resulting in 18 distinct species-locality combinations across the 15 independent localities (Table 1). Botanical identification of the collected specimens was performed by Prof. Dr. A. Selçuk Ertekin (Department of Biology, Faculty of

Science, Dicle University), and voucher specimens were deposited in the Dicle University Herbarium (DUF).

At each sampling site, above-ground plant parts (leaves, stems, and inflorescences) were harvested at a cutting height of approximately 5 cm above ground level. Plant specimens were collected in a completely randomized design with three independent biological replications per species-locality sample. Each replicate weighed approximately 500 g fresh weight and comprised a spatial composite of 8-10 individual plants to ensure population representativeness.

Sample preparation and chemical analyses

The plant specimens were dried in a forced-air oven at 65°C for 48 hours until reaching constant weight and subsequently ground in a laboratory mill to pass through a 1-mm screen prior to analysis. Crude protein (CP), acid detergent insoluble protein (ADIP), acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium (Ca), magnesium (Mg), phosphorus (P), and potassium (K) contents were determined on the dried and ground herbage samples using a Near Infrared Spectroscopy (NIRS) instrument (Foss Model 6500, FOSS NIRSystems, Silver Spring, MD, USA). Spectral measurements and calibrations were performed using established multivariate forage equations (WinISI software), a method widely and successfully employed for evaluating forage quality and mineral composition in rangeland and forage species (Ayan et al., 2010; Aydın et al., 2014; Basbag et al., 2018; Wróbel et al., 2022; Wróbel et al., 2025). Based on the measured ADF and NDF contents, digestible dry matter (DDM), dry matter intake (DMI), and relative feed value (RFV) were calculated according to the standard equations described by Morrison (2003): $DDM (\%) = 88.9 - (0.779 \times \%ADF)$, $DMI (\% \text{ of BW}) = (120 / \%NDF)$, $RFV = (DDM \times DMI) / 1.29$.

The forage quality classification of the species-locality samples was evaluated according to the quality standards established for legumes, grasses, and legume-grass mixtures by Lacefield (1988) (Table 2).

Statistical analysis

Because the plant samples were obtained from naturally distributed wild populations across different geographic sites, the 18 species-locality combinations were considered as single independent treatment groups. The data were subjected to one-way analysis of variance (ANOVA) in a completely randomized design with three replications using the JMP statistical software package (Version 14.0; JMP, 2018). Differences among means were compared using the Tukey HSD test at the 5% significance level ($P < 0.05$). To determine the phenotypic proximity and dissimilarity relationships among the 18 species-locality samples, hierarchical cluster analysis was performed on standardized variables using Euclidean distances and Ward's minimum variance method (JMP, 2018), and the resulting dendrogram was plotted (Figure 3). To prevent artificial multi-collinearity arising from mathematically derived quality indices and mineral ratios, clustering was computed using the primary measured variables (CP, ADIP, ADF, NDF, Ca, P, K, and Mg).

RESULTS

The crude protein (CP), acid detergent insoluble protein (ADIP), acid detergent fiber (ADF), neutral detergent fiber (NDF), digestible dry matter (DDM), dry matter intake (DMI), and relative feed value (RFV) of the *Alcea* species-locality samples are presented in Table 3. Statistically significant differences were detected among the species-locality samples for all examined forage quality parameters ($P < 0.01$).

The CP content of the *Alcea* samples ranged from 12.7% to 24.2%, with an overall mean of 19.1%. The highest CP content was recorded in *Alcea apterocarpa* collected from Mardin-1 (24.2%), whereas the lowest was observed in *Alcea striata* from Şanlıurfa-4 (12.7%). The ADIP contents ranged from 0.33% to 1.74%, averaging 0.73%. The highest ADIP concentration was

found in *Alcea setosa* from Adıyaman-1 (1.74%), and the lowest was in *Alcea striata* from Gaziantep-2 (0.33%) (Table 3).

The ADF concentrations varied between 25.5% and 36.6% (mean: 31.0%). The lowest ADF values were determined in *Alcea apterocarpa* from Siirt (25.5%) and *Alcea striata* from Gaziantep-2 (26.4%), whereas the highest ADF content was recorded in *Alcea apterocarpa* from Şanlıurfa-2 (36.6%). The NDF content ranged from 32.4% to 47.6%, with an overall mean of 40.5%. The lowest NDF was measured in *Alcea apterocarpa* from Şırnak-1 (32.4%), while the highest values were obtained in *Alcea apterocarpa* samples from Mardin-2 (47.0%), Şanlıurfa-1 (47.6%), and Şanlıurfa-2 (47.6%) (Table 3).

In terms of calculated indices, DDM ranged from 60.4% to 69.0% (mean: 64.8%), DMI ranged from 2.52% to 3.71% of body weight (mean: 3.00%), and RFV ranged from 118 to 195 (mean: 151) (Table 3). Among all evaluated samples, *Alcea apterocarpa* from Şırnak-1 and *Alcea striata* from Gaziantep-2 exhibited the highest DDM, DMI, and RFV values, whereas the lowest values were recorded in *Alcea apterocarpa* from Şanlıurfa-1 and Şanlıurfa-2, and *Alcea striata* from Adıyaman-2 (Table 3).

Macroelement concentrations (Ca, P, K, and Mg) and their critical ratios [Ca:P and K:(Ca+Mg)] differed significantly among the species-locality samples ($P < 0.01$; Table 4). Calcium concentrations ranged from 1.09% to 1.71% (mean: 1.41%), with the highest value in *Alcea apterocarpa* from Şırnak-1 (1.71%) and the lowest in the same species from Şanlıurfa-1 (1.09%). Phosphorus concentrations ranged from 0.28% to 0.39% (mean: 0.34%), with the highest value recorded in *Alcea apterocarpa* from Şırnak-2 (0.39%) and the lowest in *Alcea setosa* from Adıyaman-1 (0.28%). Consequently, the Ca:P ratio varied from 3.03 to 5.50 (mean: 4.15), with the lowest ratio observed in *Alcea acaulis* from Gaziantep-1 (3.03) and the highest in *Alcea striata* from Şanlıurfa-4 (5.50) (Table 4).

Potassium concentrations ranged from 2.11% to 3.64% (mean: 2.89%), reaching the highest level in *Alcea apterocarpa* from Siirt (3.64%) and the lowest in the same species from Diyarbakır-1 (2.11%). Magnesium contents varied between 0.29% and 0.53% (mean: 0.41%), with the maximum concentration detected in *Alcea setosa* from Adıyaman-1 (0.53%). The tetany ratio $[K:(Ca+Mg)]$ ranged from 1.11 to 2.17 (mean: 1.62); the lowest ratio was observed in *Alcea apterocarpa* from Şırnak-1 (1.11) and the highest in *Alcea acaulis* from Gaziantep-1 (2.17) (Table 4).

Hierarchical cluster analysis grouped the 18 *Alcea* species-locality samples into two distinct clusters (Figure 3). The second cluster comprised seven samples: *Alcea apterocarpa* (Diyarbakır-1, Mardin-2, Şanlıurfa-1, and Şanlıurfa-2), *Alcea striata* (Adıyaman-2 and Şanlıurfa-4), and *Alcea setosa* (Mardin-2), while the first cluster contained the remaining 11 samples. Within the first cluster, *Alcea apterocarpa* and *Alcea setosa* collected from Mardin-1 exhibited the highest phenotypic similarity, whereas *Alcea acaulis* from Gaziantep-1 and *Alcea apterocarpa* from Diyarbakır-1 represented the most distant pair across the entire dendrogram.

DISCUSSION

The CP, ADF, and NDF contents of plants are the primary indicators of forage quality and digestibility, varying substantially according to plant taxon, growth stage, environmental conditions, and harvest time. Lacefield (1988) reported that forages with CP >19%, ADF <31%, and NDF <40% are classified as prime quality. When evaluated against these standards, several *Alcea* species-locality samples exhibited prime-class characteristics (Table 3). For CP content, the majority of the samples fell into the prime quality class, except *Alcea acaulis* from Gaziantep-1, *A. apterocarpa* from Diyarbakır-1 and Şanlıurfa-1, and *A. striata* from Gaziantep-2 and Şanlıurfa-4. Regarding fiber fractions (ADF and NDF), most samples satisfied the prime or first-class standards, whereas samples such as *A. apterocarpa* from Diyarbakır-1, Mardin-2,

Şanlıurfa-1, and Şanlıurfa-2, as well as *A. striata* from Adıyaman-2 and Şanlıurfa-4, exhibited higher fiber concentrations and fell into lower quality classes (Table 3).

Plants growing in natural rangelands play an essential role in ruminant nutrition, and their seasonal chemical dynamics are well documented. In semi-arid rangelands of Türkiye, rangeland plants typically display higher CP and lower fiber fractions during early vegetative and early flowering stages in spring, followed by declining protein and increasing fiber levels toward maturity (Karabulut and Çomaklı, 2023). Similarly, Kazemi (2019) reported CP values ranging from 17.2% to 27.5%, NDF from 25.2% to 35.8%, and ADF from 15.5% to 25.8% among rangeland forage species, concluding that they represent viable alternative roughages. These values align closely with the overall means observed in the present study (CP: 19.1%, ADF: 31.0%, NDF: 40.5%). In contrast, Tafreshi et al. (2025) reported substantially lower CP values (6.06%-11.30%) across six *Alcea* taxa; however, their analyses were conducted strictly on isolated floral tissues rather than vegetative herbage biomass.

Calculated forage-quality indices -DDM, DMI, and RFV- provide integrated assessments for screening non-conventional forages. According to Lacefield (1988), prime-quality forage requires DDM >65%, DMI >3.0% of body weight, and RFV >151. Based on these criteria, prime quality was achieved by *A. acaulis* from Gaziantep-1, *A. apterocarpa* from Diyarbakır-2, Mardin-1, Siirt, Şırnak-1, and Şırnak-2, *A. setosa* from Adıyaman-1 and Mardin-1, and *A. striata* from Adıyaman-1 and Gaziantep-2 (Table 3). The remaining species-locality samples met first- or second-class thresholds (Table 3). Wild rangeland taxa, including *Alcea pallida*, have long been recognized for their roughage value (Acar and Güncan, 2002). Aydın and Başbağ (2017) observed mean DDM, DMI, and RFV values of 65.70%, 2.67%, and 137, respectively, in rangelands containing *Alcea species*, while Kazemi (2019) documented dry matter digestibility values of 71.1%-82.8%. Conversely, lower quality indices (DDM: 55.3%-

64.9%, DMI: 1.70%-2.46%, RFV: 77.0-124.1) have been documented in other natural grazing areas (Olomonchi et al., 2022), demonstrating that the *Alcea* herbage evaluated here maintained relatively favorable energy and intake potential.

Adequate dietary supply of essential macronutrients (P, K, Ca, and Mg) is vital for plant physiology as well as ruminant metabolic health, skeletal development, and lactation (Maathuis, 2009; Hawkesford et al., 2012; Toor et al., 2021). In the analyzed herbage samples, mean P (0.34%), K (2.89%), and Mg (0.41%) concentrations generally satisfied typical maintenance and production requirements for ruminants, whereas Ca concentrations (mean: 1.41%) were conspicuously high across all samples (Table 4). Consequently, the Ca:P ratios (3.03-5.50) exceeded the commonly recommended dietary optimum of 1:1 to 2:1 (Ayan et al., 2010). Excessive Ca relative to P may interfere with phosphorus absorption and systemic mineral metabolism; thus, if harvested *Alcea* herbage is utilized as dried roughage, blending it with phosphorus-rich feeds or dietary supplements would be advisable to balance the ration. Under free-ranging conditions, the selective and diversified grazing behavior of ruminants may naturally mitigate potential imbalances. On the other hand, the grass tetany index [K:(Ca+Mg) equivalent ratio] remained consistently below the critical threshold of 2.2 across all samples (mean: 1.62; Table 4), suggesting a minimal potential risk of inducing hypomagnesemic tetany in ruminants (Aydın and Uzun, 2002).

Comparable macroelement patterns have been documented in related Malvaceae taxa. In *Alcea rosea*, Kordalı et al. (2021) determined Ca, P, K, and Mg concentrations of 1.23%, 0.27%, 1.66%, and 0.27%, respectively. In *Alcea kurdica*, Görmez et al. (2019) observed CP values of 12.27%-24.46%, Ca values of 2.13%-2.48%, K values of 1.51%-2.07%, and Mg values of 0.25%-0.30%. In contrast, Tafreshi et al. (2025) reported markedly higher elemental values in flower tissues (P: 2.53%, K: 15.05%, Ca: 9.26%, Mg: 3.23%), reflecting tissue-specific nutrient

partitioning. In a multi-altitude rangeland study that included *Alcea* species, Aydın and Başbağ (2017) reported mean levels of 1.09% Ca, 0.34% P, 0.31% Mg, 2.42% K, and a tetany ratio of 1.73, corroborating the mineral baselines observed in the present investigation.

Hierarchical cluster analysis revealed clear multivariate segregation among the 18 *Alcea* species-locality samples (Figure 3). Populations of the same botanical species sampled from different geographic localities did not always aggregate within the same cluster, underscoring the substantial influence of local microclimates, soil properties, and phenotypic plasticity across divergent habitats. Öztürk et al. (2009) similarly identified genetic and morphological differentiation among Turkish *Alcea* taxa, observing close affiliations between *A. setosa* and *A. apterocarpa*, as well as between *A. acaulis* and *A. striata*. Cluster analysis has likewise served as an effective tool for delineating geographic and ecotypic variation in other rangeland and forage species across the Southeastern Anatolia Region, such as *Medicago sativa* (Öten and Albayrak, 2018), *Astragalus hamosus* (Başbağ et al., 2019), and wild *Crepis* species (Başbağ and Çağan, 2025).

CONCLUSIONS

This study evaluated the forage quality attributes and macroelement composition of wild *Alcea* populations collected from 15 distinct localities in southeastern Türkiye. On average, the analyzed *Alcea* herbage samples met prime quality standards for crude protein and first-class quality for fiber fractions and calculated quality indices, although substantial variation occurred among individual species-locality samples. Specifically, *Alcea apterocarpa* from Şırnak-1 and *Alcea striata* from Gaziantep-2 stood out with superior fiber digestibility, intake potential, and relative feed values. While potassium, phosphorus, and grass tetany ratios [K:(Ca+Mg)] remained within safe dietary limits, elevated calcium concentrations led to high Ca:P ratios (>2.0), indicating that dietary supplementation or blending with phosphorus-rich feeds would

be required if fed as conserved roughage. Hierarchical cluster analysis confirmed meaningful multivariate differentiation among the 18 species-locality samples, reflecting habitat-driven variation and phenotypic plasticity. Overall, wild *Alcea* species show potential as alternative roughage genetic resources; however, given that this initial screening was based exclusively on chemical profiling and calculated indices, practical feeding recommendations must await future in vivo trials evaluating actual digestibility, animal performance, voluntary intake, palatability, and antinutritional compounds.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Mehmet Basbag and Erdal Cacan: Conducted field study, collected and analyzed data, drafted the manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICS APPROVAL

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Data will be made available on reasonable request from the corresponding author

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Table 1. Sampling localities, *Alcea* species, and geographic coordinates of the study sites

Species	Locality	Latitude (N)	Longitude (E)	Altitude (m)
1. <i>Alcea acaulis</i> (Cav.) Alef.	Gaziantep-1	37° 23' 01.20"	37° 33' 23.93"	679
2. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Diyarbakır-1	37° 53' 13.39"	39° 48' 04.89"	1006
3. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Diyarbakır-2	38° 22' 40.94"	40° 14' 48.82"	813
4. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Mardin-1	37° 26' 35.56"	40° 38' 17.10"	1002
5. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Mardin-2	37° 26' 42.76"	41° 01' 31.79"	1100
6. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Siirt	37° 43' 32.89"	42° 14' 28.46"	1024
7. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Şırnak-1	37° 16' 34.55"	41° 35' 34.43"	886
8. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Şırnak-2	37° 23' 02.60"	42° 10' 52.13"	413
9. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Şanlıurfa-1	37° 48' 01.59"	39° 13' 05.65"	713
10. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Şanlıurfa-2	37° 31' 28.47"	38° 53' 44.52"	765
11. <i>Alcea apterocarpa</i> (Fenzl) Boiss.	Şanlıurfa-3	37° 46' 30.38"	39° 47' 01.44"	1469
12. <i>Alcea setosa</i> (Boiss.) Alef.	Adıyaman-1	37° 52' 31.30"	38° 53' 51.68"	726
13. <i>Alcea setosa</i> (Boiss.) Alef.	Mardin-1	37° 26' 35.56"	40° 38' 17.10"	1002
14. <i>Alcea setosa</i> (Boiss.) Alef.	Mardin-2	37° 26' 42.76"	41° 01' 31.79"	1100
15. <i>Alcea striata</i> Alef.	Adıyaman-1	37° 52' 31.30"	38° 53' 51.68"	726
16. <i>Alcea striata</i> Alef.	Adıyaman-2	37° 43' 08.82"	37° 57' 13.04"	634
17. <i>Alcea striata</i> Alef.	Gaziantep-2	36° 59' 38.49"	37° 34' 21.30"	774
18. <i>Alcea striata</i> Alef.	Şanlıurfa-4	37° 05' 55.20"	38° 11' 02.57"	756

Table 2. Forage quality classification thresholds used in this study (after Lacefield, 1988)

Quality Standard	CP	ADF	NDF	DDM %	DMI % of BW	RFV
	% of DM					
Prime	>19	<31	<40	>65	>3.0	>151
1	17-19	31-35	40-46	62-65	3.0-2.6	151-125
2	14-16	36-40	47-53	58-61	2.5-2.3	124-103
3	11-13	41-42	54-60	56-57	2.2-2.0	102-87
4	8-10	43-45	61-65	53-55	1.9-1.8	86-75
5	<8	>45	>65	<53	<1.8	<75

CP: crude protein; ADF: acid detergent fiber; NDF: neutral detergent fiber; DDM: digestible dry matter; DMI: dry matter intake; BW: body weight; RFV: relative feed value; DM: dry matter.

Table 3. Chemical composition and calculated forage-quality indices of *Alcea* species-locality samples (n = 3)

Species	Locality	CP (%)	ADIP (%)	ADF (%)	NDF (%)	DDM (%)	DMI (%BW)	RFV
1. <i>Alcea acaulis</i>	Gaziantep-1	15.2 fg	0.47 g	30.1 b-g	39.5 cd	65.5 a-f	3.04 cd	154 cde
2. <i>Alcea apterocarpa</i>	Diyarbakır-1	14.5 fg	0.63 ef	35.8 abc	41.7 bc	61.0 efg	2.88 def	136 efg
3. <i>Alcea apterocarpa</i>	Diyarbakır-2	21.1 abc	0.68 c-f	29.4 d-g	40.0 cd	66.0 a-d	3.04 cd	157 cde
4. <i>Alcea apterocarpa</i>	Mardin-1	24.2 a	0.70 c-f	26.6 fg	37.2 c-f	68.1 ab	3.23 bc	171 a-d
5. <i>Alcea apterocarpa</i>	Mardin-2	20.2 bcd	0.64 def	34.6 a-e	47.0 a	62.0 c-g	2.55 efg	123 fg
6. <i>Alcea apterocarpa</i>	Siirt	23.2 abc	0.70 c-f	25.5 g	36.6 def	69.0 a	3.28 bc	176 abc
7. <i>Alcea apterocarpa</i>	Şırnak-1	24.0 ab	0.71 cde	26.9 fg	32.4 f	68.0 ab	3.71 a	195 a
8. <i>Alcea apterocarpa</i>	Şırnak-2	20.2 bcd	0.96 b	26.5 fg	38.6 cde	68.2 ab	3.11 cd	165 bcd
9. <i>Alcea apterocarpa</i>	Şanlıurfa-1	16.1 efg	0.66 def	35.4 a-d	47.6 a	61.4 d-g	2.52 g	120 g
10. <i>Alcea apterocarpa</i>	Şanlıurfa-2	20.4 a-d	0.76 c	36.6 a	47.6 a	60.4 g	2.52 g	118 g
11. <i>Alcea apterocarpa</i>	Şanlıurfa-3	21.0 abc	0.97 b	30.8 a-g	47.3 a	64.9 a-g	2.54 fg	128 fg
12. <i>Alcea setosa</i>	Adıyaman-1	19.5 cde	1.74 a	30.8 a-g	36.5 def	64.9 a-g	3.29 bc	166 bcd
13. <i>Alcea setosa</i>	Mardin-1	20.6 abc	0.66 def	29.1 efg	38.2 cde	66.2 abc	3.14 cd	161 b-e
14. <i>Alcea setosa</i>	Mardin-2	19.9 cd	0.65 def	32.5 a-f	40.4 cd	63.6 b-g	2.97 cd	146 def
15. <i>Alcea striata</i>	Adıyaman-1	20.3 bcd	0.63 f	29.9 c-g	37.1 c-f	65.6 a-e	3.23 bc	164 bcd
16. <i>Alcea striata</i>	Adıyaman-2	16.8 def	0.72 cd	35.9 ab	46.2 ab	60.9 fg	2.60 efg	123 fg
17. <i>Alcea striata</i>	Gaziantep-2	14.5 fg	0.33 h	26.4 g	34.1 ef	68.3 a	3.52 ab	186 ab
18. <i>Alcea striata</i>	Şanlıurfa-4	12.7 g	0.45 g	34.7 a-e	41.8 bc	61.9 c-g	2.89 de	138 efg
Mean		19.1	0.73	31.0	40.5	64.8	3.00	151
CV (%)		6.46	3.80	6.28	3.89	2.34	3.71	5.57

Means within the same column followed by the same lowercase letter are not significantly different according to the Tukey HSD test ($P < 0.05$). CP: crude protein; ADIP: acid detergent insoluble protein; ADF: acid detergent fiber; NDF: neutral detergent fiber; DDM: digestible dry matter; DMI: dry matter intake; BW: body weight; RFV: relative feed value; CV: coefficient of variation.

Table 4. Macroelement concentrations and mineral ratios of *Alcea* species-locality samples (n = 3)

Species	Locality	Ca (%)	P (%)	Ca:P	K (%)	Mg (%)	K:(Ca+Mg)
1. <i>Alcea acaulis</i>	Gaziantep-1	1.10 e	0.36 a-e	3.03 f	3.15 a-d	0.35 cd	2.17 a
2. <i>Alcea apterocarpa</i>	Diyarbakır-1	1.38 b-e	0.32 e-h	4.31 a-e	2.11 g	0.44 a-d	1.16 gh
3. <i>Alcea apterocarpa</i>	Diyarbakır-2	1.50 abc	0.38 ab	4.07 b-f	3.40 ab	0.41 a-d	1.80 a-e
4. <i>Alcea apterocarpa</i>	Mardin-1	1.41 a-d	0.37 a-d	3.86 b-f	3.10 a-e	0.41 a-d	1.72 a-f
5. <i>Alcea apterocarpa</i>	Mardin-2	1.31 cde	0.33 c-g	3.98 b-f	2.70 c-g	0.29 d	1.69 b-f
6. <i>Alcea apterocarpa</i>	Siirt	1.44 a-d	0.38 abc	3.82 b-f	3.64 a	0.43 a-d	1.95 abc
7. <i>Alcea apterocarpa</i>	Şırnak-1	1.71 a	0.36 a-e	4.82 abc	2.47 efg	0.52 ab	1.11 h
8. <i>Alcea apterocarpa</i>	Şırnak-2	1.54 abc	0.39 a	3.99 b-f	3.00 a-e	0.47 abc	1.50 c-h
9. <i>Alcea apterocarpa</i>	Şanlıurfa-1	1.09 e	0.32 d-h	3.37 ef	2.70 c-g	0.33 cd	1.91 a-d
10. <i>Alcea apterocarpa</i>	Şanlıurfa-2	1.51 abc	0.36 a-e	4.24 b-f	2.59 d-g	0.37 bcd	1.38 e-h
11. <i>Alcea apterocarpa</i>	Şanlıurfa-3	1.17 de	0.33 d-h	3.58 c-f	3.45 ab	0.44 a-d	2.14 ab
12. <i>Alcea setosa</i>	Adıyaman-1	1.33 b-e	0.28 h	4.71 a-d	3.07 a-e	0.53 a	1.65 c-f
13. <i>Alcea setosa</i>	Mardin-1	1.41 a-d	0.37 a-d	3.85 b-f	2.92 b-f	0.41 a-d	1.60 c-g
14. <i>Alcea setosa</i>	Mardin-2	1.63 ab	0.33 d-h	4.99 ab	2.68 c-g	0.38 a-d	1.34 e-h
15. <i>Alcea striata</i>	Adıyaman-1	1.34 b-e	0.38 ab	3.56 def	3.32 abc	0.37 bcd	1.94 a-d
16. <i>Alcea striata</i>	Adıyaman-2	1.36 b-e	0.34 b-f	4.03 b-f	2.31 fg	0.36 cd	1.34 e-h
17. <i>Alcea striata</i>	Gaziantep-2	1.51 abc	0.30 fgh	5.03 ab	2.85 b-f	0.43 a-d	1.47 d-h
18. <i>Alcea striata</i>	Şanlıurfa-4	1.58 abc	0.29 gh	5.50 a	2.56 d-g	0.52 ab	1.26 fgh
Mean		1.41	0.34	4.15	2.89	0.41	1.62
CV (%)		7.01	4.40	9.81	7.42	12.15	9.57

Means within the same column followed by the same lowercase letter are not significantly different according to the Tukey HSD test ($P < 0.05$). Ca: calcium; P: phosphorus; K: potassium; Mg: magnesium; Ca:P: calcium-to-phosphorus ratio; K:(Ca+Mg): potassium-to-(calcium + magnesium) tetany ratio; CV: coefficient of variation. Mineral concentrations are expressed on a dry matter percentage basis.

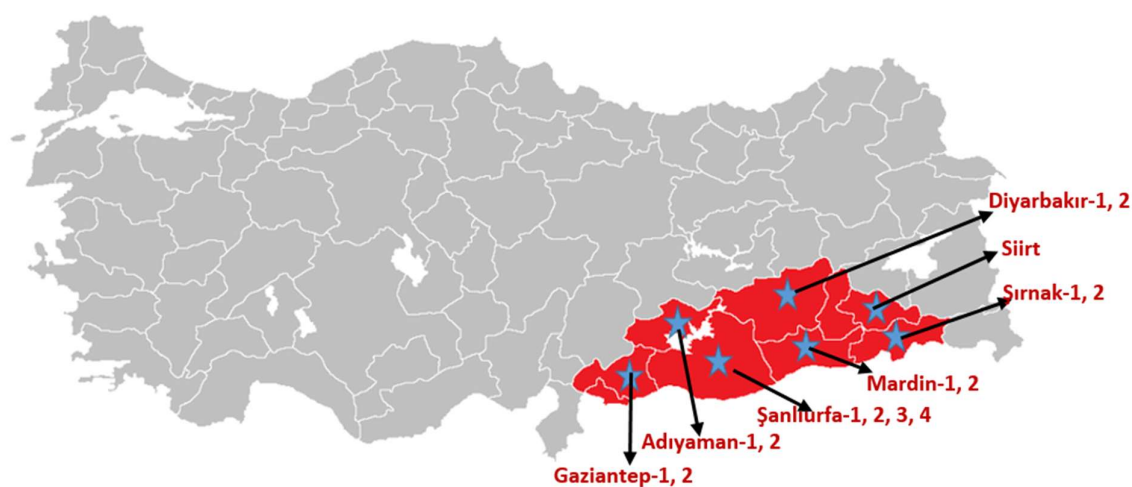


Figure 1. Sampling sites of *Alcea* species in southeastern Türkiye

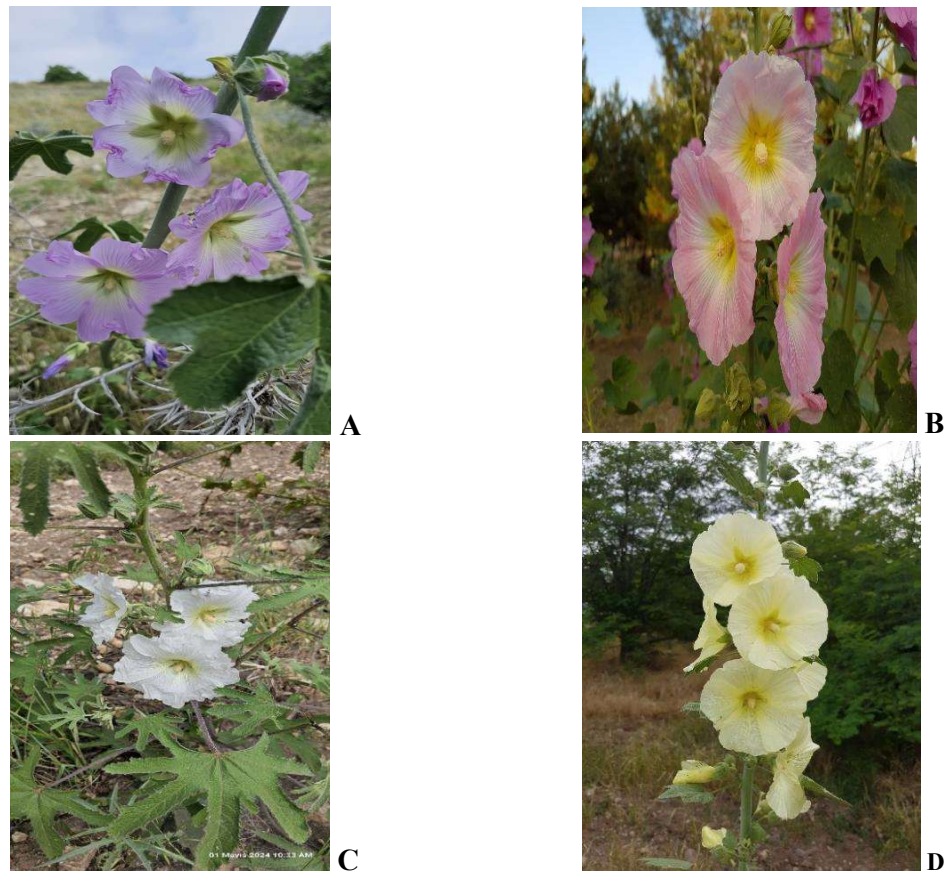


Figure 2. Representative photographs of the *Alcea* species examined: (A) *A. acaulis*, (B) *A. apterocarpa*, (C) *A. setosa*, and (D) *A. striata*.

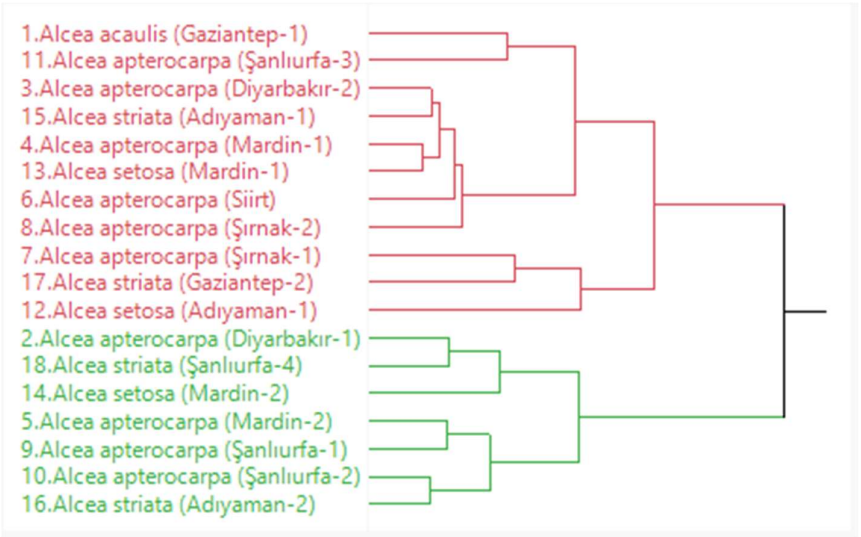


Figure 3. Hierarchical cluster analysis dendrogram of the 18 *Alcea* species-locality samples based on chemical and macroelement traits (CP, ADIP, ADF, NDF, Ca, P, K, and Mg).