Journal of Elementology ISSN 1644-2296

Keskin, L., Yüceol, F., Çınar, N., Çınar, O., Hacıküçük, A., Namal, H., Türkmen, Ö., Paksoy, M. and Göktürk, R.S. (2023)
'Determination of some morphological traits and total phenolic and flavonoid contents in *Cynara* spp. collected from Turkey and North Cyprus Turkish Republic',
Journal of Elementology, 28(4), 971-985,
available: http://doi.org/10.5601/jelem.2023.28.3.2326

RECEIVED: 25 August 2023
ACCEPTED: 30 October 2023

ORIGINAL PAPER

Determination of some morphological traits and total phenolic and flavonoid contents in *Cynara* spp collected from Turkey and North Cyprus Turkish Republic*

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Abstract

Preserving gene resources is important for sustainable agriculture. It is also essential to determine the fruit and vegetable content of flavonoids and phenolics that are beneficial for health. In future breeding studies, local varieties, wild types, and their content of flavonoid and phenolic compounds may gain prominence. This study focused on the properties of the artichoke, a plant which originates from Turkey and Cyprus. A collection of local and wild artichokes composing a Cynara gene pool was submitted to analysis in order to determine the morphological features, as well as the total flavonoid and phenolic content in accordance with the UPOV criteria. The total phenolic content was calculated as 4.97 mg GAE g^{-1} in Sakızvariety, 6.41 mg GAE g^{-1} in early Cyprus variety and 5.22 mg GAE g^{-1} t in Hasanağa. Total flavonoid content was 1.05 mg CE g^{-1} in Sakız, 3.77 mg CE g^{-1} in early Cyprus, 1.45 mg CE g^{-1} in Hasanağa (Bayrampaşa) type, 2.70 mg CE g^{-1} and 2.10 mg in *Cynara cornigera*. All local and wild varieties showed 97.89% variation in morphological characters. As a result of the research, morphological features were determined in accordance with the UPOV criteria, and total phenolic and total flavonoid contents were also assayed. The values obtained from the determination of the total phenolic and flavonoid content in the collected local and wild varieties, and relationships between the content of phenolics and flavonoids were examined. Following this study, some varieties were chosen for a future breeding program. Thus, it is thought that an innovation can be brought to research on artichoke by evaluating the above features and their mutual relationships for the purpose of future breeding programs.

Keywords: *Cynara*, artichoke, local varieties, UPOV, phenolic, flavonoid

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* Fundıng Financial support was received for the research from the Western Mediterranean Agricultural Research Institute and the Ministry of Agriculture and Livestock of the Republic of Turkey.

INTRODUCTION

The homeland of the artichoke is the area surrounding the central and western Mediterranean Sea basin (Ryder et al. 1983); Turkey and the North Cyprus Turkish Republic are the regions where this plant grows naturally. In countries lying around the Mediterranean Sea, the artichoke production is large, in terms of both yields and area under plantations. Consumption of artichoke, very beneficial food for human health, is increasing. Today, the annual artichoke production, which is very popular especially in the Mediterranean countries and in America, reaches 1.505.328 tons globally. Approximately 75% of its production takes place in the Mediterranean countries. Leading countries are Italy with 387.803 tons (25.76%), Spain with 223.150 tons (14.82%), and Egypt with 185.695 tons (12.33%) of output (Anonymous,2021).

There has been much research done on local varieties and wild lines of Cynara in recent years. Cravero et al. (2007) classified artichoke varieties according to the morphological characteristics, like the main head diameter as well as harvesting time, density of the leaf lobe, main flower head length, diameter and shape in longitudinal sections, color and thickness at the base of the outer bracte, presence or absence of spines on leaves, and total number of heads. According to Abak (1987), artichoke varieties also differed in head bract colors and presence or absence of spines on leaves. Early cultivars are typically grown in the southern regions during the autumn and winter months, and their production continues until spring. Many populations of each type are usually named after the place in which they grow (Bianco 1990). In other research, Ciancolini et al. (2012) analyzed the germplasm and genetic relationships between different plant materials and among local varieties in order to provide data for future plant breeding programs. Crinò et al. (2017) found significant differences between clones for most of the quantitative and qualitative morphological traits. In another study, Craveri et al. (2007) investigated the gene effect related to yield between clones of general cultivars and specific combinations of artichoke (*Cynara scolymus*).

In addition to being a nutritional, healthy and medically important plant, artichoke is also seen to be ahead of many other vegetables and fruits economically (Şalk et al. 2008). In addition, the Asteraceae family is known to be rich in polyphenols and flavonoids, while factors such as genotypes, environmental factors, processing methods also reportedly affect the amount of these phytochemicals (Pandino et al. 2012). In general, various evaluation methods are used to estimate the value of artichokes for consumption as fresh vegetables or for canning, as well as for processing into marmalade and jam, also made from the wild species *Cynara cornigera*, which are then locally known as gafgarit (Figure 1). In recent years, artichoke production and consumption have been increasing. Genetic diversity among local artichoke varieties contributes to the increase in yield. Breeding research on local

Fig. 1. Evaluation of wild artichoke *(Cynara cornigera)* as jam and marmalade. Examples of the way local people in Turkey and in the Turkish Republic of Northern Cyprus consume Cynaras apart from consumption as fresh produce during the collection of *Cynara* species

varieties is growing continually. In our study, for these and similar reasons, the morphological characteristics as well as total phenolics and flavanoids of local varieties and wild species collected from Turkey and the Turkish Republic of Northern Cyprus were examined. As a result a qualified artichoke gene pool has been created for the breeding studies to be carried out in the coming years.

MATERIAL AND METHOD

Material

This study was conducted at the Bati Akdeniz Agricultural Research Institute in Antalya, located between 36°55′0.98″ N 31°05′56.00″ E coordinates. Thirteen landraces and two wild type were collected from 25 different areas to be used as plant material. The information about their given codes, cultivation areas, and geographic locations were presented in Table 1. Some pictures of the collected materials are given in Figure 2.

Method

Morphological features

The plant material samples from the artichokes collected in the Turkish Republic of Northern Cyprus and Turkey were made in accordance with the UPOV criteria, as specified in Table 2.

Fig. 2. Photographs of some different *Cynara* species (Original). Photos taken in the field and during morphological observations of *Cynara* species collected from Turkey and the Turkish Republic of Northern Cyprus

Table 1

The given codes, their cultivation areas, and geographic locations

Code	Origin name	Cultivation area	Location
Y1	Sakız	Aydın, İzmir,	37.838018, 27.845620
Y2	Early Cyprus	Kıbrıs	35°06′11″ K 33°44′13″ D
Y3	Late Cyprus	Kıbrıs	35°11.213″ N 33°30.196
Y4		İzmir	38.2849118,26.3520641
Y5		Hatay	36.97800830, 3613197840
Y6		Aydın	37.799766, 27.934413
Y7		Mersin	36.8654693,34.4898342,
Y8		Antalya	36.91370320,31.09947140
Y9	Hasanağa (Bayrampaşa type)	Bursa	40°14′14.3″ N 2850′03.5″ E
Y10		Adana	36.9605013,356163413
Y11		Cyprus	35°03.993 N,033° 37.180 E
Y12		Cyprus	35°09.753 N, 033° 27.304
Y13	Green Bursa (Bayrampaşa type)	Bursa	40,1748290,28,8066580
Y14	*Cynara.cornigera*	Cyprus	35°11.327 N, 033° 51.170 E
Y 15	*Cynara cardunculus*	Cyprus	35°12.973 N, 033O10.857 E

Table 2

Morphologic descriptors derived from UPOV

Features	Explanation	Features	Explanation	Features	Explanation
1- Time of appearance of central head (day)	early (1) medium-early (3) medium (5) medium-late (7) late (9)	2- height including central head	cm	3- number of lateral shoots on main stem	number
4- Main stem height	cm	5- leaf attitude	erect (1) semi-erect (3) horizontal (5)	6- leaf length	cm
7- Main stem diameter	mm	8-spines	absent (1) present (9)	9- intensity of leaf green colour	light green (1) medium green (2) dark green (3) grey green (4)
10- Leaf hairness	weak (3) medium (5) strong (7)	11- anthocyanin coloration at base of petiole	weak (1) medium (2) strong (3) very strong (4)	12- central flower head length	mm
13- Central flower head diameter	mm	14- central flower head: shape of apex	acute (1) rounded (2) flat (3) depressed (4)	15- thickness of the tip of the main flower head	thin (3) medium (5) thick (7)
16- Length of first order head on lateral shoots	cm	17- diameter of first order head on lateral shoots	mm	18-length of outer bract	mm
19- Width of outer bract	mm	20-thick of outer bract;	mm	21- main shape of outer bract	triangular (1) ovate (3) oblong (5) circular (7) oblate (9)
22- Depth of incision of outer bract	shallaow (3) medium (5) deep (7)	23- anthocyanin coloration of central flower head inner	weak (1) medium (2) strong (3) very strong (4)	24- density of inner bract	very sparse (1) sparse (3) medium (5) dense (7) very dense (9)
25- Receptacle diameter	mm	26- receptacle thickness	mm	27- receptacle: shape in longitudinal section	flat or slightly depressed (1) moderately depressed (2) strongly depressed (3)
28- Total number of heads	number	29- weight of main head	gram		

Total phenolic and flavonoid substance analysis

For each Cynara spp., the receptacle of the species was calculated. The total phenolic analysis was carried out with the gallic acid standard used to measure the total amount of phenolic substances in a sample. Absorption spectra of gallic acid solutions prepared in methanol at 7 different concentrations were recorded on a Shimadzu brand UV-Visible spectrophotometer (Spanos and Wrolstad, 1990). The total flavonoid analysis employed a catechin standard to measure the total amount of flavonoids in a sample. The absorption spectra of the catechin solution prepared in methanol at 5 different concentrations were recorded on a Shimadzu UV-Visible spectrophotometer (Karadeniz et al. 2005).

Statistical analysis of data

In order to determine the morphological similarities and differences among the genotypes, the data from the Cluster Analysis from multiple comparisons and the Principle Component Analysis were analyzed in order to highlight the characteristics representing each population and group of populations in 2 dimensions, according to the characterized features. These analyses were made using an NTSYS-pc version 2.2 computer package program (Rohlf 2005).

RESULTS AND DISCUSSION

The results of measurements and observations in the research were given in Table 2. In the observations, which were made as per the UPOV criteria, three samples were used from each genotype for each observation. The data obtained from the means of the determinations of the morphological traits of local and wild varieties in 2019 and 2020 are given in Table 3.

Time of the appearance of the central head (day); Sakiz and early Cyprus local artichoke varieties were found to be earlier than the others. This trait was determined the latest in Hasanağa (Bayrampaşa type) and Y13 genotypes. Other genotypes were found between “early” and “late”. According to Ekbiç (2005), Sakiz variety was reported to be harvested on 145.01 day. Ciancolini et al. (2012) reported that in the first year of their research, local varieties were determined to be harvestable on 166.33 day in the case of Castellammare and 181 day for Ascolano; in the second year, Castellammare was reported to be harvested on 174.5 day and Ascolano on 189.67 day. The results of our study are in parallel with these studies.

Plant height (cm); The maximum plant height was found to be 167.5 cm in genotype Sakiz, Y5,Y12 and Y13 genotypes, whereas the minumum plant height was measured as 67.5 cm in *Cynara cornigera.* According to Ciancolini et al. (2012) measured the plant height of Bianco di Pertosa as 106.4 cm

Table 3

The average values of morphological traits of local varieties and wild forms of artichoke in years 2019 and 2020

Number	E	PH (cm)	NL shoots	MS height (cm)	Leafatt	Length (cm)	MsDiam (mm)	Spines	IntGreen	Hair	Anthocpet	Head length (mm)	Head diameter (mm)	Tip shape
Y1	1	167.5 A	3.5 A	84.5 A	3	85 A	38.2 A	1	2	3	1	130.5 A	132 A	4
Y2	1	145 B	4 A	81 A	5	77.5 A-C	19.81	1	2	3	3	116.5 A-C	92.5 G	1
Y3	3	155 AB	4 A	72.56 AB	5	85 A	26 D	1	2	3	3	96.0 D-F	82 H	2
Y4	3	157.5 AB	4.5 A	80 A	3	69 C	19.5 H	1	2	3	1	85.5 F	97.5 G	1
Y5	3	165 A	4.5 A	55 BC	5	78.5 A-C	21 F-H	1	1	5	2	89.5 EF	96.5 G	1
Y6	5	145 B	3.5 A	67.5 AB	5	78.5 A-C	25 DE	1	3	3	2	128.5 A	114 C-E	1
Y7	5	150 AB	3.5 A	72.5 AB	3	78.5 A-C	22.15 E-G	1	2	3	1	96.5 D-F	118 CD	4
Y8	5	152.5 AB	4 A	75 AB	3	71 BC	25. DE	1	1	3	1	101.5 C-E	129 AB	1
Y9	9	155 AB	4 A	71 AB	3	77.5 A-C	33.5 B	1	3	5	3	91 EF	121 BC	4
Y10	5	162.5 AB	4.5 A	62.5 A-C	3	79 A-C	24 DE	1	3	5	2	103 C-E	94.5 G	1
Y11	7	155 AB	3.5 A	64 A-C	5	81 AB	23 EF	1	2	3	4	110 B-D	101 FG	4
Y12	7	167.5 A	3.5 A	73 AB	3	73 BC	29 C	1	3	3	4	104.5 C-E	111.5 DE	1
Y13	9	167.5 A	4 A	72.5 AB	3	74 A-C	32.5 B	1	3	5	1	120.5 AB	109 EF	4
Y14	5	67.5 D	4 A	45 C	5	37.5 E	5.5 J	9	3	5	2	41.5 G	49.5 I	2
Y15	5	97.5 C	8 B	62.5 A-C	5	53.5 D	10.5 I	9	2	5	3	84 F	36 J	3
Average		147.43	4.3	69.20		73.2	23.64					99.95	98.9	

Code descriptor: E – time of appearance of central head, PH – height İncludung central head, NL shoots – number of lateral shoots on main stem, MS Height – main stem height, Leafatt – leaf Attitude, Llenngth – leaf length, MsDiam – main stem diameter, Intgreen – intensity of leaf green colour, Hair – leaf hairness, Anthocpet – anthocyanin coloration at base of petiole, HeadLength – central flower head length, Head Diameter – central flower head diameter, Tipshape – shape of tip in central head.

cont. Table 3

Average values of morphological traits and total phenolic and total flavonoid content of local varieties and wild lines in 2019 and 2020

Number	LH1	DH1	Shape Bract	Depth Bract	Antho Head Bract	Den-sity Bracts	Recep Diam	Recep Height	Recep Shape	TNH	WMH	TPS mg GAE/g receptacle	TFS mg CE g^{-1} recep-tacle
Y1	66.5 A-C	21.5 D-F	3	5	1	7	81 CD	17 B	5	4.5 F	565 A	4.97±0.40	1.05±0.52
Y2	61 B-D	21 E-G	3	3	2	7	59 H	16.5 BC	5	8.5 C	472 B	6.41±0.15	3.77±0.32
Y3	68 AB	22 DE	3	5	4	7	65.5 G	24 A	5	12 B	440 B-D	4.68±0.12	1.34±0.15
Y4	62.5 B-D	16.5 I	3	3	1	7	74.5 EF	17 B	5	6 C-F	447 BC	3.29±1.15	0.90±0.52
Y5	59.5 B-D	18 H	3	5	3	9	75 E	14 D-F	5	6.5 C-F	415 C-E	3.36±0.42	0.98±0.26
Y6	48.5 EF	22.5 CD	3	3	1	7	76.5 DE	16 B-D	5	7.5 C-F	385 DE	3.51±0.44	1.20±0.14
Y7	73.5 A	20.5 FG	3	3	1	7	69 FG	16 B-D	5	8 CD	275G	2.86±0.25	0.59±0.16
Y8	64 A-D	23.5 C	3	3	2	5	84.5 BC	13 E-G	5	7 C-F	325 FG	4.49±0.52	0.64±0.38
Y9	63.5 A-D	29 A	9	5	4	7	87.5 AB	14.5 C-E	5	12 B	435 B-D	5.22±0.28	1.45±0.26
Y10	55 DE	20 G	3	5	1	7	64.5 GH	23.5 A	7	5.5 D-F	382 DE	5.45±0.29	0.98±0.18
Y11	65 A-D	21 E-G	3	3	1	7	65.5 G	23.5 A	5	6 C-F	305 G	6.72±1.12	1.21±0.26
Y12	59.5 B-D	27 B	3	5	1	7	77.5 DE	23 A	5	5 EF	380 DE	5.12±0.14	1.48±0.44
Y13	55.5 DE	27.5 B	3	5	1	7	92 A	14 D-F	5	5.5 D-F	367.5 EF	4.50±0.32	1.92±0.36
Y14	41 F	12 J	5	3	1	7	47.5 I	12 FG	5	6 C-F	47.5 H	4.99±0.28	2.70±0.15
Y15	54.5 C-E	12 J	5	3	1	7	34 J	11 G	5	18.5 A	97.5 H	4.01±0.72	2.10±0.51
Average	57.5	20.9					70.2	17		7.9	355.9	4.64	1.49

Code descriptor: LH1 – length of first order head on lateral shoots, DH1 – diameter of first order head on lateral shoots, Shape Bract – main shape of outer bract, Depth Bract – depth of incision of outer bract, Antho Head Bract – anthocyanin coloration of central flower head inner bracts, Density Bracts – density of inner bract; Recep Diam – receptacle diameter, Recep Height – receptacle height, Recep Shape – receptacle shape; TNH – total number of heads, WMH – weight of main head, TPS – total phenolic substance, TFS – Total Flavonoid substance

in 2008 and 102.9 cm in 2009. Crinò et al. (2017) determined the maximum height as 90.7 cm in the S20 clone. These results support our work.

Number of lateral shoots on main stem; The minimum number of lateral shoots on the main stem were calculated as 3.5 in Sakiz, Y6,Y7,Y11 and Y12, and the maximum was calculated as 8 in *Cynara cardunculus*. The remaining genotypes ranged between these two values. In other research (Ciancolini 2012), it was reported that Ascolano had 3.33 lateral shoots on the main stem, compared to other varieties: Campagnano 3.17, Castellammare 2.67, Jesino 2.83 and Bianco Pertosa 3.33, in the first year.

Main stem diameter (mm): In our study, the minimum stem diameter was measured as 5.5 mm in *C.cornigera*, and the maximum was measured as 38.2 mm in Sakiz landraces. Parallel to our work, Ciancolini et al. (2012) found that the main stem diamater in different varieties was as follows: Castellammare 30.8 mm, Ascolano 27.6 mm, Campagnano 27.5 mm, Pisa 25.9 mm in the first year, while Castellammare 20.9 mm, Ascolano 25.4 mm, Campagnano 25.4 mm and Pisa 27.7 mm in the second year.

Main stem height; The mean main stem height of the genotypes was calculated as 69.20 cm. The maximum main stem height was found to be in Sakiz as 84.5 cm, whereas the minumum was determined in *C. cornigera* as 45 cm. The main stem height of the remaining genotypes ranged between 45 and 84.5 cm. According to Ciancolini (2012), this trait was determined to be as follows: 133.88 cm for AFB, 126.88 cm for AFFG, 101 cm for AFGR, and 102.57 cm for AFGI in first year.

Leaf attitude; Sakiz, Hasanağa (Bayrampaşa type), Y7,Y8,Y10,Y13 genotypes were classified as having "semi-erect" leaves. Others are classified as "horizontal" in terms of leaf attitude. According to Ciancolini (2012), there was no significant difference between genotypes in terms of leaf attitude.

Leaf length; The maximum leaf length were found to be in Sakız and late Cyprus as 85 cm whereas, the minimum was detected in C.Cornigera as 37.5 cm. Early Cyprus and Hasanağa with 77.4 cm, Y13 genotypes with 74 cm, respectively. According to Ciancolini (2012) determined Ascolano as 95.06 cm, Campagnano as 110.31 cm, Castellammare as 114.81 cm, Jesino as 86.32 cm and Bianco Pertosa as 95.53 cm in the first year.

Spines; While spines were determined in *Cynara cornigera* and *Cynara cardunculus*, the presence of spines was not observed in the other genotypes. According to Ciancolini (2012), Ascolano, Campagnano, Castellammare, Jesino and Bianco Pertosa had spines in the first year.

Intensity of leaf green colour; In the present work, it was determined that leaves of Sakiz, early Cyprus, late Cyprus, Y4,Y7,Y11, *C. cardunculus* were "medium green", Hasanağa, Y6, Y10,Y12, Y13, *Cynara cornigera* had "dark green" leaves, and the other genotypes grew "light green" leaves. In the study by Ciancolini (2012), it was determined that leaves of Ascolano were "medium", Campagnano – "dark", Jesino and Bianco Pertosa – "dark" green in the first year; In the second year, Ascolano had "medium" green

leaves, while Campagnano, Jesino and Bianco Pertosa grew “dark” green leaves.

Leaf hairness; In our study; the leaf hairness of Sakiz, early Cyprus, late Cyprus,Y4,Y6,Y7,Y11 and Y12 genotypes was determined as “weak”, Hasanaga,Y13, *C. cornigera*, *C. cardunculus* and others as “medium”. According to Ciancolini (2012), the hairness of leaves of Ascolano was “weak”, Campagnano as “weak”, Jesino as “strong” and Bianco Pertosa as “weak” in the first year.

Anthocyanin coloration at the head of petiole; In the present work, this trait in Sakiz, Y4, Y7,Y8,Y13 genotypes was determined as “weak”, in Y5,Y6,Y10,Y14 genotypes as “medium”, Early Cyprus, late Cyprus, Hasanağa (Bayrampaşa), *Cynara cardunculus* as “strong”, and in Y11 and Y12 genotypes as “very strong”. In another study (Crinò et al. 2017), S11, S18, and S21 clones exhibited the most intense purple color, and S5, S17, S22, and S23 clones were characterized by green colored heads.

Main head length (mm): In our study, the minimum main head length was measured as 41.5 mm in Cynara cornigera and the maximum was measured as 130.5 mm in Sakiz landrace. The mean main head length was calculated as 99.95 mm. The main head length in Early Cyprus was measured as116.5 mm, in Hasanağa as 91 mm, and in Y13 genotype as 120.5 mm. Bianco et al. (1990) achieved the following results: 90 mm in F1A3 hybrid and 105 mm in the Opal variety.

Main head diameter (mm): The minimum main head diameter was measured as 49.5 mm in *Cynara cornigera*, whereas the maximum value of 132 mm was determined for Sakiz landrace. The mean main head diameter for all genotypes was found to be 98.9 mm. This trait in early Cyprus was determined to be 92.5 mm, in Hasanağa 121 mm, and in Y13 genotype 109 mm. According to Ciancolini (2012), the main head length was 93 mm for Ascolano, 89.2 mm for Campagnano, 100.2 mm for Castellammare and 99.5 mm for Bianco Pertosa in the first year.

Outer bract length (cm); The minimum outer bract length was measured as 2.3 cm in *Cynara cornigera*, whereas the maximum value was 7.95 cm in genotype # Y5. Some other genotypes were determined to have intermediate values of this trait, namely Sakız 5.9 cm, early Cyprus 7.1 cm, late Cyprus 7.75 cm, and *C. cardunculus* 2.55 cm. Outer bract length of the remaining genotypes ranged between 3.1-1.42 mm. In another study (Cravero et al. 2004), the average outer bract length was 6.23 cm in the 1st set and 5.74 cm in the 2nd set. These data support our work.

Outer bract width (cm); The outer bract width was determined to be 4.3 cm in Sakiz with, 4.35 cm in early Cyprus, 5 cm in late Cyprus, 5.9 cm in Hasanağa, 5.15 cm in Y13 genotype, 1.25 cm in *C.cornigera* and 1.5 cm in *Cynara cardunculus*. The outer bract width of the remaining genotypes ranged between 1.25-5.9 cm. In their study, Cravero et al. (2004) determined the outer bract width as 4.25 cm in NATO and 4.17 cm in PI genotype.

Outer bract thickness (mm); The outer bract thickness was determined to be 0.42 mm in Sakiz, 0.7 mm in early Cyprus, 0.63 mm in late Cyprus, 0.35 mm in Hasanağa, 0.28 mm in *Cynara cornigera* and 0.29 mm in *Cynara cardunculus*. In another study, Ciancolini (2012) determined the outer bracket thickness in several varieties to be as follows: Ascolano 0.63 mm, Campagnano 0.43 mm, Castellammare 0.52 mm, Jesino 0.75 mm and Bianco Pertosa 0.63 mm.

Depth of incision of outer bract; In our study, Sakiz, late Cyprus, Hasanağa, Y5, Y10, Y12, and Y13 landraces were determined as "medium" , while *Cynara cornigera* and *Cynara cardunculus* were determined as "shallow" regarding the depth of an incision on the outer bracket. According to Ciancolini et al. (2012), no significant differences between local varieties were observed as regards this trait.

Central flower head; anthocyanin coloration of inner bracts: in the present work, Sakiz,Y4,Y6, Y7, Y10, Y11,Y12 and Y13 genotypes as well as *Cynara cornigera* and *Cynara cardunculus* were determined as "weak", early Cyprus with Y8 genotypes as "medium" and late Cyprus and Hasanağa as "strong" in terms of the anthocyanin coloration. In the study by Crinò et al. (2017), S11, S18, and S21 clones exhibited the most intense purple color, while S5, S17, S22, and S23 clones were characterized by green colored heads.

Receptacle diameter (mm): In our study, the minimum receptacle diameter was measured as 34 mm in *Cynara cardunculus* and the maximum as 92 mm in Y13 genotype. The mean receptacle diameter was determined as 70.2 mm. Crinò et al. (2017) measured the receptacle diameter of the S22 clone as 48.9 mm.

Total number of heads; The total number of heads counted in Sakiz was 4.5, in early Cyprus 8.5, in late Cyprus 12, in Hasanağa 12, in *Cynara cornigera* 5, in *Cynara cardunculus* 18.5. The mean total number of heads for 15 genotypes was calculated as 7.5. According to Ciancolini et al. (2012), the total number of heads was 13.65 for Castellammare landrace and 13.40 for the Pisa landrace, as determined in 2008.

Weight of main head; on average, the weight of the main head was determined to be as follows: 565 g in Sakiz, 440 g in early Cyprus, 472 g in late Cyprus, 435 g in Hasanağa, 47.5 g in *C.cornigera* and 97.5 g in *C. cardunculus*. According to Ciancolini (2012), the total weight of the main head was determined to be 1881.76 g in Ascolanoto, 1974.44 g in Campagnano, 1938.77 g in Castellammare, 992.11 g in Jesino and 916.38 g in Bianco Pertosa in the first year, and 1587.42 g, 1841.43 g, 1906.77 g, 350.77 g and 1638.22 g, respectively, in the second year

Total phenolic substance**;** the total phenolics were determined to reach the content of 4.99 (in mg GAE g^{-1} receptacle) for *Cynara cornigera*, 4.01 for *Cynara cardunculus*, 4.97 for Sakiz, 6.41 for early Cyprus, 4.68 for late Cyprus, 5.22 for Hasanağa. The minimum total phenolic substance was measured as 2.86 mg GAE g^{-1} receptacle in Y7 genotype, and the maximum reached 6.72 mg GAE g^{-1} receptacle in Y11 genotype.

Total flavonoid substance; the total flavonoids were determined to reach the content of 1.05 (mg CE g^{-1} receptacle) in Sakiz, 3.77 in early Cyprus, 1.34 in late Cyprus, 1.45 in Hasanağa, 2.70 in *Cynara cornigera*, 2.10 in *Cynara cardunculus*. The total flavonoid substance content in the remaining genotypes ranged between 0.59-3.77 mg CE g^{-1} receptacle. In other research, Pandino et al. (2011*a*) found that capitulas of clones of the local variety Violetti Sicilia contained an average of 6.3 mg/g^{-1} of fresh weight total phenolics compared to 4.5 mg/ g^{-1} of the two commercial varieties. Galieni et.al. (2019) studied the total flavanoid contents of some artichoke genotypes in Italy. The total flavonoids varied between 1.8 mg RE g^{-1} receptacle and 4,1 mg RE g^{-1} receptacle. In the study by Ciancolini (2012), the total polyphenol content was reported to be: 20.14 g^{-1} DM for Ascolano, 7.83 for Campagnano, 112.54 for Grato, 22.60 for Jesino, 14.35 for Pisa and 11.66 for Castellammare.

In the present study, 29 morphological traits were investigated in 15 genotypes. The classification made according to the traits investigated in 15 genotypes and the 7 different clusters consisting of genotypes can be seen in Figure 3. The farthest distances between genotypes were found to be in genotype combinations of Y1-Y14 (12.17), as demonstrated in Table 4. The distance between Sakiz and Hasanağa is determined as 5.09. The distribution of Cynara spp. is shown in Figure 4. Results of the principal component analysis (PCA) revealed that the total rate of variation observed was 97.89 %. The PCA conducted on clones of the same typology by Crinò et al. (2017) revealed that 37.61% of the total variance is explained by the first three components. In addition, they reported that the first three factors explained >90% of the total variance.

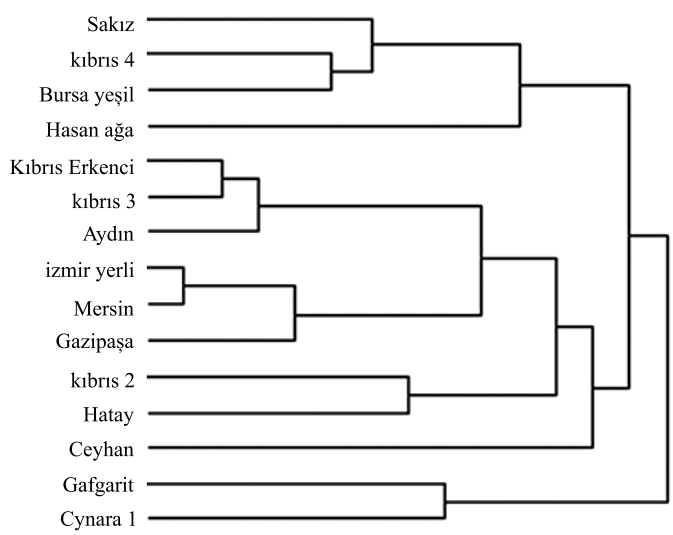

Fig. 3. Cluster analysis of local artichoke and wild types using morphological data

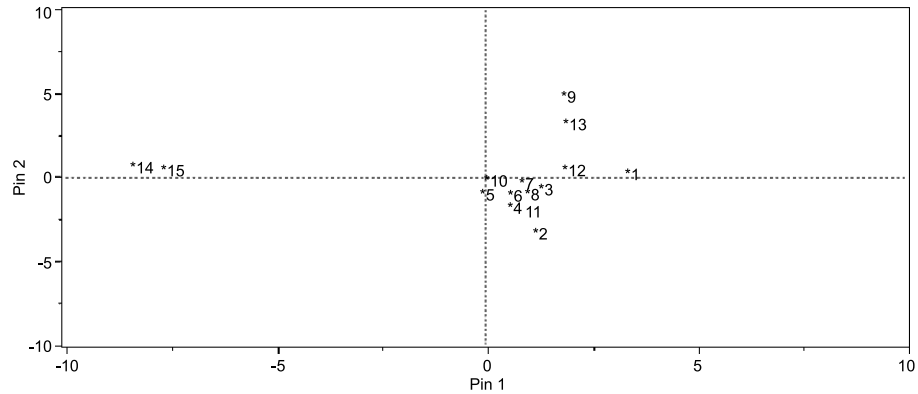

Fig. 4. Distribution of *Cynara* spp

Table 4

Principle Component Analysis performed on artichoke samples

Factor	1	2	3	4	5	6	7	8
Eigenvalue	6.39	2.00	1.61	1.48	1.26	**1.18**	**1.12**	1.05
Variation (%)	49.22	64.68	75.51	83.06	89.10	93.61	96.19	97.89
E	-0.0098	0.6054	0.1423	0.0639	-0.0750	-0.4423	0.5410	-0.0962
PH	0.3609	0.0246	0.0328	0.2921	-0.1786	-0.0944	-0.1492	-0.3046
NL shoots	-0.2495	-0.0748	-0.1482	0.6644	0.3525	-0.1157	0.1195	-0.1435
MS Height	0.3045	-0.1040	-0.0859	0.0203	0.6379	-0.1367	-0.1166	0.0081
Leafatt	-0.2144	-0.3816	0.4342	0.0172	-0.2239	0.2658	0.3117	0.0134
Llenngth	0.3496	-0.1258	0.1852	0.2480	-0.1611	0.1083	-0.1234	-0.1879
MsDiam	0.3493	0.1857	0.0364	0.1650	0.0346	0.1497	-0.1376	0.5921
Spines	-0.3707	0.0159	-0.0714	-0.0410	0.2536	0.0693	0.0913	0.4403
Intgreen	-0.0376	0.5204	0.3040	-0.2511	0.3299	0.4764	-0.1795	-0.3144
Hair	-0.2209	0.3631	-0.1079	0.4894	-0.2912	0.3275	-0.2267	0.1685
Anthocpet	-0.0746	-0.0205	0.7540	0.1266	0.0956	-0.3862	-0.2884	0.2439
HeadLength	0.3156	-0.0808	0.1790	0.1927	0.2260	0.4036	0.5698	0.0675

CONCLUSION

The production and consumption of artichoke, which is very beneficial for human health owing to the substances it contains, is increasing day by day. A collection garden was established from local varieties and wilds collected as a result of surveys conducted in Turkey and the Turkish Republic of Northern Cyprus, which are the countries where the artichoke grows naturally, whose homeland is the Mediterranean countries. Some morpholo-

gical, phenolic and flavonoid substances of genotypes of artichoke local and wild (*Cynara* spp.) collected as a result of the research were determined and artichoke gene pool was created. As a result of our studies, the obtained datas are considered to be used in future breeding studies.

ACKNOWLEDGMENTS

Acknowledgments: The authors thank the Bati Akdeniz Agricultural Research Institute for their financial support (BATEM project). We would like to thank the Bati Akdeniz Agricultural Research Institute for the research we have done. LK, FY and MP collected Cynara types. LK, MP, ÖT, RG made morphological observation. LK, OÇ, did their laboratory work.

Conflict of interest

The authors declare that they have no conflict of interest. These authors contributed equally to this work.

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