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Development and morphological characterization of purple sweet corn lines

Ahmet Öztürk[1]*, Bülent Uzun[2]

1 Batı Akdeniz Agricultural Research Institute, 07100 Antalya, Turkey

2 Department of Field Crops, Faculty of Agriculture, Akdeniz University, 07058 Antalya

*Corresponding author: E-mail: aozturk20@gmail.com

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Abstract

Purple colored corn has significantly higher anthocyanin concentration than uncolored corn. The demand of purple corn is increasing due to being more beneficial to health compared to yellow corn. There is no any registered variety, genetic pool and breeding program to meet this demand in Turkey. The objectives of this study were to (i) develop purple sweet corn inbred lines, (ii) morphologically define the developed lines and (iii) determine consumer preference on purple sweet corn. Standard sweet corn lines (su) and a purple waxy corn as a color donor that provided from Thailand were used in this study. The study was carried out in Antalya Turkey under field and greenhouse conditions during the consequent of 2017-2021 years. The sweet and the purple donor lines were crossed and then selfed according to the pedigree breeding procedure to develop lines varied for purple and sweetness characters. Developed lines were characterized according to morphological traits and divided into totally seven clusters. Twenty lines were finally selected based on agronomic characteristics under investigation among 118 lines. The results showed that developed purple sweet corn lines had higher anthocyanin (26.09 mg/L), antioxidant capacity (147.50 IC50/DPPH) and phenolic compounds (1014.7 mg Gallic Acid Equivalent/kg) than yellow sweet lines . According to the panel test results, purple sweet corn had higher scale of appearance and purchase request (8.09 and 7.68) than yellow ones (7.60, 7.49) respectively. This is first report on development of purple sweet corn lines in Turkey.

Abbreviations

ALBA: angle between main axes and lateral branches
AT: time of anthesis
BA: attitude of blade
BGA: anthocyanin coloration at base of glume
BRA: anthocyanin coloration of brace roots
CGA: anthocyanin coloration of glumes of cob
CGAI: intensity of anthocyanin coloration of glumes of cob
CGE: cyanidin 3-O-glucoside equivalent
DPPH: 2,2-Diphenyl-1-picrylhydrazyl
ED: ear diameter
EH: first ear height
EL: ear length
ES: ear shape
GA: anthocyanin coloration at glume
GAE: Gallic Acid Equivalent
GDSC: color of dorsal side of grain
GT: type of grain
GTC: color of top of grain
HPLC: High Performance Liquid Chromatography
IC: inhibition capacity
LBA: attitude of lateral branches
LBN: number of primary lateral branches
LSBL: length of main axis above lowest side branch
LW: width of leaf blade
NKR: number of kernel rows
PC: Principal Component
PCA: Principal Component Analysis
PH: plant height
PL: length of peducle
SA: anthocyanin coloration of silks
SAI: intensity of anthocyanin coloration of silks
SBL: length of side branch
SD: density of spikelets
SHA: anthocyanin coloration of sheath
ST: time of silk emergence
TS: shape of tip
UPOV: International Union for the Protection of Cultivated Varieties of Plants
UPGMA: Unweighted Pair-Group Method with Arithmetic Mean
USBL: length of main axes above upper side branch
ZD: degree of zig-zag of internode in corn stalk

Introduction

Sweet corn is a well-established product in the market and a very popular ingredient in the diet especially all over the world. Turkey is an importer country in terms of use of sweet corn products although sweet corn cultivation and consumption is gradually increasing in Turkey (Erdal *et al.*, 2011; Ozata 2019).

Corn kernels have several colors such as yellow, white, purple, blue, red, pink, or black (Mendoza *et al.*, 2019). Hong *et al.*, (2014) stated that colored corn generally has higher anthocyanin concentration than uncolored ones. Purple sweet corn with a special place among other corn varieties has been used as functional food due to its nutritional value, especially high anthocyanin, antioxidant, and phenolic compounds in human diet all around the world (Lago *et al.*, 2014). The anthocyanin, antioxidants and phenolic compounds are the molecules which have preventive function against human diseases such as, diabetes (Kim *et al.*, 2013), cardiovascular disease (Yang and Zhai,2010), obesity (Tsuda *et al.*, 2003), chronic diseases (Virgili and Marino, 2008), and cancer (Joshi *et al.*, 2017). Reports showed that consumption of sweet corn seems can restrain tumour growth in mice probably due to the presence of some phenolic compounds, especially as ferulic acid (Tokuji *et al.*, 2009). The antioxidant potential of corn seeds can be increased because of its capacity to storage anthocyanins in the seeds. At the same time, anthocyanins are antioxidant molecules known to be beneficial for health if consumed regularly. Therefore, foods having high levels of anthocyanin, antioxidants and phenolic compounds are now entering into human diet as essential functional food around the world. Diverse socioreligious consumers can easily accept plant-based carotenoids and tocopherols in contrast to a dietary source of animal and also people with low socio-economic structure especially in rural areas of developing countries can more easily access plant-based foods (Chander *et al.*, 2008). For this reasons, purple colored sweet corn can be evaluated as a functional food. Therefore, developing purple colored sweet corn genotypes might be an interesting issue for maize breeders (Lago *et al.*, 2014). The purple sweet corn breeding studies, therefore, have started recently in the world especially Peru, Italia (Lago *et al.*, 2014), Australia (Anonymous 2019), Mexico (Mendoza *et al.*, 2019), Argentina (Mansilla *et al.*, 2020), Vietnam (Tuan et al., 2021).

Genetic diversity and wide variation are one of the basic requirements for hybrid maize breeding. It has also been reported by Mohammadi and Prasanna (2003) that knowing the genetic relationship between the pure lines obtained in breeding is very important in the planning of cross breeding. Genetic diversity is the first phase of crop improvement which is described through different marker systems such as agro-morphological (Iqbal *et al.*, 2015). Agro-morphological characterization is an initial step of genetic diversity studies (Smith and Smith, 1989; Khan *et al.*, 2014). Morphological characterization can also be used to detect genetic diversity (Oliveira *et al.*, 2004). The cluster analysis and Principal Component Analysis (PCA) are preferred methods based on similarity basis for morphological characterization of maize genotypes (Al-Naggar *et al.*, 2020).

The demand of purple corn is increasing due to being more beneficial to health compared to yellow ones. To our best knowledge, there is any registered varieties and also any genetic pool and breeding program to meet this demand in Turkey. Therefore, purple sweet corn breeding scheme was planned and started for Turkey in 2017. The development of the gene pool and new purple sweet corn lines will allow to obtain new purple sweet corn hybrids in the medium or long-term program.

In this research we aimed (i) to develop new purple sweet corn inbred lines, (ii) to evaluate some morphologic traits for characterization and (iii) to determine the acceptability of purple sweet corn for consumers.

Material and methods

Development of purple sweet corn lines

Parents of a yellow sweet corn hybrid named BATEM TATLI (Ant-234-F-3-2 x 224-E-1 were used in this study. In order to identify best purple color donor, purple grain color genotypes from Thailand, China, Argentina and Peru were tested in Antalya in 2017. A color donor that is originated from Thailand was selected based on its better agronomic characteristics. Yellow sweet corn parents were crossed with purple waxy corn in 2017 in the field and obtained F1s were planted to greenhouse in the same year. The field and greenhouse combination enabled two generations of progress annually. Selfings were carried out in subsequent years of 2017-2021 at the Bati Akdeniz Agricultural Research Institute's fields and greenhouses placed in Antalya, Turkey (36°52′N, 30°45′E). In the selfing studies, the first ears of each segregating lines were isolated by bags to prevent open pollination. The tassels of the same plants were closed by paper bags before pollen lobes dehisce. The pollen saved in the paper bags were spilled carefully to ear of the same plant, when the ear silks fell out and ready to receive pollen, and the selfed ears were kept with bags collected pollen until harvest. The seeds of purple sweet corn lines were planted approximately in mid-March, selfed approximately in mid-June and harvested in early-August in field season in this breeding studies. In greenhouse season, these seeds of lines were planted in early-September, selfed approximately mid-November and harvested at the end of March. Following to this selfing scheme according to pedigree method proposed by Russel and Eberhart (1975), 118 purple sweet corn inbred lines in the 5^{th} selfing generation were finally developed (Table 1).

Table 1 - The number of purple sweet corn lines for each selfing generations

Years	Generation	Total number of lines
2017	Parent seed production	
2017-2018 greenhouse	F1	10
2018 field season	S_1	42
2019 field season	S_2	129
2020 field season	S_3	127
2020-2021 greenhouse	S_4	112
2021 field season	S_5	118

Climatic data of the location for breeding studies period is presented in supplementary file Table S1. The total rainfall, mean relative humidity, average temperature, maximum temperature and minimum temperature for average of five years studied were 664.2 mm, 71.5%, 19.2°C, 43.5°C and 0.1°C, respectively (Table S1).

Morphological characterization of purple sweet corn lines

A total of 118 purple sweet corn lines were morphologically characterized under field conditions. The experimental plots consisted of two rows, 5 m long and 0.7 m spacing. Nitrogen (80 kg/ha) and phosphorus (80 kg/ha) were applied before sowing and remain nitrogen (170 kg/ha) was applied equally for 4 times. Harvest of lines were carried out by hand.

Morphological characterization was done according to the International Union for the Protection of Cultivated Varieties of Plants (UPOV) descriptors. To characterize purple sweet corn lines, 34 UPOV agro-morphological traits (21 qualitative and 13 quantitative) were used (Babic *et al*., 2012). Quantitative traits such as anthesis (AT), number of primary lateral branches (LBN), time of silk emergence (ST), length of main axis above lowest side branch (LSBL), length of main axes above upper side branch (USBL), length of side branch (SBL), plant height (PH), first ear height (EH), width of leaf blade (LW), length of peducle (PL), ear length (EL), ear diameter (ED), number of kernel rows (NKR) were investigated. Besides, anthocyanin coloration of sheath (ACS), shape of tip (TS), angle between blade and stem (ABS), attitude of blade (BA), degree of zig-zag of internode in corn stalk (ZD), anthocyanin coloration of brace roots (BRA), anthocyanin coloration at base of glume (BGA), anthocyanin coloration at glume (GA), anthocyanin coloration of anthers (AA), density of spikelets (SD), angle between main axes and lateral branches (ALBA), attitude of lateral branches (LBA), anthocyanin coloration of silks (SA), intensity of anthocyanin coloration of silks (SAI), anthocyanin coloration of sheath (SHA), ear shape (ES), type of grain (GT), color of top of grain (GTC), color of dorsal side of grain (GDSC), anthocyanin coloration of glumes of cob (CGA), intensity of anthocyanin coloration of glumes of cob (CGAI) qualitative traits were also evaluated.

Determination of total sugar content, monomeric anthocyanins, total phenolic content and antioxidant activity

Total sugar content, monomeric anthocyanin concentration, total phenolic content and antioxidant activities of the corn samples were determined in the HPLC device according to Turhan (2014), by using the pH differential method according to Lee *et al*., (2005), with spectrophotometric method according to Spanos and Wrolstad (1990) and by DPPH method according to Cemeroglu (2007) respectively.

Panel (Consumer) Test

To evaluate the acceptability of purple sweet corn, 85 people with an average age of 40.5 years and range of 18-63 years were randomly selected and asked them to taste both the yellow sweet corn and purple sweet corn boiled ear. After the tasting, each person filled out the panel form according to scale from 1, the worst, to 10, the best for each question (appearance, flavor, acceptability and purchase request). The average point of a person for two different colored sweet corn were calculated (Lago *et al*., 2014).

Data analyses

To determine genetic diversity among the studied 118 lines according to the agro-morphological traits, the quantitative traits data of UPOV descriptor were averaged and analyzed for simple statistical approaches (minimum, maximum, mean, standard deviation and coefficient of variation) (Iqbal *et al*., 2015). Through numerical taxonomic approaches, the data of the whole agro-morphological characters were analyzed by cluster and Principal Component Analysis (PCA), according to the Sneath and Sokal (1973).

Results and discussion

Development of purple sweet corn lines

The yellow sweet corn lines were crossed with purple waxy corn and F_1 seeds were obtained in 2017-2018 greenhouse season. F_2 plants were planted and totally 42 purple-colored sweet corn lines were selfed to obtain first selfing generation in 2018 field season (Table 1). Purple sweet corn seeds visually selected according to both purple-colored and wrinkled seeds on ear (Figure 2a). 42 S_1 purple sweet corn lines were planted and selfed in 2019 field season and 129 lines were selected. Similarly, 129 lines were planted for breeding studies and 127 lines were selected for third selfing generation (S_3) in 2020 field season. 127 lines were

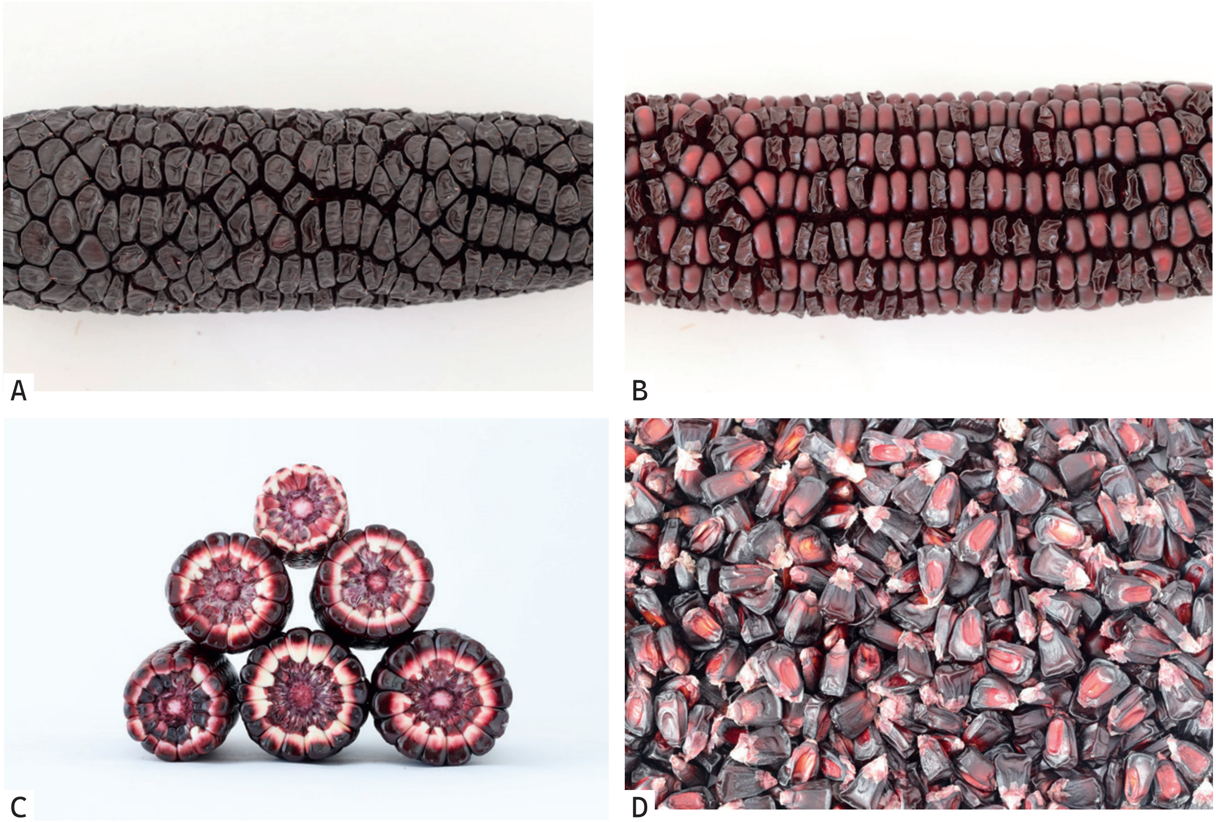

Fig. 2 -The ear and seeds of purple sweet corn. a and b: ear; c: fresh purple colored sweet corn ear; d: seeds

cultivated and 112 lines were selected as S_4 breeding generation in 2020-21 greenhouse season. Of those, 118 lines were selected for 5 selfing generation in 2021 field season (Figure 2b). Finally, 118 purple sweet corn inbred lines were developed (Figure 2c, d). 20 out of 118 inbred lines were selected for better adaptation capability to the environment studied as well as plant vigor and ear characteristics (Table S2).

Morphological characterization of purple sweet corn lines

The data related to quantitative morphological traits are given in Table 2. The mean of 13 quantitative agro-morphological traits for AT, LBN, ST, LSBL, USBL, SBL, PH, EH, LW, PL, EL, ED and NKR was 97.0 , 18.8, 98.4, 27.6, 16.1, 15.0, 163.7, 64.1, 7.6, 5.6, 14.2, 3.97 and 15.3, respectively (Table 2). Maximum variance was observed for plant height (794.11) followed by first ear height (227.19), number of primary lateral branches (39.80), time of silk emergence (27.44), time of anthesis (27.10) and length of main axes above lowest side branch (26.04) (Table 2).

In the morphological characterization, all of the purple sweet corn lines are in the same category in terms of flowering time. Thus, it is considered to provide convenience in crossing studies in future breeding programs that will be used these materials in terms of matching of flowering time of the parent line.

According to the UPOV observations, BRA anthocyanin was observed in the brace roots in the whole studied material, however anthocyanin density was different. It has been determined that almost all purple sweet corn lines had strong or very strong anthocyanin brace ro-

Table 2 - Basic statistics of 13 studied quantitative traits

	AT	LBN	ST	LSBL	USBL	SBL	PH	EH	LW	PL	EL	ED	NKR
Minimum	88	6	90	10	5	5	60	30	4	2	9	2.7	10
Maximum	108	39	110	40	30	30	230	100	11	11	20	4.9	20
Mean	96.99	18.77	98.42	27.64	16.08	15.04	163.69	64.11	7.61	5.57	14.22	3.97	15.34
SD	5.21	6.31	5.24	5.10	4.67	4.36	28.18	15.07	1.22	2.09	2.49	0.48	1.83
CV%	5.37	33.61	5.32	18.46	29.04	29.02	17.21	23.51	16.12	37.39	17.51	12.13	11.94
Variance	27.10	39.80	27.44	26.04	21.80	19.05	794.11	227.19	1.50	4.33	6.19	0.23	3.35

ots. The purple sweet lines have a very short, short and medium-length tassel structure. In maize breeding, it is desirable to have a releatively small tassel, especially when the target is grain yield. Because the millions of pollens that the tassel has in its small structure will be enough for pollination and fertilization. This small structure of tassel may cause to having more nutrients to different parts of plant

When the PH and EH observations are examined, purple sweet corn lines had different plant heights varied from very short to tall structures. They also showed very small, small and medium characteristics according to the ear height ratio. Considering that the ear height ratio is not desired above 50%, the studied purple sweet corn lines seem promising in terms of this feature.

When the EL and ED are examined, purple sweet corn lines are included in the very short and short scale groups. Since the germplasm studied was inbred line, it is thought that the length and the diameter of the ear were short. It is thought that the length and thickness of the purple sweet corn hybrids to be obtained from these lines would be enough long.

Cluster analysis which performed by 34 agro-morphological traits using UPGMA (Unweighted Pair-Group Method with Arithmetic Mean) divided purple sweet corn lines into 7 clusters by the method at similarity coefficient values and these lines were found to show a wide genetic diversity (Figure 1). Among the studied purple sweet corn lines, line 18 and line 84 were similar to each other, which came from similar genetic backgrounds (from Ant 224-E-1 genetic background). The similarity coefficients of purple sweet corn lines are presented in Table S3. Although line 1 and 4 were obtained from the same genetic base (Ant 234-F-3-2 genetic background), they were determined as the farthest purple sweet corn lines from each other. The groups including the lines with close genetic bases show a high similarity according to the pedigree information of the studied material. According to their initial state, the lines consisting of the hybrid of the purple line and the 234-F-3-2 line are mostly in similar groups and are generally gathered in the first three groups. The lines consisting of the expansions of the hybrid of the purple line and the 224-E-1 line are also in similar groups (5^{th}, 6^{th}, and 7^{th}).

In order to interpret and evaluate PCA effectively and correctly, the first two or three principal component axes must represent more than 25% of the total variation (Mohammadi and Prasanna, 2003). In our study, the first two PCA represented 26.15% of the total variance (Table S5). The eigenvalues calculated on the purple sweet corn lines as a result of PCA, the variance and total variance ratios of the value, the PC axes on the basis of the examined characteristics and the corresponding factor coefficients are presented in Table S5. According to Iqbal *et al.*, (2015) and Karagül *et al.*, (2016), component axes with eigenvalues greater than 1 are effective in defining the total variation. For this reason, the main component axes with eigenvalues greater than 1 were taken into account, and 11 independent PCA axes greater than 1.00 were determined. The eigenvalues of these PC axes range from 1.04 to 4.65, defining 73.3% of the total variation of purple sweet corn lines.

In terms of the morphological features examined in the PCA axes, if the weight values of the components are 0.30 and above, it is accepted that they have a significant weight in explaining the variance (Gözen, 2008). When the eigen values of the main components of the examined features for the morphological characterization was analyzed, among the features in the PC1 axes, LSBL, PH, SBL and USBL had important effect for ac-

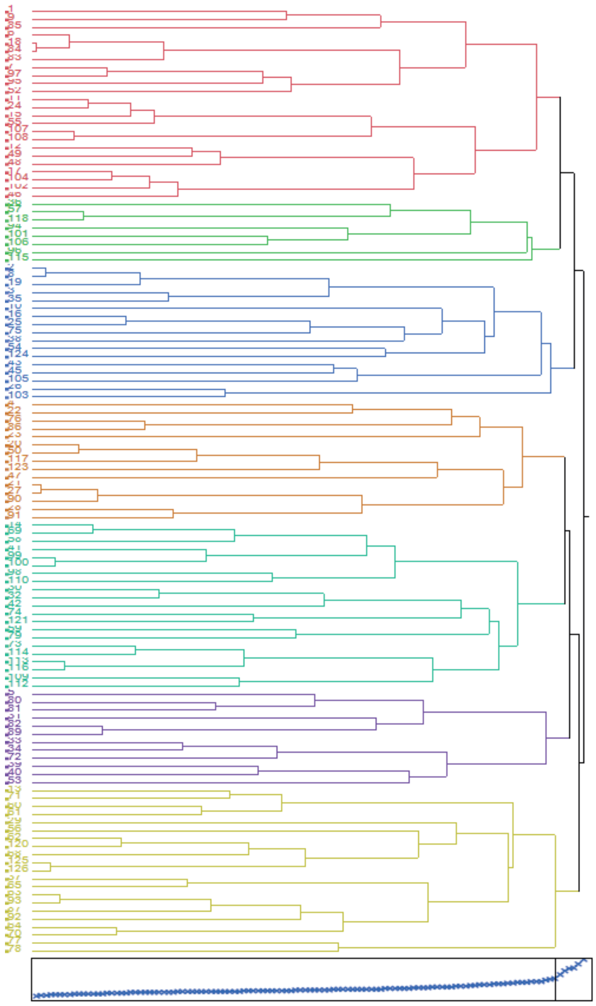

Fig. 1 - UPGMA dendrogram of 118 purple sweet corn lines based on 34 agro-morphological traits

count for 16.04% of the total variation thanks to had higher value than 0.30 (0.327, 0.326, 0.325 and 0.304) respectively. It has been seen that the SA and SAI were the properties that determined 10.11% of the total variation with eigen value 0.452 and 0.449 respectively in the PC2 axes. In the PC3 axes, which determines 7.46% of the total variance, AT and ST were noted with had higher eigen value 0.412 and 0.410 value respectively than 0.30. The PC4 axes, on the other hand, represented 7.11% of the variation and consisted of LBN, ABS, LW, BA traits with 0.442, 0.347, 0.310 and 0.306 eigen value respectively. It was seen that the PC6 axes represented 7.19% of the variation, and the ALBA feature had 0.334 value in this axes stands out. They stood out with ZD and SHA had same eigen values (0.361) in the PC7 axes, which represented 4.92% of the total variation. The PC9 axes represented 4.44 of the total variation with ST feature had 0.405 eigen value. The NKR and CGAI had 0.382 and 0.409 respectively noteworthy in the PC10 axes, which represented 3.92% of the total variation. It was determined that the NKR feature was also located in the PC11 axes, which represented 3.58% of the total variation (Table 3).

Table 3 - PCAs for morphological data

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Eigenvalue	4.65	2.93	2.16	2.06	1.68	1.57	1.43	1.32	1.29	1.14	1.04
Total Variance (percent)	16.04	10.11	7.46	7.11	5.78	5.42	4.92	4.56	4.44	3.92	3.58
Cumulative Variance (percent)	16.04	26.15	33.61	40.72	46.50	51.92	56.84	61.40	65.84	69.76	73.34
Traits	Eigenvectors										
Length of main Axes above lowest side branch (LSBL)	**0.327**	-0.248	0.068	0.039	0.069	-0.008	-0.068	0.271	0.107	0.016	0.059
Plant height (PH)	**0.326**	-0.111	0.174	0.168	-0.126	-0.156	0.155	0.161	0.063	0.180	0.017
Length of side branch (SBL)	**0.325**	-0.198	0.057	-0.231	0.228	0.075	-0.035	0.153	0.015	-0.088	0.013
Length of main Axes above upper side branch (USBL)	**0.304**	-0.138	0.062	-0.230	0.307	0.049	-0.090	0.128	-0.044	-0.126	0.085
Anthocyanin coloration of silks (SA)	0.008	**0.452**	0.037	0.027	0.283	0.059	0.252	0.189	-0.130	0.007	0.062
Intensity of anthocyanin coloration of silks (SAI)	0.041	**0.449**	0.015	-0.015	0.256	0.061	0.218	0.275	-0.150	-0.069	0.034
Time of antesis (AT)	-0.234	-0.221	**0.412**	-0.060	-0.059	0.143	0.209	0.098	0.008	-0.156	-0.017
Time of silk emergence (ST)	-0.240	-0.225	**0.410**	-0.061	-0.046	0.126	0.216	0.121	0.006	-0.134	0.001
Number of primary lateral branches (LBN)	-0.055	-0.041	-0.145	**0.442**	-0.182	0.054	-0.206	0.104	0.169	0.030	0.026
Angle between blade and stem (ABS)	-0.161	-0.034	-0.119	**0.347**	-0.001	0.352	0.150	0.101	-0.058	-0.040	-0.005
Width of leaf blade (LW)	0.131	0.143	0.072	**0.310**	0.099	-0.194	0.170	-0.162	0.202	-0.392	-0.130
Attitude of blade (BA)	0.050	-0.120	-0.152	**0.306**	0.120	**0.400**	0.077	0.095	-0.288	-0.012	0.229
Angle between main Axes and lateral branches (ALBA)	0.214	-0.165	-0.109	0.046	-0.078	**0.334**	0.160	-0.350	-0.164	-0.180	-0.056
Degree of zig-zag (ZD)	0.024	-0.035	0.076	-0.045	0.120	0.067	**0.361**	-0.173	0.549	0.299	0.027
Anthocyanin coloration of sheath (SHA)	0.115	-0.038	-0.205	0.156	-0.224	-0.105	**0.361**	0.101	0.014	0.013	0.205
Shape of tip (TS)	-0.052	0.075	0.183	0.106	0.214	0.277	0.028	-0.101	**0.405**	0.016	0.071
Number of kernel rows (NKR)	0.078	0.113	0.265	0.110	0.076	0.059	-0.202	-0.162	-0.073	**0.409**	**0.427**
Intensity of anthocyanin coloration of glumes of cob (CGAI)	0.058	0.165	0.100	-0.042	-0.081	0.226	0.092	0.109	-0.100	**0.382**	-0.626

Bold numbers indicate have higher eigen value than 0.30.

Total sugar content, monomeric anthocyanins, total phenolic content, and antioxidant activity

In this study, sweet corn generally had higher level of sugar content than waxy corn. While the lowest sugar content (2.38%) was determined in purple waxy, the highest sugar content was determined in yellow sweet corn (8.05%) and purple sweet corn (5.85%) (Table 4). Similar results were found by Ji *et al.*, (2010), Tuan *et al.*, (2016), Ibrahim and Ghada (2019), Hong and Hare (2020) and Feng *et al.*, (2020) for total sugar content with values of 10.2-14.8%, 8.8-14.8%, 3.0-7.6%, 2.7-11.6% and 12-15%, respectively.

The yellow-colored sweet and waxy corn had lower monomeric anthocyanin content than purple-colored corns with 0.00 and 0.26 mg CGE (cyanidin 3-O-glucoside equivalent)/l respectively, while purple sweet corn involved the highest anthocyanins content 26.09 mg CGE/l (Table 4). The current results are similar to previous findings of Feng *et al.*, (2020); Ramos-Escudero *et al.*, (2012); Zilic *et al.*, (2012); Khampas *et al.*, (2015); Mohamed *et al.*, (2017); Hu *et al.*, (2020); Mansilla *et al.*, (2020) and Kapcum *et al.*, (2021) for monomeric an-

Table 4 - The total sugar content, anthocyanins, phenolic content and antioxidant activity of purple or yellow corn

	Total sugar content (g/100 g)	Anthocyanin (mg/L)	Phenolic content (mg GAE/kg)	Antioxidant activity (IC50) (mg DPPH)
Yellow waxy corn	3.46±0.14	0.26±0.01	306.9±18.41	319.49±22.44
Yellow sweet corn	8.05±0.32	0.00±0	633.3±37.99	198.80±13.96
Purple waxy corn	2.38±0.09	2.54±0.11	527.4±31.64	256.53±18.02
Purple sweet corn	5.85±0.23	26.09±1.04	1014.7±60.88	147.54±10.36

thocyanin content with values 38-62; 20.1; 5.97; 27.1-73.0; 18.5- 26.2; 0.2-12.43; 8.9-25.4; 5.69-108.25 mg/L, respectively.

Sweet corns can synthesize phenolic compounds (Balasubashini *et al.*, 2003; Tokuji *et al.*, 2009). Therefore, we analyzed total phenolic content of purple sweet corn lines. Yellow-colored samples generally showed lower content than purple-colored samples. Total phenolic content of the samples was changed from 278.3 to 1014.7 mg/kg (Table 4). The highest total phenolic content of the samples was determined in purple sweet corn as 1014.7 mg/kg.

Antioxidant capacities of the samples were determined as inhibition capacity (IC50) and ranged from 147.54 to 382.70 mg DPPH. Sweet corn kernels could find some antioxidant substances (Tokuji *et al.*, 2009; Lago *et al.*, 2014). If antioxidant activity value of any sample is low, this sample has higher antioxidant activity (Bayır Yeğin and Uzun 2018). Therefore, the lowest antioxidant activity was showed in check sample as 319.49 mg DPPH. Moreover, purple sweet corn crossed purple corn and sweet corn had the highest antioxidant activity by 147.54 mg. It was showed that purple corns had the higher antioxidant activity than those of yellows (Table 4). In maize, the more anthocyanin accumulates in corn kernels, the more antioxidant capacity of this corn kernel is increase (Lago *et al.*, 2014). In our research, purple sweet corn involved the highest anthocyanins content with 26.09 mg/l, as well as had the highest antioxidant activity by 147.54 mg DPPH (Table 4). The results of this study showed that purple colored sweet corn have significantly higher amount of anthocyanin, phenolic content and antioxidant activity than the yellow and (Table 4) which makes it as a good candidate for functional food.

Table 5 - The means of appearance, flavor, acceptability and purchase request scores in a randomly group of subjects

	Purple sweet corn lines	Yellow sweet corn varieties
Appearance	8.1±1.63	7.6±2.21
Flavor	6.8±2.11	7.9±2.17
Acceptability	6.7±2.20	6.9±1.79
Purchase request	7.7±1.78	7.5±2.52

Panel (Consumer) Test

To find out acceptability of purple sweet corn, eighty-five persons were randomly chosen and involved in panel test. They were asked to express a judgement about the appearance, flavor, acceptability, and purchase request for both yellow sweet corn and purple sweet corn which were served as boiled. Consumers were very positive about purple sweet corn. The appearance, flavor, acceptability and purchase request mean scores for yellow lines were 7.6, 7.9, 6.9 and 7.5 respectively. The appearance, flavor, acceptability and purchase request mean scores for purple lines were 8.1, 6.8, 6.7 and 7.7 respectively (Table 5).

The average scores of acceptability for purple and yellow corn were almost the same points which were 6.7 and 6.9, respectively. Purchase request mean scores for purple and yellow sweet corn almost same point 7.7 and 7.5 too respectively. The results of panel test showed that purple corn can be accepted comparing to yellow corn for consumers. Our panel test results are similar to previous studies of Lago *et al.*, 2014 and Mantilla *et al.* 2020 in terms of acceptability of purple sweet corn. In parallel, Lago *et al.*, (2015) stated that acceptability score of colored popcorn was 6.75/10.

Conclusions

As a result of intensive breeding efforts carried out for five years within this study, many purple colored sweet corn lines were developed. The methods that is used in this study can be adapted to many breeding programs around the World. The characterization statistics showed that there is a wide diversity among the developed lines. These lines are ready for further studies to develop purple colored sweet corn hybrids for growers in Turkey. Our study showed that purple colored sweet corn lines had advantageous in terms of anthocyanin, antioxidant phenolic compounds over their yellow counterparts. Moreover, panel (taste) test results supported and encouraged that purple sweet corn can be preferred by the consumers.

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