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Research Paper

Determining Total Phenolic Compound, Tannin and Anthocyanin Ratios of Grape Varieties Cultivated in Şanlıurfa Province

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Abstract

This study was conducted to determine the total phenolic compound, tannin, and anthocyanin ratios in 29 grape varieties cultivated in Şanlıurfa Province in 2013 and 2014. The skin, fruit flesh and seeds of grape varieties were analyzed separately by using spectrophotometric methods. As a result, in this study conducted; It has been determined that grape varieties are rich in phenolic compounds and their content differs from each other. Comparison of the white and colored varieties showed that total phenolic compound and anthocyanin contents of colored varieties were higher in skin, flesh and seed. Besides, this study determined that total tannin content of colored varieties was higher in skin and flesh, while it was at the same level in seeds of both colored and white varieties. Moreover, the study revealed that different climatic structures have an effect on the accumulation of phenolic compounds in the berry over the years.

Introduction

The role of grape in nutrition has been known since ancient times and it still preserves this feature today. Factors such as variety, ecological conditions and cultivation techniques are effective on the composition of the grape (Yavaş and Fidan, 1986).

Determining the chemical composition of grape and grape products, which have important roles in human nutrition and health, is considered to play an important role in the formation of a more conscious consumption habit, as it enables a selection according to the purpose and need. In addition, it is particularly important in terms of revealing the values of table grapes, dried and wine grapes of local varieties (Aras, 2006).

Currently, phenolic compounds, which are the subject of studies in many fields such as agriculture, food, biology, chemistry and pharmacology are synthesized not only during the normal development of plants; but also, in cases such as being infected, injured and exposed to UV light (Naczk and Shahidi, 2004).

They are considered as secondary plant metabolites, knowing that they are formed as side compounds during aromatic amino acid metabolism (Van Buren, 1970; Acar, 1998; Naczk and Shahidi, 2004). Secondary plant metabolites are compounds that are not vital for the whole or certain parts of the plant. These compounds are classified into a group of characteristic features that include biosynthetic precursors (phosphoenolpyruvate, pyruvate, acetate and some amino acids, acetyl CoA and malonyl CoA), including structural diversity and synthesis. (Robards et al., 1999).

Grape is a plant species rich in phenols and phenols are mainly found in the skin, stem, leaves and seeds of the grape (Pastrana-Bonilla et al., 2003; Makris et al., 2008). The phenolic content of grapes differs depending on the variety, soil structure, climate, growing conditions and if it is contaminated by fungal diseases (Bruno and Sparapano, 2007).

The most widely studied metabolites in viticulture are phenolic compounds. It has been reported that these substances are found in different forms and in different amounts in all organs of the vine such as roots, branches, shoots, leaves, bunches and berries (Sivritepe, 2001).

The most important group of phenolic compounds found in grapes are anthocyanins which are responsible for the color (Cemeroglu et al., 2001). Anthocyanins are natural color pigments that give their distinctive red, blue and purple hues (Costa et al., 2000; Ho et al., 2001; Camire et al., 2002).

The anthocyanin content of grapes is an important quality criterion for winemaking. Tannins, another group of phenolic compounds, are responsible for the formation of taste in grapes and are predominantly found in the pedicel, skin and seeds. In general, the amount of tannins in the berry reaches the highest level just before the veraison phase, and decreases towards maturity (Harborne and Grayer 1993).

Previous findings obtained by authors have revealed that some of the varieties identified in the region by the study of Gürsöz (1993) could not survive until today, while some of them were in danger of extinction. It is necessary to take some precautions and perform certain studies to bring these varieties back to production. Determining the characteristic features of the varieties known only in the region is the main work to start with.

Material and Methods

This study was conducted by observing and taking samples from the 29 grape varieties determined in different districts and parcels in Şanlıurfa province in 2013 and 2014. The grape variety from each district is as follows: from Akçakale district; Tahannebi, Perlette, Yediveren (table grapes) Öküzgözü, Syrah, Chardonnay, Cabernet Sauvignon (wine grapes), from Bozova district; Hatun Parmağı, Şeffafi (table grapes), Tilgören, Azezi (must and wine grapes), from Hilvan District; Horoz Karası, Kabarcık, Top Üzüm, Hönüsü, Su Üzümü, Serpenekıran (table grapes), from Karaköprü District; Küllahi, Zeyni, Çiloreş, Kara Kabarcık (table grape), Çilorut (must and table grape), Sergi Karası (Dried), from Siverek District; Simore, Elma Üzümü, Kızıl Banki, Şire, Hasani, Ağ Banki (Table grapes). The soils are generally basic in character, rich in lime and poor in organic matter.

For phenolic compound, tannin and anthocyanin analysis, the skin, flesh and seed parts of the berries were separated and analyzed separately. Analyzes were performed as 3 replications.

Determination of Total Phenolic Compounds and Tannin

Extraction: 5 g of skin, flesh or seed samples were weighed and cut into small pieces by using a scalpel. Later, 50% ethanol was added to the samples and they were thoroughly crushed in the homogenizer. Then, they were filtered through whatmann paper and the 50 % ethanol was added to a final volume of 25 mL. They were kept in 4 °C until the anlysis is done (Yu and Meredith, 1986; Tangolar et al., 1999).

Determination of total phenolic compound: Analysis of total phenolic compounds was determined using Folin-Ciocalteu colorimetric method defined by Singleton and Rossi (1965), and the results were noted in gallic acid (mg kg^{-1}).

Determination of total tannins: The prepared extractions were analyzed according to AOAC, (1998).

Determination of Total Anthocyanin Content

Extraction: After separating the skin, fruit flesh and seeds of 10 randomly selected grape berries and recording their weight, they were kept separately at 30 °C in 40 mL solution with a pH of 3.2 for 72 hours. Then they were stored at -20 °C until analysis (Di Stefano and Cravero, 1991).

Determination of Total Anthocyanin: The samples were analyzed on the spectrophotometer after diluting them in 1/10 hydrochloric ethanol [EtOH (95%): H_2O (deionized distilled water): HCl (70: 30: 1 v/v/v)]. The total anthocyanin amounts were determined according to Di Stefano and Cravero, (1991) by calculating the absorbance values obtained expressed in equivalents of malvidin 3-glikozide compound (mg kg^{-1}).

Hach lange DR 5000 UV-VIS model spectrophotometer was used for analyzes.

Statistical Analysis

After all the data obtained were divided into two as colored and white grapes, they were evaluated statistically according to the randomized blocks trial design. The results were evaluated by analysis of variance, and the differences between years and varieties were revealed by Duncan multiple comparison test. For this purpose, "SPSS 16" software was used.

Results and Discussion

Maturity criteria of grape varieties harvested in 2013 and 2014 are given in Table 1.

Total Phenolic Compound Content

It was found that total phenol content in the skin of the white grape varieties as the average of both years was 167 mg kg^{-1} in the Kabarcık and it was the lowest value, in Chardonnay it was 504 mg kg^{-1} as the highest value. Total phenolic content of fruit flesh was found as 51 mg kg^{-1} in Ağ Banki is the lowest and 178 mg kg^{-1} in Tahannebi as the highest. Besides that, it was determined that the lowest total phenol content in the seed was 364 mg kg^{-1} in the Ağ Banki and the highest was 731 mg kg^{-1} in the Çiloreş (Table 2). Among the colored varieties as the average of the years, total phenol content in the skin of the fruit was found to be lowest in Kızıl Banki with the value of 366 mg kg^{-1} and it was determined as the highest with the value of 511 mg kg^{-1} in Kara Kabarcık. Fruit flesh was found to have the lowest total phenol content and it was 61 mg kg^{-1} in Yediveren, while by 172 mg kg^{-1} it was the highest in Horoz Karası.

Table 1. Maturity criteria of grape varieties harvested

Varieties	Harvest date		Brix (%)		pH		Acidity (%)		Maturity Index	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Ağ Banki	Sep, 5	Sep, 11	23.30	19.50	3.99	3.73	0.448	0.408	52.10	47.80
Azezi	Sep, 9	Sep, 4	18.60	18.50	3.72	3.99	0.296	0.327	63.00	56.40
Chardonnay	Aug, 27	Agu, 11	20.70	21.20	3.74	3.60	0.621	0.572	33.30	37.20
Çiloreş	Sep, 1	Agu, 29	21.20	19.00	3.74	3.82	0.330	0.369	64.20	51.60
Çilorut	Aug, 21	Agu, 20	17.00	18.20	3.80	3.86	0.430	0.464	39.50	39.10
Elma Üzümü	Sep, 5	Agu, 26	14.60	20.00	3.49	3.76	0.503	0.532	29.00	37.50
Hasani	Aug, 26	Sep, 11	16.50	18.10	3.52	3.78	0.610	0.492	27.10	36.80
Hatun Parmağı	Aug, 12	Agu, 7	17.30	17.00	3.98	3.39	0.475	0.423	36.40	40.20
Kabarcık	Aug, 15	Agu, 18	16.10	17.70	3.83	3.85	0.473	0.421	34.10	42.00
Küllahi	Aug, 12	Agu, 12	15.50	18.30	3.83	3.84	0.480	0.277	32.20	66.20
Perlette	July, 29	July, 24	20.30	19.10	3.68	3.59	0.505	0.669	40.20	28.50
Serpenekıran	Sep, 9	Sep, 8	19.30	18.50	3.76	3.77	0.399	0.367	48.40	50.40
Simore	Aug, 26	Agu, 26	19.90	19.80	3.32	3.56	0.767	0.582	26.00	34.00
Su Üzümü	Sep, 9	Sep, 3	20.70	17.30	3.94	4.01	0.492	0.347	42.00	49.80
Şeffafi	Aug, 12	Agu, 7	19.40	19.70	3.84	3.27	0.367	0.449	52.90	43.80
Şire	Sep, 12	Sep, 11	19.20	18.20	3.39	3.65	0.416	0.478	46.30	38.00
Tahannebi	July, 15	July, 22	17.50	23.00	4.00	4.21	0.389	0.451	45.00	50.90
Zeyni	Aug, 12	Agu, 7	15.90	20.10	3.88	3.85	0.448	0.462	35.40	43.60
Cabernet Sauvignon	Aug, 27	Agu, 25	20.80	20.10	3.82	3.71	0.588	0.643	35.40	31.30
Horoz Karası	Aug, 15	Agu, 18	18.10	19.50	3.95	3.97	0.482	0.536	37.60	36.40
Hönüsü	Sep, 9	Agu, 29	18.10	19.40	3.41	3.63	0.406	0.534	44.70	36.30
Kara Kabarcık	Aug, 26	Sep, 3	13.30	17.20	3.87	4.34	0.381	0.267	34.90	64.50
Kızıl Banki	Sep, 5	Sep, 3	16.20	16.70	3.88	4.28	0.277	0.361	58.60	46.30
Öküzgözü	Aug, 17	Agu, 11	19.40	17.20	4.13	3.82	0.350	0.562	55.50	30.70
Sergi Karası	Aug, 21	Agu, 20	24.10	24.20	3.98	3.86	0.506	0.471	47.70	51.30
Şiraz	Aug, 27	Agu, 25	24.70	24.10	3.96	4.05	0.472	0.578	52.20	41.70
Tilgören	Aug, 12	Agu, 18	14.40	18.70	3.65	3.89	0.577	0.417	25.00	44.80
Top Üzüm	Sep, 9	Agu, 29	16.20	18.70	3.83	3.30	0.485	0.461	33.40	40.60
Yediveren	Aug, 17	Agu, 21	17.70	20.20	4.13	4.23	0.434	0.350	40.80	57.70

Hönüsü was determined to have the lowest total phenol content of the seed with 513 mg kg^{-1} and the highest value was found to be 1183 mg kg^{-1} in the Shiraz (Table 3).

The amount of total phenolics in grapes varies according to the year and variety and decreases during the ripening period (Doshi et al., 2006; Jin et al., 2009). Similarly, in a similar study carried out under the conditions of Tekirdağ Province in 2007 and 2008, it has been reported that the total amount of phenolic compounds in grapes varies according to the

Table 2. Total phenolic compound contents of white grapes

Varieties	Total Phenolic Compound (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Ağ Banki	410±1.14f	47±1.07 j	365±4.03l	432±0.64d	56±1.52i	363±1.87g
Azezi	265±2.12j	164±2.00b	643±4.08b	176±1.60j	126±1.72c	570±4.20ef
Chardonnay	487±2.31a	38±0.59k	580±5.11ef	370±3.73e	74±0.51h	684±3.40b
Çiloreş	375±2.55h	35±1.32k	675±6.12a	437±3.07cd	73±0.79h	787±4.45a
Çilorut	112±0.83no	47±1.10j	535±4.91h	368±3.20ef	95±0.72ef	560±5.10efg
Elma Üzümü	136±2.47m	71±1.24h	628±5.09c	227±2.49i	73±0.40h	592±2.73de
Hasani	262±0.40j	54±1.62i	514±3.45i	361±3.26f	55±0.85i	564±0.52efg
Hatun Parmağı	254±1.78k	54±1.35i	567±4.97fg	375±1.83e	93±1.08ef	551±2.44fg
Kabarcık	108±0.04o	96±1.20g	501±4.81i	225±2.08i	99±1.35e	582±0.49e
Küllahi	116±2.57n	118±1.98e	485±3.87j	287±2.98h	101±1.27e	558±2.58efg
Perlette	418±1.32e	123±2.51e	Seedless	469±1.68b	147±2.68b	Seedless
Serpenekıran	132±0.54m	129±3.40d	587±5.08de	232±2.05i	115±1.27d	634±1.93d
Simore	445± 2.36d	105±1.30f	571±1.40efg	361±2.54f	105±1.38e	591±2.79de
Su Üzümü	384±5.03g	105±1.49f	584±7.79de	340±1.06g	108±0.77e	667±3.52c
Şeffafi	234±1.14l	107±1.49f	455±3.10k	281±2.50h	85±1.59g	659±2.14cd
Şire	453±0.92c	146±0.61c	598±5.49d	556±6.58a	130±6.27c	583±2.83e
Tahannebi	465±1.68b	186±2.87a	582±9.36ef	444±2.36c	170±1.54a	660±4.95cd
Zeyni	296±2.42i	34±2.58k	559±2.50g	344±1.01g	88±1.26g	580±1.76e
Mean	297.00	92.00	555.00	349.00	100.00	599.00
$F_{0.05}$	4040.72	639.69	862.62	1284.49	128.47	4800.83

Main Effects

Varieties	Skin	Flesh	Seed
Ağ Banki	421±0.70e	51±0.86g	364±1.40h
Azezi	220±0.61l	145±1.06b	607±3.33c
Chardonnay	429±0.81d	56±0.40g	632±0.98b
Çiloreş	406±1.89f	54±0.63g	731±5.20a
Çilorut	240±1.60k	71±0.89ef	548±4.84ef
Elma Üzümü	182±1.73n	72±0.81ef	610±3.90c
Hasani	312±1.56i	55±0.97g	539±1.93f
Hatun Parmağı	314±0.52i	74±0.47ef	559±3.68e
Kabarcık	167±1.26o	98±0.24def	542±2.50f
Küllahi	201±2.67m	110±0.86d	522±2.91g
Perlette	444±0.27c	135±2.46c	Seedless
Serpenekıran	182±0.79n	122±2.10cd	610±2.06c
Simore	403±1.97f	105±0.29d	581±2.02d
Su Üzümü	362±2.43g	106±0.64d	626±4.45bc
Şeffafi	258±0.80j	96±0.10def	557±0.95e
Şire	504±3.25a	138±3.01bc	590±2.80cd
Tahannebi	454±1.49b	178±1.63a	621±7.14bc
Zeyni	320±0.92h	61±0.79fg	570±1.92de
Mean	323.00	96.00	577.00
$F_{0.05}$	4537.71	424.13	2464.64

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

Table 3. Total phenolic compound contents of colored grapes

Varieties	Total Phenolic Compound (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Cabernet Sauvignon	375±3.55f	154±2.72c	594±6.07c	466±2.61e	127±1.46d	569±1.87e
Horoz Karası	465±1.45b	174±1.20a	717±3.19b	544±1.32b	170±0.30a	817±4.84b
Hönüsü	423±2.56d	78±0.85i	492±1.50g	448±2.17g	122±1.52d	535±2.04f
Kara Kabarcık	476±3.42a	123±3.11f	561±2.90e	545±1.76b	112±1.60e	585±2.92d
Kızıl Banki	362±1.01g	137±3.10e	537±5.04f	371±2.05i	140±1.37c	583±0.83d
Öküzgözü	426±1.26d	167±1.89b	462±3.39h	564±0.80a	153±1.54b	582±1.70d
Sergi Karası	403±3.61e	152±0.80d	574±6.43de	545±2.88b	144±3.73bc	574±2.66de
Syrah	464±2.89b	76±1.75i	1247±6.70a	534±1.89c	101±2.26f	1119±1.84a
Tilgören	435±2.81c	95±2.47h	574±3.24de	494±3.84d	105±0.83ef	575±2.67de
Top Üzüm	364±1.52g	103±2.02g	578±9.72d	417±1.58h	123±1.52d	608±0.91c
Yediveren	367±0.82fg	59±0.82j	544±1.13f	457±4.72f	63±2.25g	586±2.31d
Mean	415.00	120.00	625.00	490.00	124.00	648.00
$F_{0.05}$	290.19	357.29	1632.16	573.94	160.22	6729.00

Main Effects

Varieties	Skin	Flesh	Seed
Cabernet Sauvignon	421±1.64g	140±0.63c	582±3.39c
Horoz Karası	505±0.88b	172±0.74a	767±3.02b
Hönüsü	436±1.59f	100±0.90e	513±0.30g
Kara Kabarcık	511±1.30a	118±1.78d	573±0.03d
Kızıl Banki	366±0.63j	139±2.22c	560±2.23e
Öküzgözü	495±1.03c	160±0.29b	522±1.51f
Sergi Karası	474±3.07d	148±1.90c	574±3.55d
Syrah	499±0.87c	88±1.80f	1183±2.62a
Tilgören	464±1.76e	100±1.49e	575±2.44d
Top Üzüm	390±0.11i	113±1.39de	593±4.63c
Yediveren	412±2.06h	61±0.83g	565±1.19e
Mean	452.00	122.00	637.00
$F_{0.05}$	950.40	386.86	5870.76

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

year and variety (Yayla, 2008). The amount of phenolic compounds in colored varieties is higher than in white varieties. The reason for this is that anthocyanins increase the total amount of phenolic compounds (Kaur and Kapoor 2001). Dávalos et al. (2005) have reported that the total amount of phenolic compounds was higher in red grape juice than in other samples based on the results of their study conducted in red and white grape juices and vinegar.

Grape varieties differ in terms of the amount of phenolic compounds. These differences are due to the differences such as water content, size, skin thickness, number of seeds and size of the seed. In this study, the differences observed between years are determined to be due to the differences in climate difference between the years.

Total Anthocyanin Contents

When we examined the average of both years of white grape varieties, we determined that the total anthocyanin content of the skin was 0.322 mg kg^{-1} in the Azezi being the lowest and 1.981 mg kg^{-1} in the Tahannebi being the highest. We determined that the total anthocyanin content of the fruit flesh was 0.099 mg kg^{-1} in the Kabarcık as the lowest value, and 0.528 mg kg^{-1} in the Chardonnay as the highest value. Besides, Çilorut was determined to have the lowest total anthocyanin content in the seed with the value of 2.48 mg kg^{-1} and Serpenekıran was found to have the highest content with the value of 7.23 mg kg^{-1} (Table 4). While the average yearly average of the colored grape varieties was the Kızıl Banki with the lowest 59 mg kg^{-1} in terms of total anthocyanin

Table 4. Total anthocyanin contents of white grapes

Varieties	Total Anthocyanin (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Ağ Banki	0.728±0.01e	0.252±0.01gh	4.62±0.26de	0.721±0.02fgh	0.246±0.03c	4.24±0.12d
Azezi	0.266±0.02k	0.356±2.00def	3.59±0.06f	0.378±0.09j	0.328±0.01c	3.76±0.19de
Chardonnay	0.560±0.03ghi	0.507±0.59a	4.53±0.10e	0.513±0.19hi	0.550±0.01a	4.39±0.09cd
Çiloreş	0.383±0.05j	0.179±1.32ij	4.52±0.10e	0.447±0.02i	0.196±0.01d	4.34±0.19cd
Çilorut	0.676±0.03f	0.278±1.10fg	2.63±0.03h	0.731±0.06fgh	0.266±0.01c	2.33±0.14f
Elma Üzümü	1.036±0.03b	0.479±1.24b	4.94±0.06d	0.857±0.02ef	0.482±0.0b	4.77±0.05c
Hasani	0.983±0.09c	0.302±1.62f	3.35±0.07f	0.854±0.13ef	0.293±0.01c	3.20±0.07e
Hatun Parmağı	0.453±0.03i	0.160±1.35j	6.12±0.11b	0.545±0.08h	0.140±0.01d	5.51±0.06b
Kabarcık	1.950±0a	0.102±1.20l	3.43±0.10f	1.941±0.13ab	0.097±0.28e	3.90±0.17de
Küllahi	0.495±0.28i	0.118±1.98k	3.08±0.10g	0.533±0.06h	0.130±0.01de	3.28±0.32e
Perlette	0.982±0.09c	0.301±2.51f	Seedless	0.846±0.09ef	0.294±0.02c	Seedless
Serpenekıran	1.015±0.18bc	0.442±3.40cd	7.17±0.07a	1.062±0bc	0.453±0.01b	7.29±0.16a
Simore	0.943±0.19d	0.458±1.30bc	3.25±0.13f	0.815±0.04efg	0.471± 0.01b	3.04±0.14e
Su Üzümü	1.030±0.12b	0.437±1.49cde	7.15±0.10a	1.045±0.03cd	0.427±0.02bc	6.84±0.17ab
Şeffafi	0.608±0.08g	0.241±1.49gh	4.93±0.06d	0.632±0.33gh	0.252±0.0c	4.88±0.12c
Şire	0.964±0.19cd	0.500±0.61a	7.05±0.07a	0.970±0.03de	0.517±0.02ab	7.17±0.33a
Tahannebi	1.943±0.13a	0.457±2.87bc	5.44±0.19c	2.020±0.21a	0.448±0.01b	5.46±0.24b
Zeyni	0.520±0.05hi	0.189±2.58i	4.53±0.10e	0.499±0.02i	0.194±0.03d	4.62±0.05c
Mean	0.86	0.32	4.73	0.85	0.32	4.65
$F_{0.05}$	35.05	8.96	271.61	35.37	3.91	199.58

Main Effects

Varieties	Skin	Flesh	Seed
Ağ Banki	0.725±0.01fg	0.249±0.02ef	4.43±0.07bc
Azezi	0.322±0.05k	0.342±0.02d	3.67±0.12bcd
Chardonnay	0.537±0.09h	0.528±0.01a	4.46±0.06bc
Çiloreş	0.415±0.04j	0.188±0.01fg	4.43±0.14bc
Çilorut	0.703±0.02fg	0.272±0.06e	2.48±0.06e
Elma Üzümü	0.946±0.01de	0.481±0.02b	4.86±0.04b
Hasani	0.918±0.07ef	0.298±0.01e	3.28±0.04cde
Hatun Parmağı	0.499±0.05i	0.150±0.02fg	5.81±0.09ab
Kabarcık	1.945±0.06b	0.099±0.13h	3.66±0.04bcd
Küllahi	0.514±0.13hi	0.124±0.0gh	3.18±0.20cde
Perlette	0.914±0.04ef	0.297±0.02e	Seedless
Serpenekıran	1.038±0.09c	0.448±0.0c	7.23±0.11a
Simore	0.879±0.10efg	0.465±0.02bc	3.15±0.11cde
Su Üzümü	1.038±0.06c	0.432±0.03c	6.99±0.13a
Şeffafi	0.620±0.15g	0.246±0.02ef	4.91±0.08b
Şire	0.967±0.11cde	0.508±0.03ab	7.11±0.18a
Tahannebi	1.981±0.11a	0.453±0.04bc	5.45±0.07ab
Zeyni	0.510±0.03hi	0.192±0.01fg	4.58±0.03bc
Mean	0.86	0.32	4.69
$F_{0.05}$	47.99	3.56	369.84

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

content in skin, it was observed that the Kara Kabarcık had the highest value with 1370 mg kg^{-1}. On the other hand, the total anthocyanin content of the fruit flesh was found to be 0.354 mg kg^{-1} in the Kızıl Banki as the lowest, and the highest was 5.67 mg kg^{-1} in the Top Üzüm. The total anthocyanin content of the seeds in colored grape varieties ranged from 3.08 to 9.05 mg kg^{-1}, and the lowest value was determined in Sergi Karası, whilst the highest value was determined in Öküzgözü (Table 5).

The most important group of phenolic compounds found in grapes are anthocyanins which are responsible for color (Cemeroglu et al., 2001). Anthocyanins are natural color pigments that give their distinctive red, blue and purple hues (Costa et al., 2000; Camire et al., 2002). Anthocyanins are a very large and important subgroup of phenolic substances and they start to form in the veraison phase in grapes, accumulate during ripening phase and reach the highest level after maturity (Kunter et al., 2013).

Cangi et al. (2011) reported that the amount of anthocyanin in grapes increased in parallel with the color change. Also, Fernandez - Lopez et al. (1992) demonstrated that the anthocyanin content in grapes was 310 mg kg^{-1} at the beginning of maturity and it was 1140 mg kg^{-1} during the maturity period. Similarly, Revilla et al. (2001) showed in their study that the total amount of anthocyanin varied between 273-804 mg kg^{-1} in Cabernet Sauvignon grapes and 218-693 mg kg^{-1} in Tempranillo grapes during maturity and increased with maturity.

Previous studies have shown that the ecological conditions have also great impact on the anthocyanin content of grapes. Toprak, (2011) compared the anthocyanin content of the Kalecik Karasi cultured in four different ecology (Ankara - Kalecik, Ankara - Keçiören, Ankara -

Table 5. Total anthocyanin contents of colored grapes

Varieties	Total Anthocyanin (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Cabernet Sauvignon	658±5.14d	1.438±0.08cd	5.23±0.21c	628±3.31c	1.463±0.05de	5.54±0.10d
Horoz Karası	465±1.32g	0.942±0.08e	8.33±0.12ab	421±2.98f	1.585±0.04d	8.22±0.52ab
Hönüsü	96±0.94i	1.822±0.07c	8.37±0.07ab	132±2.17h	2.148±0.05cd	8.44±0.04a
Kara Kabarcık	1381±1.21a	5.271±0.10a	5.11±0.19cd	1360±7.68a	5.719±0.10ab	5.27±0.59d
Kızıl Banki	49±1.83j	0.192±0.02f	7.24±0.16b	70±5.18i	0.516±0.03e	7.02±0.24b
Öküzgözü	689±4.33c	2.466±0.07b	9.22±0.03a	660±4.46bc	2.176±0.03cd	8.88±0.20a
Sergi Karası	479±4.27f	2.896±0.07b	3.14±4.24e	437±1.93ef	3.306±0.20c	3.02±0.27f
Syrah	727±5.59b	1.156±0.20de	4.19±0.09de	731±2.52b	1.298±0.03de	4.12±0.07e
Tilgören	535±1.53e	1.064±0.06de	5.51±0.07c	482±0.92d	1.686±0.07d	5.25±0.09d
Top Üzüm	331±2.75h	5.302±0.39a	4.95±0.06cd	368±1.76g	6.037±0.20a	4.70±0.05de
Yediveren	476±7.22fg	0.930±0.08e	5.70±0.12c	468±1.18de	0.876±0.0e	6.07±0.32 c
Mean	535	2.13	6.09	523	2.44	6.05
$F_{0.05}$	7830.59	159.22	198.16	9050.00	261.00	94.52

Main Effects

Varieties	Skin	Flesh	Seed
Cabernet Sauvignon	643±3.73c	1.451±0.04e	5.39±0.10de
Horoz Karası	443±0.85f	1.263±0.02f	8.28±0.25b
Hönüsü	114±1.42h	1.985±0.01d	8.41±0.03b
Kara Kabarcık	1370±3.70a	5.495±0.06a	5.19±0.37e
Kızıl Banki	59±3.45i	0.354±0.01i	7.13±0.09c
Öküzgözü	674±4.39bc	2.321±0.06c	9.05±0.08a
Sergi Karası	458±2.98ef	3.101±0.10b	3.08±0.21g
Syrah	729±3.36b	1.227±0.09g	4.16±0.05f
Tilgören	509±0.68d	1.375±0.06ef	5.38±0.07de
Top Üzüm	350±2.15g	5.67±0.24a	4.83±0.05f
Yediveren	472±3.06e	0.903±0.04h	5.89±0.17d
Mean	529.00	2.29	6.07
$F_{0.05}$	12365.19	340.38	175.31

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

Polatlı and Nevşehir – Çat) and he reported that for Kalecik the total anthocyanin content was 202 mg kg^{-1}, for Keçiören 196 mg kg^{-1}, for Polatlı 319 mg kg^{-1} and for Çat 299 mg kg^{-1}.

Total Tannin Contents

The average total tannin content of the skin of the white grape varieties varies between 197 mg kg^{-1} and 740 mg kg^{-1}, while the total

Table 6. Total tannin contents of white grapes

Varieties	Total Tannin (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Ağ Banki	427±7.71g	131±2.53b	1458±5.93j	384±1.78e	120±2.31c	1309±27.45g
Azezi	237±5.79ij	114±1.27d	1612±6.07ef	211±7.88g	100±1.96f	1569±7.49e
Chardonnay	501±2.59de	109±1.12de	1558±1.40hi	484±17.73d	122±0.72bc	1561±6.15e
Çiloreş	750±3.08a	100±4.85e	1630±9.33def	729±32.42a	104±2.09e	1592±7.41cd
Çilorut	579±12.92c	40±1.64j	1614±15.99def	593±16.99b	50±0.49j	1580±9.40d
Elma Üzümü	317±2.67h	100±1.59f	1599±3.33fgh	260±1.49f	94±1.20gh	1623±2.50 bc
Hasani	486±4.92e	77±0.48h	1636±6.19def	460±12.99d	75±1.65i	1590±2.23cd
Hatun Parmağı	581±2.21c	60±1.90i	1888±42.83a	532±14.00c	48±1.20j	1888±30.63a
Kabarcık	245±3.60i	161±2.04a	1658±4.13cd	261±14.07f	182±3.32a	1602±1.92c
Küllahi	502±4.63de	59±2.35i	1594±6.91fgh	478±13.46d	46±1.15j	1574±15.17de
Perlette	605±4.08b	91±2.56fg	Seedless	547±1.48bc	109±1.31de	Seedless
Serpenekıran	319±4.36h	92±1.25fg	1645±4.54de	280±17.88f	97±0.40fg	1604±7.25c
Simore	617±4.45b	110±3.29e	1576±10.53gh	560±17.40bc	90±1.33h	1587±10.11cd
Su Üzümü	518±10.71d	116±2.55d	1594±6.51fgh	468±13.11d	126±0.91b	1577±12.0d
Şeffafi	509±8.40d	81±3.18h	1591±11.74fg	439±8.44d	92±1.91h	1561±3.05e
Şire	221±2.47j	130±2.91c	1700±15.00b	174±10.76g	110±1.71de	1637±38.39b
Tahannebi	509±1.58d	107±0.69e	1683±14.47bc	459±28.47d	111±0.73d	1586±2.43cd
Zeyni	461±1.91f	90±1.04g	1529±5.61i	437±6.23d	91±1.66h	1448±18.74f
Mean	466.00	98.00	1621.00	431.00	98.00	1581.00
$F_{0.05}$	634.76	156.39	925.62	86.33	404.29	611.24

Main Effects

Varieties	Skin	Flesh	Seed
Ağ Banki	405±3.06f	126±2.36b	1384±10.86k
Azezi	224±2.37i	107±1.61e	1591±4.92fgh
Chardonnay	493±8.47d	116±0.82d	1560±2.95i
Çiloreş	740±15.75a	102±2.11e	1611±8.20defg
Çilorut	586±7.76b	45±0.59k	1597±4.31efg
Elma Üzümü	289±1.38g	97±1.39g	1611±2.50defg
Hasani	473±4.23d	76±1.04i	1613±4.15def
Hatun Parmağı	556±6.53c	54±0.79j	1888±18.94a
Kabarcık	253±5.61h	172±2.02a	1630±2.86cd
Küllahi	490±8.19d	52±1.47j	1584±10.99fgh
Perlette	576±1.91bc	100±1.87f	Seedless
Serpenekıran	299±10.31g	95±0.59g	1625±4.30cde
Simore	589±9.82b	100±1.12fg	1582±8.09fghi
Su Üzümü	493±3.73d	121±1.69c	1586±9.25fghi
Şeffafi	474±7.58d	86±1.37h	1576±4.81ghi
Şire	197±4.33j	120±2.05cd	1669±17.22b
Tahannebi	484±13.75d	109±0.27e	1635±8.40c
Zeyni	449±4.06e	90±0.34h	1489±8.06j
Mean	448.00	98.00	1602.00
$F_{0.05}$	349.20	449.28	2215.40

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

tannin content of the fruit flesh is between 45 mg kg^{-1} and 172 mg kg^{-1}. On the other hand, the total tannin content of the seed was observed to range between 1384 mg kg^{-1} and 1888 mg kg^{-1} (Table 6).

As a result of the statistical analysis performed between the varieties by calculating the average of both years of the colored varieties, we determined that the difference between the varieties is significant. Kızıl Banki had the lowest value of the total tannin content in the skin, while this value in Kara Kabarcık was the highest. Besides, it was determined that the total tannin content of the fruit flesh ranged between 88 and 234 mg kg^{-1}, a"nd the total tannin content of the seed ranged between 1478 and 1659 mg kg^{-1} (Table 7).

In addition to the differences in tannin content of different varieties, it was observed that different climatic conditions in different years had also effects on the tannin content of the grapes. In addition, significant differences were observed in terms of the ratio of tannins contained in the skin, fruit flesh and seeds of the grape varieties.

The tannins found in grape skins have a larger structure than the ones in the seed. As the degree of polymerization of tannins increases, their reactivity potential with proteins also enhances. The polymeric tannins in the skin of the grape react with the proteins and make the cell wall tighter and thus the grape gains resistance against external factors. Tannins are mostly located in the inner cells of the skin (Gagne et al., 2006). Souquet et al. (2000) reported that the amount of tannin in the pedicel is between the amount of tannin in the skin and the amount of tannins in the seed, and that the

Table 7. Total tannin contents of colored grapes

Varieties	Total Tannin (mg kg^{-1})					
	2013			2014		
	Skin	Flesh	Seed	Skin	Flesh	Seed
Cabernet Sauvignon	895±18.92f	80±2.18g	1591±2.25c	861±23.32g	95±1.06g	1562±4.08de
Horoz Karası	1098±3.34c	113±6.78e	1589±5.95c	1057±34.73d	95±1.16g	1564±14.69de
Hönüsü	753±3.87g	156±1.38d	1514±7.83d	699±2.04h	153±1.97e	1442±10.37f
Kara Kabarcık	1150±8.83b	111±3.68e	1579±3.71c	1279±14.51b	109±2.76f	1579±23.94d
Kızıl Banki	595±4.55h	99±1.52f	1674±4.33a	594±15.60i	98±0.94g	1644±29.16ab
Öküzgözü	967±4.77d	259±3.93a	1591±2.89c	1023±60.88e	209±2.34a	1616±23.25b
Sergi Karası	1247±16.80a	159±1.69d	1595±9.38c	1140±16.82c	163±1.99d	1586±22.36c
Syrah	1095±6.62c	162±1.22cd	1618±20.67b	998±36.42f	177±1.55c	1571±12.40de
Tilgören	1069±15.86c	171±3.52c	1592±3.60c	1306±62.73a	150±3.27e	1548±8.57e
Top Üzüm	1065±11.60c	209±3.02b	1586±6.40c	1128±4.43cd	192±2.30b	1546±11.95e
Yediveren	928±5.0e	96±1.70f	1601±7.38c	870±24.46g	89±0.36h	1657±12.81a
Mean	987.00	147.00	1593.00	996.00	139.00	1574.00
$F_{0.05}$	290.89	275.00	28.77	42.35	545.15	12.04

Main Effects

Varieties	Skin	Flesh	Seed
Cabernet Sauvignon	878±21.09e	88±1.59i	1577±2.27de
Horoz Karası	1077±18.89c	104±2.89g	1577±6.40de
Hönüsü	726±2.25f	154±1.60e	1478±4.44de
Kara Kabarcık	1214±3.43a	110±0.75f	1579±10.12de
Kızıl Banki	595±6.38g	99±0.34h	1659±16.72a
Öküzgözü	995±28.68d	234±2.97a	1604±12.36c
Sergi Karası	1194±10.69ab	161±0.75d	1591±9.27cd
Syrah	1046±15.33cd	169±1.13c	1595±9.55cd
Tilgören	1188±33.09b	160±3.20d	1570±2.68e
Top Üzüm	1096±3.85c	201±1.28b	1566±9.17e
Yediveren	899±12.39e	93±0.84hi	1629±9.57b
Mean	992.00	143.00	1584.00
$F_{0.05}$	126.37	666.99	28.09

Values marked with different letters in the same column were statistically significant at $p<0.05$ level according to the Duncan's test. Main effects were grouped as mean of two years, and interactions were grouped within the year to which they belong. All results expressed as mean of repetitions ± standard error.

grape being red or white does not affect the amount of tannins in the pedicel. Harbertson et al. (2002)singleton stated that the amount of tannin in the seed is approximately three times higher than in the skin. Torchio et al. (2010) found that the amount of tannin in the skin of Barbera grapes with different sugar levels grown in various vineyards was 595 - 1196 mg kg^{-1}, and the amount of tannins in the seed was between 516 - 1092 mg kg^{-1}. Peng et al. (2001) reported that the amount of tannins in the seeds of Syrah grapes varied between 1360 - 2830 mg kg^{-1} and approximately half of the tannins in wines passed from the seeds.

Conclusion

In conclusion, in this study conducted with 29 different grape varieties, it was determined that grape varieties are rich in phenolic compounds and their content significantly differs from each other. Comparing the white and colored varieties; it has been found that colored varieties had higher amount of total phenolic compound and anthocyanin content in skin, fruit flesh and seeds compared to the white varieties. Also, colored varieties had higher amount of tannin content in skin and fruit flesh than white varieties while it was the same in the seeds.

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Conflicts of Interest

There is no conflict of interest between the authors.

Author Contribution

A.P. Performed the experiments, field work, took role in conceptualization, data analysis and writing of the manuscript. İ.R. performed experiments and field work and participated in writing the manuscript. S.G. took role in conceptualization and writing the manuscript. All authors read and approved the final manuscript.

References

Acar, J. (1998). *Phenolic Compounds and Natural Colors, Food chemistry*, Ed. Saldamlı, F. Hacettepe Univ. Publications, Ankara, p 435-452.

AOAC, (1998). *Official Method of Analysis. 15th Edition*, Association of Official Analytical Chemists, Washington DC.

Aras, Ö. (2006). Determination of Total Carbohydrate, Protein, Mineral Substance and Phenolic Compound Content of Grapes and Grape Products. Süleyman Demirel University, Institute of Natural and Applied Sciences, Master Thesis, Isparta, p 59.

Bruno, G., & Sparapano, L. (2007). Effects of three esca-associated fungi on *Vitis vinifera* L: V. Changes in the chemical and biological profile of xylem sap from diseased cv. Sangiovese vines. *Physiological and Molecular Plant Pathology, 71*, 210–229. http://dx.doi.org/10.1016/j.pmpp.2008.02.005

Camire, M. E., Chaovanalikit, A., Dougherty, M. P., & Briggs, J. (2002). Blueberry and grape anthocyanins as breakfast cereal colorants. *Journal of Food Science, 67*(1), 438-441. https://doi.org/10.1111/j.1365-2621.2002.tb11425.x

Cangi, R., Saraçoğlu, O., Uluocak, E., Kiliç, D., & Şen, A. (2011). Chemical changes during ripening in some wine grape varieties cultivated in Kazova (Tokat) Rregion. *Journal of the Institute of Science and Technology, 1*(3), 9-14.

Cemeroğlu, B., Yemenicioğlu, A., & Özkan, M. (2001). *Meyve ve Sebze İşleme Teknolojisi, Cilt 1, Meyve ve Sebzelerin Bileşimi Soğukta Depolanmaları.* Gıda Teknolojisi Derneği Yayınları, Ankara, 24, p 328.

Costa, C. T., Horton, D., & Margolis, S. A. (2000). Analysis of anthocyanins in foods by liquid chromatography, liquid chromatography-mass spectromery and capillary electrophoresis. *Journal of Chromatography A, 881,* 403-410. https://doi.org/10.1016/s0021-9673(00)00328-9

Dávalos, A., Bartolomé, B., & Cordovés, C.G. (2005). Antioxidant properties of commercial grape juices and vinegars. *Food Chemistry, 93*(2), 325-330. http://dx.doi.org/10.1016/j.foodchem.2004.09.030

Di Stefano, R., & Cravero M. C. (1991). Metodi Per lo Studio dei Polifenoli dell'Uva. *Rivista di Viticoltura e di Enologia 44*(2), 37- 45.

Doshi, P., Adsule, P., & Banerjee, K. (2006). Phenolic composition and antioxidant activity in grapevine parts and berries (*Vitis vinifera* L.) cv. Kishmish Chornyi (Sharad Seedless) during maturation. *International Journal of Food Science and Technology*, *41*(1), 1–9. http://dx.doi.org/10.1111/j.1365-2621.2006.01214.x

Fernández-López, J.A., Hidalgo, V., Almela, L., & Roca, J. M. L. (1992). Quantitatif changes in anthocyanins pigments of *Vitis vinifera* cv. Monastrell during maturation. *Journal of the Science of Food and Agriculture, 58*(1), 153-155. http://dx.doi.org/10.1002/jsfa.2740580127

Gagne, S., Saucier, C. & Geny, L. (2006). Composition and cellular localization of tannins in Cabernet Sauvignon skins during growth. *Journal of Agricultural and Food Chemistry, 54*(25), 9465-9471. https://doi.org/10.1021/jf061946g

Gürsöz, S. (1993). GAP Alanına Giren Güneydoğu Anadolu Bölgesi Bağcılığı ve Özellikle Şanlıurfa İlinde Yetiştirilen Üzüm Çeşitlerinin Ampelografik Nitelikleri ile Verim ve Kalite Unsurlarının Belirlenmesi Üzerinde Bir Araştırma. Çukurova University, Institute of Natural and Applied Sciences, Doctorate Thesis, Adana, p 363.

Harbertson, J. F., Kennedy, J. A., & Adams, D. O. (2002). Tannin in skins and seeds of Cabernet Sauvignon, Syrah, and Pinot Noir berries during ripening. *American Journal of Enology and Viticulture, 53*(1):54-59.

Harborne, J. B., & Grayer, R. J. (1993). Flavonoids and Insects. In The Flavonoids: Advances in Research Since 1986. J.B. Harborne (Ed.), Chapman & Hall, London, p. 589-618.

Ho, P., Silvia, M. C., & Hogg, T. A. (2001). Changes in colour and phenolic composition during the early stages of maturation of port in wood, stainless steel and glass. *Journal of the Science of Food and Agriculture, 81*(13), 1269-1280. https://doi.org/10.1002/jsfa.938

Jin, Z. M., He, J. J., Bi, H. Q., Cui, X.Y., & Duan, C. Q. (2009). Phenolic compound profiles in berrys from nine red wine grape cultivars in Northwest China. *Molecules, 14*(12), 4922-4935. https://dx.doi.org/10.3390%2Fmolecules14124922

Kaur, C. & Kapoor, H. C. (2001). Antioxidants in fruits andv - the millennium's health. *International Journal of Food Science+Technology*, *36*(7), 703-725. https://doi.org/10.1111/j.1365-2621.2001.00513.x

Kunter, B., Cantürk, S., & Keskin, N. (2013). Histochemical Structure of Grape Berry. J*ournal of the Institute of Science and Technology 3*(2), 17-24.

Makris, D. P., Boskou, G., Andrikopoulos, N. K., & Kefalas, P. (2008). Characterisation of certain major polyphenolic antioxidants in grape (*Vitis vinifera* cv. Roditis) stems by liquid chromatography-mass spectrometry. *European Food Research and Technology, 226*(5), 1075–1079. https://doi.org/s00217-007-0633-9

Naczk, M., & Shahidi, F. (2004). Extraction and analysis of phenolics in food. *Journal of chromatography A, 1054*(1-2), 95-111. https://doi.org/10.1016/s0021-9673(04)01409-8

Pastrana-Bonilla, E., Akoh, C. C., Sellappan, S., & Krewer, G. (2003). Phenolic content and antioxidant capacity of Muscadine grapes. *Journal of Agricultural and Food Chemistry, 51*(18), 5497–4503. https://doi.org/10.1021/jf030113c

Peng, Z., Hayasaka, Y., Iland, P. G., Sefton, M., Hoj, P., & Waters, E. J. (2001). Quantitative analysis of polymeric procyanidins (tannins) from grape (*Vitis vinifera*) seeds by reverse phase high-performance liquid chromatography. *Journal of Agricultural and Food Chemistry, 49*(1), 26-31. https://doi.org/10.1021/jf000670o

Revilla, I., Luisa, M., & González-Sanjozé, L. (2001). Evolution during the storage of red wines treated with pectolytic enzymes: New anthocyanin pigment formation. *Journal of Wine Research, 12*(3), 183-197. https://doi.org/10.1080/09571260120106820

Robards, K., Prenzler, P.D., Tucker, G., Swatsiteng, P., & Glover, W. (1999). Phenolic compounds and their role in oxidative processes in fruits. *Food Chemistry, 66*(4), 401-436. https://doi.org/10.1016/S0308-8146(99)00093-X

Singleton, V. L., & Rossi, J. R. (1965). Colorimetry of total phenolics with phosphomolibdic - phosphothungstic acid. *American Journal of Enology and Viticulture, 16*(3), 144-158.

Sivritepe, N. (2001). Oxidative stress in nature: antioxidants in grapevine, grape and wine (in Turkish with English abstract). *Journal of Aegean Agriculture Research Institute, 11*(2), 108-135.

Souquet, J. M., Labarbe, B., Le Guerneve, C., Cheyneir, V., & Moutounet, M. (2000). Phenolics composition of grape stems. *Journal of Agricultural and Food Chemistry, 48*(4), 1076–1080. https://doi.org/10.1021/jf991171u

Tangolar, S., Büyüktaş, N., Gök, S., & Ergenoğlu, F. (1999). Distribution of Phenolic Compounds in Vine Shoot Tips During Vegetation Period and Its Effect on Shoot Tip Culture (in Turkish with English abstract). III. National Horticultural Congress, Ankara, Turkey, 14 - 17 September, 383-388 p.

Toprak, F. E. (2011). Studies on the Phytochemical Properties of Kalecik Karası Grape Varieties Cultivated in Ankara and Nevşehir Provinces. Ankara University, Institute of Natural and Applied Sciences, Master Thesis, Ankara. 64 p.

Torchio, F., Cagnasso, E., Gerbi, V., & Rolle, L. (2010). Mechanical properties, phenolic composition and extractability indices of Barbera grapes of different soluble solids contents from several growing areas. *Analytica Chimica Acta, 660*(1-2), 183–189. https://doi.org/10.1016/j.aca.2009.10.017

Van Buren, J. (1970). *Fruit Phenolics. The Biochemistry of Fruits and Their Products*, Vol:1 (Ed: Hulme, A. C.), Academic Pres, London, p 269-304.

Yavaş, I., & Fidan, Y. (1986). The Value of Grapes in Human Nutrition. The Problems of the Food Industry and the Expected Effect of the Free Zone on the Food Industry Symposium. 15-17 October, Adana, p 225-236.

Yayla, F. (2008). Investigation of Wine Characteristics of Grape Varieties in the National Collection Vineyard (in Turkish with English abstract, interim report 2006-2008). Tekirdağ Viticulture Research Institute. https://arastirma.tarimorman.gov.tr/bagcilik/Menu/7/Sonuclanan-Projeler. Acess: 15.06.2021

Yu, D., & Meredith, C. P. (1986). The influence of explant origin on tissue browning and shoot production in shoot tip cultures of grapevine. *Journal of the American Society for Horticultural Science, 111*(6), 972-975.