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DETERMINATION OF ORGANIC ACIDS, SUGARS, AND MACRO-MICRO NUTRIENT CONTENTS OF MUST IN SOME GRAPE (*Vitis vinifera* L.) CULTIVARS

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ABSTRACT

Effects of organic acids found in fruits on human health have been appreciated by both researchers and consumers in recent years. Sugar, macro and micro nutrient contents are also traits exposing taste and nutritional value. This study was carried out to determine the organic acids, sugars, macro-micro nutrient contents in grape must of some grape cultivars (*Vitis vinifera* L. cv. Silfoni, cv. Agin Beyazi, cv. Kis Kirmizisi, cv. Okuzgozu and cv. Ercis Uzumu) grown in Van province of Turkey. The organic acid values (citric, tartaric, malic, succinic, lactic, fumaric and acetic acids) varied a lot in the cultivars. The highest individual organic acid value (24.33 g tartaric acid l^{-1}) was determined in cv. Agin Beyazi. There was no detected sucrose in the grape cultivars, but the highest amount of fructose and glucose (17.947 g 100 ml^{-1} and 16.670 g 100 ml^{-1}, respectively) were determined in cv. Silfoni. There was generally a variance in macro and micro nutrient contents in the cultivars, but cv. Kis Kirmizi had the highest micronutrients except manganese.

Key words: Grape, Macro and micro nutrients, Organic acids, Sugar.

INTRODUCTION

Organic acids are water-soluble substances mostly found in fruit and show differences based on the species. They combine with sugars and constitute fruit's taste (Cemeroglu *et al.* 2004). In grapes, tartaric acid and malic acids consist of the 90 % of total organic acids (Agaoglu, 2002).

Sugars that are generally synthesized by photosynthesis in leaves are converted from organic acids in grape berries. The basic sugars in grapes are glucose and fructose in 99 % or more carbonhydrates, and there might be few some other sugars such as sucrose, rafinose, maltose, and galactose (Fidan, 1985). Glucose and fructose are the most common carbohydrates, monosaccarits, which all fruit and vegetables contain. Sucrose is the combination of glucose and fructose, reducing sugars, and is rare in vegetables and fruit (Cemeroğlu *et al*., 2004).

Various studies have been conducted to determine organic acids, sugars, and macro-micro nutrient contents of different grape varieties (Soyer *et al*., 2003; Nakajima *et al*., 2004; Xie *et al*., 2009; Etchebarne *et al*., 2010; Sabir *et al*. 2010; Shiraishi *et al*., 2010; Bertoldi *et al*., 2011; Cozzolino *et al*., 2011; Pavlousek and Kumsta, 2011). Turkey is one of the leading grape producer and exporter countries. However, organic acids, sugars, and macro-micro nutrient contents of some grape cultivars have not been quantified yet. Although Turkey has great biodiversity in grapes especially in Van province (located in eastern Anatolia of Turkey), limited studies have been conducted on organic acids, sugars, and macro-micro nutrient contents of the grapes cultivars grown in this region. Accordingly, this study was carried out to determine organic acids (citric, tartaric, malic, succinic, lactic, fumaric and acetic acids) and sugars (glucose and fructose), and macro-micro nutrient contents (N, P, K, Ca, Mg, Fe, Zn, Cu, and Mn) in the grapes cultivars (Silfoni, Agin Beyazi, Kis Kirmizisi, Okuzgozu and Ercis Uzumu) grown in Van province of the Turkey.

MATERIALS AND METHODS

Plant materials: Mature grape samples were collected at the harvest time (SSC contents above 16 ºbrix) of the 12-year-old grapes cultivars (*Vitis vinifera* L. cv. Silfoni, cv. Agin Beyazi, cv. Kis Kirmizisi, cv. Okuzgozu and cv. Ercis Uzumu) grown in Yesilsu village of Van province in Turkey (Sensoy and Balta, 2010; Sensoy, 2012). Approximately 200 ml grape must samples in three replicates from each cultivars were maintained at -20 ºC before analysis.

Chemicals: In the present study, chemicals with analytical purity were used. Organic acids standards (Citric acid, tartaric acid, malic acid, succinic acid, lactic acid, fumaric acid, and acetic acid) and sugar standards (glucose, fructose, and sucrose) were obtained from Sigma–Aldrich (St. Louis, MO,USA). The other chemicals such as H_2SO_4 were obtained from Merc (Darmstadt, Germany).In standard and sample preparation, Milli-Q water (Bedford, MA, ABD) was used.

Determination of organic acids: For organic acid extraction, the method by Bevilacqua and Califano (1989) was modified. Five ml grape must from each

sample was transferred to centrifuge tubes. The 20 ml of 0.009 N H_2SO_4 was added to the samples and the samples were homogenized with Heidolph Silent Crusher M, Germany. Then, the samples were mixed for an hour with a shaker (Heidolph Unimax 1010, Germany) and centrifuged at 15000*g* for 15 minutes. The supernatant were passed through coarse filter paper, then twice in 0,45 µm membrane filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA), and last in the SEP-PAK C_{18} cartridge. The concentration of organic acids was determined by HPLC using an Aminex column (HPX-87H, 300 × 7.8 mm, Bio-Rad) fitted on an Agilent 1100 series HPLC G 1322 A, Germany) (Bevilacqua and Califano, 1989). Organic acids were detected at 214 and 280 nm wavelengths. As the mobile phase, 0.009 N H_2SO_4 was passed through 0.45 µm filter membrane.

Determination of sugars: The samples were prepared according to the method described by Melgarejo *et al*., (2000) with minor modifications; Briefly, the samples of 5 ml grape must was centrifuged at 12.000 rpm for 2 minutes at 4 C^0. Then the supernatant was filtrated with SEP-PAK C_{18} cartridges and transferred into a vial until used for analysis at -20 ^oC. Analysis of sugars was performed by HPLC (isocratic program) with µbondapak-NH_2 column and refractive index (RI) detector using 85% acetonitrile as a mobile phase. The calculation of concentrations was based on standards prepared in the laboratory.

Determination of macro and micro nutrients: In grape must, contents of calcium (Ca), magnesium (Mg), potassium (K), iron (Fe), manganese (Mn) , zinc (Zn), and copper (Cu) contents (ppm) were determined by an Atomic Absorption Spectrophotometer (Kacar and Inal, 2008). Total phosphorus (P) in grape must was determined by the method of vanado molibdo phosphoric yellow method in a spectrophotometer, and total nitrogen (N) was determined using the Kjedahl method (Kacar and Inal, 2008).

RESULTS AND DISCUSSION

Organic acids: Variations among grape berry organic acids contents in some grape cultivars grown in Lake Van Basin were determined in the present study (Table 1). The highest citric acid content (62.39±2.87 mg l^{-1}) was determined in cv. Kıs Kirmizisi, while the lowest one (29.41±4.77 mg l^{-1}) was found in cv. Agin Beyazi. For tartaric acid, the highest (24.33±1.56 g l^{-1}) and the lowest (9.60±1.37 mg l^{-1}) contents were determined in cv. Agin Beyazi and cv. Kis Kirmizisi, respectively. The highest malic content (3.10±0.52 g l^{-1}) was determined in cv Ercis Uzumu, while the lowest one (1.48 ±0.36 mg l^{-1}) was found in cv. Agin Beyazi. For succinic acid, the lowest (0.35±0.07 g l^{-1}) and the highest (0.96±0.10 g l^{-1}) contents were determined in cv. Okuzgozu and cv. Kis Kirmizisi respectively. The highest lactic content (10.73±0.42 mg l^{-1}) was determined in cv. Silfoni cv, while the lowest one (5.07±1.27 mg l^{-1}) was found in cv. Kis Kirmizisi. For fumaric acid, the lowest (0.07±0.006 mg l^{-1}) and the highest (0.40±0.05 mg l^{-1}) contents were determined in cv. Agin Beyazi and cv. Ercis Uzumu, respectively.

The most common organic acid was tartaric acid followed by malic, succinic, citric, lactic, and fumaric acids, respectively. None of the cultivars had acetic acid. There was no detected lactic acid in cv. Okuzgozu and cv. Agin Beyazi. The variation among the organic acid contents could be caused genetically, ecologically factors and/or cultural practices. Soyer *et al*. (2003) studied the organic acid contents in eleven different white grape berry and juices by HPLC in Ankara province of Turkey. These researchers found that in grape berries, citric acid ranged from 30 to 164 mg l^{-1}; tartaric acid ranged from 4,98 to 7,48 g l^{-1}; malic acid ranged from 1.43 to 3.40 g l^{-1}. In grape juices, citric acid ranged from 31 to 181 mg l^{-1}; tartaric acid ranged from 4.07 to 4.92 g l^{-1}; malic acid ranged from 1.36 to 3.47 g l^{-1}. The main organic acid was also tartaric acid, which was comparatively lower in grape berry juice due to retardation. The citric acid and malic acid contents determined in the present study were similar to those detected by Soyer *et al*. (2003), but the tartaric acid content was higher than that of theirs. Pavlousek and Kumsta (2011) profiled the primary metabolites in Czeck interspecific grape varieties and determined that the content of tartaric acid ranged from 6.85 g $l^{-1}$to 8.24 g l^{-1}, that of malic acid from 2.68 g l^{-1} to 3.72 g l^{-1}, and that of citric acid from 0.22 g l^{-1} to 0.24 g l^{-1}. Sabir *et al*. (2010) studied the juices of five cultivars cultivated in Adana province of Turkey, and determined that tartaric acid content of ripe berries was between 3.8 (Alphonse Lavallée) and 5.2 g l^{-1} (Isabella) with a mean value of 4.6 g l^{-1}.

Organic acids are water soluble materials found in the cytoplasm of fruit and vegetable at various amounts. Accompanied with the sugars, they contribute to taste of fruit and vegetables (Cemeroglu *et al*. 2004). In the present study, there were some differences among the organic acid contents of grape cultivars (Table 1). The differences between cultivars in terms of organic acid content might be caused by genetic factors as well as cultural practices and ecological factors (temperature, light, humidity etc.) (Pereira *et al*., 2006; Etchebarne *et al*., 2010; Kamiloglu, 2011; Pavlousek and Kumsta, 2011).

Acids found in fruits are rapidly oxidized in the metabolism; therefore, they have no negative effects in the body. They have an important effect on diet because their salts have an alkaline effect (Schobinger, 1988; Savran, 1999). Organic acids could make up complexes with heavy metal ions, and their oxidation avoids their catalyzing effect (Balci, 1996; Savran, 1999). For a

maturity criterion, the ratio of total acid content to the amount of sugar in fruits could be used. Organic acids have an important effect on taste because of their effects on sweetness and sourness. In addition, the sort and quantity of acidity could affect purity and food decay (Ozkaya, 1988; Savran, 1999).

Sugar contents: Sugar contents (fructose, glucose, and sucrose) in some grape cultivars grown in Lake Van Basin were also determined in the present study (Table 2). No significant sucrose was determined in the studied grape cultivars. The highest fructose content (17.947±0,011 g 100 ml^{-1}) was determined in cv. Silfoni, while the lowest one (5.587±0,003g 100 ml^{-1}) was found in cv. Okuzgozu. For glucose, the highest (16.670±0,018 g 100 ml^{-1}) and the lowest (6.303±0,001 g 100 ml^{-1}) contents were also determined in cv. Silfoni and cv. Okuzgozu, respectively. Cemeroglu *et al*., (2004) stated that different grape cultivars had approximately 8.3 % glucose and 8.0 % fructose.

Sugars are also among the leading factors affecting taste formation in fruits. Our findings in the present study are in line with the results of the mentioned researchers. The differences between cultivars in terms of sugar content might be caused by genetic factors as well as cultural practices and ecological factors (temperature, light, humidity etc.) (Özgen *et al*. 2008; Xie *et al*., 2009; Etchebarne *et al*., 2010; Shiraishi *et al*., 2010; Kamiloglu, 2011). Pavlousek and Kumsta (2011) profiled the sugars in Czech interspecific grape varieties and determined that the content of glucose ranged from 9.70 g 100 ml^{-1} to 11.25 g 100 ml^{-1} and that of fructose from 9.59 g 100 ml^{-1} to 11.32 g 100 ml^{-1}. Xie *et al*., (2009) studied the changes in sugar content in grape berry (Kyoho grapevines) in response to root restriction. These researchers determined that peak concentration of glucose and fructose in grape berries from the control plants was 56.2 and 55.3 mg g^{-1} FW, while concentration in root restriction berries was 65.2 and 62.1 mg g^{-1} FW, respectively. There were also trace quantities of sucrose compared to glucose and fructose. Shiraishi *et al*., (2010) studied the variation in sugar composition of table grape berries and classified the cultivars into two groups on the basis of their sugar composition: hexose accumulators, which accumulate fructose, glucose, and trace amounts of sucrose; and sucrose accumulators, which accumulate fructose, glucose, and large amounts of sucrose. These researchers found out that more that 90% of cultivars were hexose accumulators. Sabir *et al*. (2010) studied the juices of five cultivars cultivated in Adana, and determined that glucose and fructose content varied from 86.4 (Italia) to 107.0 g l^{-1} (Muscat of Hamburg), and from 73.1 (Italia) to 94.1 g l^{-1} (Alphonse Lavallée), respectively.

Nutrient Contents: In the present study, among the macro nutrients, nitrogen contents were ranged from 89.15 ppm (cv. Silfoni) to 213.21 ppm (cv. Ercis Uzumu); phosphorous contents were ranged from 212.57 ppm (cv. Kis Kirmizisi) to 378.76 ppm (cv. Silfoni); potassium contents were ranged from 407.45 ppm (cv. Silfoni) to 1206.52 ppm (cv. Okuzgozu); calcium contents were ranged from 95.79 ppm (cv. Kis Kirmizisi) to 213.54 ppm (cv. Okuzgozu); and magnesium contents were ranged from 89.15 ppm (cv. Silfoni) to 142.02 ppm (cv. Agin Beyazi) (Table 3). Among the micro nutrients, iron contents were ranged from 1.07 ppm (cv. Silfoni) to 2.83 ppm (cv. Kis Kirmizisi); zinc contents were ranged from 0.73 ppm (cv. Agin Beyaz) to 1.81 ppm (cv. Kis Kirmizisi); manganese contents were ranged from 0.51 ppm (cv. Agin Beyazi) to 1.88 ppm (cv. Ercis Uzumu); cupper contents were ranged from 1.13 ppm (cv. Agin Beyazi) to 4.78 ppm (cv. Kis Kirmizisi) (Table 4).

Table 1. Organic acid contents of the must in grape cultivars.

	MEAN ORGANIC ACID CONTENTS						
Cultivars	**Citric acid (mg l^{-1})**	**Tartaric Acid (g l^{-1})**	**Malic Acid (g l^{-1})**	**Succinic Acid (g l^{-1})**	**Lactic Acid (mg l^{-1})**	**Fumaric Acid (mg l^{-1})**	**Acetic Acid (mg l^{-1})**
Okuzgozu*	29.90 ± 5.10	10.16 ± 0.91	1.89 ± 0.17	0.35 ± 0.07	0.00	0.21 ± 0.03	0.00
Kis Kirmizisi*	62.39 ± 2.87	9.60 ± 1.37	2.38 ± 0.37	0.96 ± 0.10	5.07 ± 1.27	0.26 ± 0.04	0.00
Ercis Uzumu*	50.30 ± 4.24	16.42 ± 1.92	3.10 ± 0.52	0.43 ± 0.02	6.50 ± 0.25	0.40 ± 0.05	0.00
Silfoni**	49.05 ± 1.18	10.99 ± 1.33	1.96 ± 2.30	0.53 ± 0.08	10.73 ± 0.42	0.14 ± 0.02	0.00
Agin Beyazi**	29.41 ± 4.77	24.33 ±1.56	1.48 ± 0.36	0.89 ± 0.04	0.00	0.07 ± 0.006	0.00

*: Dark colored cultivars; **: Light colored cultivars

In the present study, it was seen that there were a variation in macro and micro nutrients in grape cultivars. The findings of the present study were mostly in line with the literature. The differences between cultivars in terms of nutrient content might be also caused by genetic factors as well as cultural practices and ecological factors (temperature, light, humidity, altitude etc.) (Nakajima *et al*., 2004; Pereria *et al*., 2006; Etchebarne *et al*., 2010; Bertoldi *et al*., 2011). Bertoldi *et al*., (2011) studied the accumulation and distribution patterns of macro and micro elements and trace elements in *Vitis vinifera* L. cv. Chardonnay berries. These researchers stated that nutrient

contents were significantly different in the grapes from two different vineyards, but the accumulation patterns and percentage distributions in different parts of the berries were generally quite similar. Etchebarne *et al*., (2010) investigated the seasonal variation in cation contents of developing grape berries (*Vitis vinifera* L. cv. Grenache noir) under different levels of water supply and leaf:fruit ratios in South of France. These researchers stated that the hierarchy of mineral nutrients (i.e K>Ca>Mg) in grape berries was similar to that found in apples.

Table 2. Sugar contents of the grape cultivars (g 100 ml^{-1}) in grape must.

Cultivars	Fructose	Glucose
Silfoni**	17.947±0.011	16.670±0.018
Agin beyazi**	11.259±0.040	13.653±0.004
Kis kirmizisi*	12.292±0.002	13.407±0.008
Okuzgozu*	5.587±0.003	6.303±0.001
Ercis uzumu*	9.635±0.004	10.224±0.008

*: Dark colored cultivars; **: Light colored cultivars

Table 3. Macro nutrient contents of the grape cultivars in grape must.

	Macro nutrient contents				
Cultivars	**N (ppm)**	**P (ppm)**	**K (ppm)**	**Ca (ppm)**	**Mg (ppm)**
Okuzgozu*	140.94±10.18	326.66±8.59	1206.52±45.97	213.54±14.39	87.03±2.79
Kis Kirmizisi*	184.40±10.33	212.57±6.33	895.38±6.03	95.79±5.30	113.30±2.17
Ercis Uzumu*	213.21±7.40	361.87±27.03	483.33±11.25	114.61±7.73	90.65±1.78
Silfoni**	89.15±2.77	378.76±3.81	407.45±15.92	200.60±8.78	71.61±1.85
Agin Beyazi**	108.81±8.15	338.57±1.35	769.59±8.90	208.07±0.77	142.02±19.36

*: Dark colored cultivars; **: Light colored cultivars

Table 4. Micro nutrient contents of the grape cultivars in grape must.

	Micro nutrient contents			
Cultivars	**Fe (ppm)**	**Zn (ppm)**	**Cu (ppm)**	**Mn (ppm)**
Okuzgozu	1.18±0.085	1.19±0.099	2.49±0.078	0.69±0.064
Kis Kirmizisi	2.83±0.226	1.81±0.064	4.78±0.021	1.41±0.120
Ercis Uzumu	2.50±0.028	1.34±0.127	3.39±0.106	1.88±0.064
Silfoni	1.07±0.021	1.55±0.141	1.84±0.127	0.85±0.042
Agin Beyazi	1.78±0.226	0.73±0.035	1.13±0.1202	0.51±0.035

*: Dark colored cultivars; **: Light colored cultivars

Conclusion: The present study was the first comprehensive study establishing organic acids (citric, tartaric, malic, succinic, lactic, fumaric and acetic acids) and sugars (glucose and fructose), macro, and micro nutrient contents in the grapes cultivars (Silfoni, Agin Beyazi, Kis Kirmizisi, Okuzgozu and Ercis Uzumu) grown in Van province of the Turkey. Van is a province having high altitude (1730 m). Some of these parameters might be used for the evaluation of authenticity of different grape cultivars. Therefore, this initial study might be valuable in germplasm assessment of future breeding and evaluative works. Moreover, based on the results obtained from the present study, employment of the cultivars having more nutritional value in fruit juice processing technology might contribute to the effective outcomes. The data obtained in the present study provide valuable information on organic acids and sugars, and macro-micro nutrient in some grape cultivars. These results, therefore, might also be useful for future research on the biochemistry of the grape berry.

REFERENCES

Agaoglu Y.S. (2002). Vine Physiology. Kavaklıdere Eğitim Yayınları 5. 445 s., Ankara. (in Turkish).

Balci, N. (1996). Distribution of Organic Acids in Fruit Juices. Unpublished Master Thesis Seminar. Ankara Üniversitesi, Ankara. (in Turkish).

Bertoldi, D., Larcher, R., Bertamini, M., Otto, S., Concheri, G., and Nicolini, G. (2011). Accumulation and distribution pattern of macro- and microelements and trace elements in *Vitis vinifera* L. cv. Chardonnay berries. J. Agri. Food Chem., 59(13), 7224-7236.

Bevilacqua, A. E., and Califano, A. N. (1989). Determination of organic acids in dairy products by high performance liquid chromatography. J. Food Sci., *54*(4), 1076-1076.

Cemeroglu, B., A. Yemenicioglu, and M. Ozkan (2004). Contents of Fruit and Vegetable. 1. Fruit and Vegetable Processing Technology (Editor: B.

Cemeroglu). 2. Başkent Klişe Matbaacılık, 1. Ankara, 670. (in Turkish)

Cozzolino, D., Cynkar, W., Shah, N., and Smith, P. (2011). Quantitative analysis of minerals and electric conductivity of red grape homogenates by near infrared reflectance spectroscopy. Computers and Electronics in Agriculture, *77*(1), 81-85.

Etchebarne, F., Ojeda, H., and Hunter, J. J. (2010). Leaf: fruit ratio and vine water status effects on Grenache noir (*Vitis vinifera* L.) berry composition: water, sugar, organic acids and cations. South Afr. J. Enology and Viticulture, 31(2), 106-115.

Fidan, Y. (1985). Special Viticulture. A.Ü. Ziraat Fak. Yayınları 930. Ders Kitabı. 401p. (in Turkish).

Kacar, B., and Inal, A. (2008*).* Plant Analysis*.* Nobel Yayın Dağıtım. (in Turkish).

Kamiloglu, O. (2011). Influence of some cultural practices on yield, fruit quality and individual anthocyanins of table grape cv.'Horoz Karasi'. J. Anim. Plant Sci., 21(2), 240-245.

Melgarejo, P., Salazar, D. M., and Artes, F. (2000). Organic acids and sugars composition of harvested pomegranate fruits. European Food Res. Tech., 211(3), 185-190.

Nakajima, H., Behboudian, M. H., Greven, M., and Zegbe-Domínguez, J. A. (2004). Mineral contents of grape, olive, apple, and tomato under reduced irrigation. Mineralstoffgehalte von Weintrauben, Oliven, Äpfeln und Tomaten bei reduzierter Bewässerung. J. Plant Nutr. Soil Sci., 167(1), 91-92.

Özgen, M., Wyzgoski F.J., Tulio A.Z., Gazula A., Miller A.R., Scheerens J.C., Reese R.N., and Wright S.R. (2008). Antioxidant capacity and phenolic antioxidants of midwestern black raspberries grown for direct markets are influenced by production site. Hortscience. 43(7):2039-2047.

Ozkaya, H., 1988. Analytical Food Quality Control. Ankara Üniversitesi Ziraat Fakültesi. Yayın 1086, s.43-46, Ankara. (in Turkish).

Pavlousek, P., and Kumsta, M. (2011). Profiling of primary metabolites in grapes of interspecific grapevine varieties: sugars and organic acids. Czech J. Food Sci., 29(4), 361-372.

Pereira, G. E., Gaudillere, J. P., Pieri, P., Hilbert, G., Maucourt, M., Deborde, C., Moing, A. and Rolin, D. (2006). Microclimate influence on mineral and metabolic profiles of grape berries. J. Agri. Food Chem., 54(18), 6765-6775.

Rodriguez-Delgado, M. A., S. Malovana, J. P. Perez, T. Borges, and F. J. Garcia-Montelongo (2001). Separation of phenolic compounds by high-performance liquid chromatography with absorbance and fluorimetric detection. J. Chromatography. 912: 249-257.

Sabir, A., Kafkas, E., and Tangolar, S. (2010). Distribution of major sugars, acids, and total phenols in juice of five grapevine (*Vitis* spp.) cultivars at different stages of berry development. Span. J. Agri. Res., 8(2), 425-433.

Savran, H.S. (1999). Pomegranate Juice Organic Acid Distribution (yüksek lisans tezi). AÜ, Fen Bilimleri Enstitüsü, Ankara. (in Turkish).

Schobinger, U., 1988. Fruit and Vegetable Production Technology. Çeviren: J.Acar. H.Ü. Basımevi, s. 63-64, Ankara. (in Turkish).

Sensoy, R. I. G. (2012). Determination of phenolic substances and antioxidant activities in some grape cultivars by HPLC. The J. Anim. Plant Sci., 22, 448-451.

Sensoy, R. I. G., and Balta, F. (2010). Adaptation of some grape cultivars to Van ecological condition. Yuzuncu Yil University J. Agric. Sci., 20(3):159-170.

Shiraishi, M., Fujishima, H., and Chijiwa, H. (2010). Evaluation of table grape genetic resources for sugar, organic acid, and amino acid composition of berries. Euphytica, *174*(1), 1-13.

Soyer, Y., Koca, N., and Karadeniz, F. (2003). Organic acid profile of Turkish white grapes and grape juices. J. Food Composition and Analysis,16(5), 629-636.

Xie, Z., Li, B., Forney, C. F., Xu, W., and Wang, S. (2009). Changes in sugar content and relative enzyme activity in grape berry in response to root restriction. Scientia Horticulturae, 123(1), 39-45.