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Determination of physicochemical characteristics, organic acid and sugar profiles of Turkish grape juices

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Abstract

This study investigated the physicochemical properties, sugar and organic acid profiles of 21 grape juice and 3 sour grape juice samples in Turkey. The pH, acidity and soluble solids were ranged from 2.64 to 4.19, 3.58 to 30.75 g L^{-1} and 5.45 to 25.45 °Bx, respectively. The turbidities varied between 1.59 and 109.50 NTU and the lowest value was in the Sultani Çekirdeksiz sour grape juices. The Denizli Karasi sample had the highest color index. The tartaric and malic acid amounts of the samples ranged from 0.53 to 13.16 g 100^{-1} g^{-1} and 0.45 to 30.80 g 100^{-1} g^{-1}, respectively. The major acid was malic acid in the sour grape juice samples and tartaric acid in the grape juice samples. For all samples, glucose and fructose constituted a great part of total sugars. The glucose, fructose and total sugar contents changed from 28.45 to 48.00 g 100^{-1} g^{-1}, 15.88 to 48.75 g 100^{-1} g^{-1} and 53.67 to 97.27 g 100^{-1} g^{-1}, respectively. The highest sugar content was observed in Kara Erik and the lowest in Yediveren. As a result; some physiochemical characteristics, sugar and organic acid contents of the examined 24 grape juice samples were revealed by the current work.

Keywords: Grapes, Juices, Physicochemical characteristics, Organic acids, Sugars

Introduction

Turkey has approximately 435,000 ha vineyards and produces 4 million tons of grapes annually (Faostat, 2018). Most of the grapes used for table and drying. A small part of the production are processed to wine, molasses, grape juice and other grape based traditional foods. Grape based traditional products such as grape juice (clarified or unclarified) and sour grape juice have been processed for a long time. In the last years, the consumer demand for these grape products has increased with emergence of benefits of them on human health. For this reason, production amounts of them have tended to upward especially last decade.

Organic acid quantity and composition are important parameters indicating the quality of grape juice. These compounds affect taste balance, chemical stability, and pH values with organoleptic features, such as flavor, taste, color, and aroma in grape juice products (Lima et al., 2014; Nascimento Silva et al., 2015). Additionally, they can affect stability in juice and can be used as microbiological indicators in beverages. Especially acetic acid is utilized as an indicator to detect undesired microbiological activities in beverages (Ali et al., 2010). Major organic acids are tartaric and malic acid in grape juice, and citric and succinic acid are also present, albeit in lower amounts (Soyer et al., 2003; Ali et al., 2010). Additionally, in a previous study, Lima et al (2014) detected lactic and acetic acid in grape juice samples.

Sugar is one of the main components of grape juice and it is very important for taste balance. Glucose and fructose are the major sugars in Vitis vinifera grapes, but sucrose and other sugars are rarely found (Ali et al. 2010). Furthermore, Coelho et al (2018) reported the detection of maltose and rhamnose in addition to glucose and fructose in Vitis labrusca L. grape juice samples.

The physicochemical features, aroma, phenolic compounds, organic acid, and sugar compositions of the grapes effect on the grape juice quality. The functional properties of the

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grape juices are directly related with their bioactive compound profiles and ingredients, especially phenolic acids (Margraf et al., 2016). Additionally, growing conditions and location, agricultural applications, climate characteristics, and maturity level and variety of grapes affect to quality also (Granato et al., 2015; Yamamoto et al., 2015; Sabir et al., 2010).

The objective of the current study was to determine physicochemical features, sugar and organic acid profiles of the 24 grape and sour grape juices that were processed with different techniques. Three of the 24 samples were un-processing sour grape juice, eight of them were processed grape juice and the others were also un-processing grape juices. The un-processing grape juices of some native grape varieties have been made for a long time in Turkey. Therefore, the traditional technique was performed for native grapes and industrial technique was for the others.

Material and Method

Chemicals

Acetonitrile and malic acid were purchased from Sigma–Aldrich (St. Louis, Missouri, USA). Waters RS for HPLC Plus were obtained from Carlo Erba (Carlo Erba Reagents S.A.S., Val de Reuil, France). D-fructose, D-glucose and L-(+)-tartaric acid were obtained from Extrasynthese (Lyon, France).

Grape samples and juice processing

The grapes and sour grapes (V. *vinifera* L.) samples were picked from Manisa Viticulture Research Institute vineyards, approximately 10 kg were used for each samples, and they were presented in Table 1. After harvest, the samples were transferred to grape processing unit of the institute. Firstly, grapes were washed and passed through a destemmer-crusher machine (Türköz Metal Makine, Turkey). The obtained grape mash samples were used to produce grape juices with traditional or industrial techniques. The grape mash was heated up to 50 °C and were kept at this temperature for 60 min for red and 30 min for white varieties. Then, they were pressed and blurred grape juice samples were obtained. Must yield of traditional produced grape juice samples has changed between 39 and 63 %. Besides, must yield was determined approximately 75 % and 40 % for industrial produced grape juice samples and SGJ, respectively. For the production with the traditional technique, this blurred juice was put into 250 mL glass bottles and pasteurized. Thus, un-processing grape juices were obtained. To manufacture processing grape juice and sour grape juice (SGJ) with industrial technique, pectolytic enzyme (Pectinex XXL, 10000 PECTU/mL) was applied (1mL L^{-1}) for 60 min at 50 °C. Bentonite (SIHA Puranit UF, Germany) was used 1.2 g/L at 50 °C for 60 min, gelatin (SIHA Gelatin Fine Granules, 80-100 Bloom, Begerow, Germany) was applied 0.2 g/L for 120 min, and kieselsol (Levasil 200 /30/FG, HC Starck, Germany) was used fivefold of the gelatin amount for 60 min. Then, the samples filtered using by a plate filter (Europor K 3 filter sheets, 10.4 gpm/ft2; 40x40 Plate filter, Turkey). After filtering, processed grape and SGJ juices was filled into 250 mL glass bottles. The un-processed and processed grape juice and SGJ samples were pasteurized in the 85 °C of water for 20 min and immediately cooled to room temperature.

Table 1. The sample properties, codes and harvest dates

No.	Code	Varieties	Color	Harvest Date	Processing techniques
1	M1	50% Hamburg muscat + 50% Siyah Dimrit	Red	08.08.2017	Processing with industrial techniques: clarified grape juice
2	M2	20% Hamburg muscat + 80% Siyah Dimrit	Red	15.08.2017	
3	M3	85% Royal + 15% Italia	Red	01.09.2017	
4	MH1	Mixed grape hybrids	Red	13.09.2017	
5	MH2	Mixed grape hybrids	Red	20.09.2017	
6	OKG	Öküzgözü	Red	28.09.2017	
7	SCGJ	Sultani Çekirdeksiz	White	15.08.2017	
8	IT	Italia	White	11.08.2017	
9	CS	Cabernet Sauvignon	Red	25.06.2017	Processing with industrial techniques: clarified sour grape juice (SGJ)
10	SC	Sultani Çekirdeksiz	White	25.06.2017	
11	YD	Yediveren	White	20.06.2017	
12	BL	Bulama	White	07.08.2017	
13	EXL	Exalta	White	07.08.2017	
14	KH	Kanon Harabı	White	06.08.2017	
15	KY	Köy Yeri	White	06.08.2017	
16	TG	Tergöynek	White	12.08.2017	
17	KO	Koca Osman	Red	11.08.2017	Processing with traditional techniques: blurred grape juice
18	CU	Çilek Üzümü	Red	10.08.2017	
19	YDM	Yerli Dimrit	Red	04.08.2017	
20	BK	Balçova Karası	Red	07.08.2017	
21	ED	Erkenci Dimrit	Red	04.08.2017	
22	KE	Kara Erik	Red	08.08.2017	
23	DK	Denizli Karası	Red	03.08.2017	
24	KK	Katı Kara	Red	07.08.2017	

Determination of physicochemical properties

The pH, titratable acidity (TA) and soluble solid (SS) analyses were conducted as described by William (2005). The pH was measured using a calibrated pH meter (Sartorius Docu-pH meter, Germany). The TA analysis was performed using the potentiometric titration method, and the results were obtained as tartaric acid equivalent (g/L). A portable refractometer (Hanna HI 96801, USA) was used to measure SS (°Bx).

The absorbance values of the samples were measured using a spectrophotometer (Thermo scientific, Multiskango, Finland) at 420, 520 and 620 nm, and the color intensity (CI) values were calculated using the formula below (1).

$$CI=A420+A520+A620 \quad (1)$$

The turbidity values of the samples were measured using a portable turbidimeter (Hach 2100Q Portable Turbidimeter, China), and the results were expressed in the nephelometric turbidity unit (NTU)

Sugar compositions of the samples

The sugar profiles of the samples were determined with slight modifications to the method described by Xu et al (2015). First, the samples were diluted with distilled water and passed through a PTFE 0.45 µm syringe filter (Sartorius). Then, they were injected into the HPLC system (Agilent 1260 infinity) for analysis. The detector was selected as the refractive index (RID), and the column was NH_2 250 x 4.6 mm, 5µm (Inertsil). The column temperature was set to 30 °C, and a 20 µL injection volume was used. The flow was isocratic, the flow rate was 1.5 mL min^{-1}, and the elution time was 20 min. Acetonitrile and distilled water (80:20; v:v) were used as the mobile phase. The R^2 values were 0.9996 and 0.9928 and detection limits (LOD) were $6.28x10^{-8}$ and $4.68x10^{-7}$ mg/L for fructose and glucose, respectively. The results were expressed as g in 100 g DW.

Organic acid compositions of the samples

The chromatographic organic acid analyses were performed according to Reuter & Shelton (2015). The samples diluted with distilled water to a certain ratio were filtered (PTFE 0.45 µm syringe filter) and injected into the HPLC instrument (Agilent 1260 infinity). The injection volume was 20 µL, and the flow rate was 1.5 mL/min. The measurements were undertaken using a diode-array detector (DAD; Agilent 1260 infinity) with the following parameters: wavelength 210 nm, column C18 ODS 250 x 4.6 mm, 5 µm (Agilent), and column temperature 30 °C, flow isocratic, and elution time 8 min. An acidified 25 mM KH_2PO_4 buffer (to pH 2.4 with H_3PO_4) was used as the mobile phase. For tartaric and malic acids, the R^2 and LOD values were 0.9998-0.9997 and 0.015-0.037 mg/L, respectively. The results were calculated according to a calibration curve and given as g in 100 g DW.

Statistical analysis

In this study, all analyses were performed in triplicate, and the results were given with standard deviations. The obtained results were subjected to an analysis of variance (ANOVA), and the Duncan multiple comparison test was used to determine the differences between the samples.

Results and Discussion

Physicochemical properties of the samples

The physicochemical properties, CI and turbidity values of the samples are presented in Table 2. The differences between the pH values of the samples were statistically significant ($p \leq 0.05$), ranging from 2.64 to 4.19 in grape juice and SGJ samples. The highest value was found in the KK sample and the lowest in YD. At the same time, the pH values of the SGJ samples were lower than those of the grape juice samples, as expected. The pH of grape juice has an important effect on many parameters, such as conservation, storage, color and characteristics of the product. Soyer et al (2003) reported that the pH of the grape juice products in Turkey varied between 3.3 and 4.0. In other studies, the pH values of the grape juice samples were found between 3.02 and 3.90 (Matos et al., 2017; Margraf et al., 2016; Yamamoto et al., 2015; Lima et al., 2014; Toaldo et al., 2014).

While the SS values of the grape juice samples ranged from 16.15 to 25.45 °Bx, these values were between 5.45 and 7.45 °Bx in the SGJ samples. In different studies, the SS values of grape juice and SGJ samples were reported to vary between 4.50 and 22.6 °Bx (Margraf et al., 2016; Öncül and Karabıyıklı, 2015; Yamamoto et al., 2015; Lima et al., 2014; Hayoglu et al., 2009). The results obtained from the current study in relation to the pH and SS values were similar to those reported in the literature.

TA is very important for the taste balance of grape juice. In grape juice and SGJ samples, the TA values ranged from 3.58 to 8.11 g/L and 25.22 to 30.75 g/L, respectively. These values are consistent with the results of previous studies (Margraf et al., 2016; Öncül and Karabıyıklı, 2015; Yamamoto et al., 2015; Lima et al., 2014; Tolado et al., 2014; Hayoglu et al., 2009; Nikfardjam, 2008; Soyer et al., 2003).

The color of grape juice is another important parameter, especially for the consumers. In the grape juice and SGJ samples produced, the CI values were measured between 0.17 and 6.75. The highest CI value was observed in red grape juice samples. Lima et al (2014) stated that the CI values of the grape juice samples obtained from six new grape varieties ranged from 2.78 to 11.15. In another study, the CI values of the grape juice samples varied between 10.87 and 16.59 (Yamamoto et al., 2015). Moreover, Margraf et al (2016) found that the CI values of grape juice were between 1.02 and 2.17. The CI values of the current study were lower than previously reported. This is considered to be due to the differences in the species and varieties, as well as the processing method.

In the analyzed samples of grape juice, turbidities were determined between 7.09 and 109.50 NTU. The highest turbidity was observed in the ED unclarified grape juice sample. Kaya & Unluturk (2016) revealed that the turbidity values of grape juice varied between 32.5 and 105 NTU, which is in agreement with our turbidity results. In the SGJ samples, the turbidity values were between 1.59 and 4.01 NTU, which were lower compared to the grape juice samples. This may be due to the processing, in addition to the chemical and physiological differences between grapes berry and sour grapes berry. Hayoglu et al (2009) reported that gelatin applications enhanced the clarity of SGJ samples.

Table 2. The physicochemical, CI and turbidity values of the samples

Samples	pH	SS, °Brix	TA, g/L	CI	Turbidity, NTU
M1	3.74±0.01^{k}	20.90±0.01^{g}	5.06±0.06^{fg}	2.58±0.11^{h}	52.90±0.01^{g}
M2	3.69±0.01^{lm}	18.14±0.05^{m}	3.58±0.05^{l}	3.64±0.11^{f}	39.13±0.17^{i}
M3	3.91±0.01^{f}	19.65±0.07^{j}	4.69±0.15^{gh}	4.93±0.05^{d}	57.15±0.13^{e}
MH1	3.65±0.01^{n}	21.00±0.01^{g}	5.68±0.03^{e}	1.81±0.04^{l}	15.10±0.14^{o}
MH2	3.77±0.01^{j}	19.60±0.01^{j}	4.59±0.05^{ghi}	2.33±0.07^{i}	70.36±0.56^{c}
OKG	3.70±0.01^{l}	19.20±0.01^{k}	5.04±0.09^{fg}	5.03±0.23^{c}	10.48±0.10^{p}
SCGJ	3.97±0.01^{d}	21.20±0.01^{f}	4.48±0.03^{hij}	0.77±0.03^{n}	18.35±0.25^{n}
IT	3.82±0.01^{i}	20.55±0.07^{h}	4.42±0.02^{hijk}	0.59±0.01^{p}	23.23±0.05^{m}
CS	2.81±0.02^{p}	7.15±0.07^{q}	25.22±0.72^{b}	0.23±0.01^{s}	3.05±0.34^{rs}
SC	2.77±0.02^{q}	7.45±0.07^{p}	25.37±0.37^{b}	0.17±0.01^{s}	1.59±0.01^{s}
YD	2.64±0.01^{r}	5.45±0.07^{r}	30.75±0.63^{a}	0.67±0.01^{o}	4.01±0.19^{r}
BL	3.75±0.01^{k}	17.75±0.07^{n}	3.99±0.10^{jkl}	0.49±0.02^{q}	26.50±0.20^{l}
EXL	3.85±0.01^{h}	18.45±0.07^{l}	3.94±0.05^{kl}	0.50±0.01^{q}	48.75±0.13^{h}
KH	3.66±0.01^{n}	16.15±0.01^{o}	4.67±0.05^{gh}	0.32±0.02^{r}	18.68±0.29^{n}
KY	3.83±0.01^{i}	18.25±0.07^{m}	3.64±0.02^{l}	0.22±0.01^{s}	7.09±0.02^{q}
TG	3.68±0.01^{m}	17.85±0.07^{n}	4.16±0.04^{jik}	0.36±0.02^{r}	30.85±0.13^{k}
KO	3.88±0.03^{g}	18.45±0.07^{l}	3.99±0.04^{jk}	2.68±0.06^{g}	26.70±0.01^{l}
CU	3.99±0.05^{d}	20.15±0.07^{i}	4.71±0.04^{gh}	1.01±0.01^{m}	24.80±0.08^{m}
YDM	3.90±0.01^{f}	18.45±0.07^{l}	7.08±0.04^{d}	2.06±0.02^{j}	69.35±0.06^{c}
BK	3.93±0.01^{e}	22.21±0.01^{d}	5.22±0.24^{ef}	1.97±0.03^{k}	55.30±0.50^{f}
ED	3.57±0.10^{o}	24.35±0.07^{b}	8.11±0.04^{c}	4.04±0.03^{e}	109.50±4.80^{a}
KE	4.02±0.07^{c}	25.45±0.07^{a}	5.66±0.07^{e}	5.75±0.08^{b}	66.60±1.10^{d}
DK	4.07±0.01^{b}	21.80±0.01^{e}	4.50±0.10^{hij}	6.75±0.07^{a}	78.70±1.93^{b}
KK	4.19±0.01^{a}	23.90±0.01^{c}	4.92±0.06^{fgh}	2.76±0.03^{g}	33.83±1.33^{j}

Values indicated with different letters within each group and column are significantly different for p≤0.05

Sugar compositions of the samples

The variations in sugar compositions and total sugar amounts of grape juice and SGJ samples are given in Table 3. The differences between the fructose, glucose and total sugar amounts of the samples were found statistically significant ($p \leq 0.05$). The fructose contents ranged from 15.88 to 48.75 g/100 g, with the highest amount being determined in KE and the lowest in YD. The highest glucose value was 48.00 g/100 g obtained from the KE sample and the lowest was 28.45 g/100 g found in CS. The total sugar amounts were found between 52.16 and 96.75 g/100 g. The highest sugar content was observed in KE and the lowest in YD. The HPLC chromatogram of YD sugars profiles was presented on Figure 1. Expectedly, the sugar contents of the SGJ samples were lower than those of the grape juice samples because they were harvested before maturity according to others.

Eyduran et al (2015) found that the fructose and glucose amounts of some grapes grown in the east of Turkey were 8.03 - 13.47 g/100 g and 9.51-16.47 g/100 g, respectively. Canbaş et al (1996) revealed that the amount of invert sugar varied between 159 and 195 g/L in carbonated grape juice samples. Munoz-Robredo et al (2011) reported that in three table grape varieties (*V. vinifera* L.), the amount of fructose was 7.74-8.74 g/100 g, glucose 8.03-8.70 g/100 g, sucrose 0.73-0.90 g/100 g, and total sugar 16.57-17.74 g/100 g at harvest. In grape juice samples produced from *V. labrusca* L. grapes, the amount of fructose was 72.90 -92.90 g/L, glucose 86.61-108.09 g/L, and total sugar 163.31-200.97 g/L (Coelho et al., 2018). In a similar study, the glucose amount was 39.70-72.16 g/L and fructose was 48.12-80.04 g/L in Concord and Bordo (*Vitis Labrusca* L.) grape juice samples (Barros et al., 2014). Additionally, in their study investigating grape juice concentrations, Piva et al (2008) reported 105 g/L glucose and 98.4 g/L fructose in fresh juice.

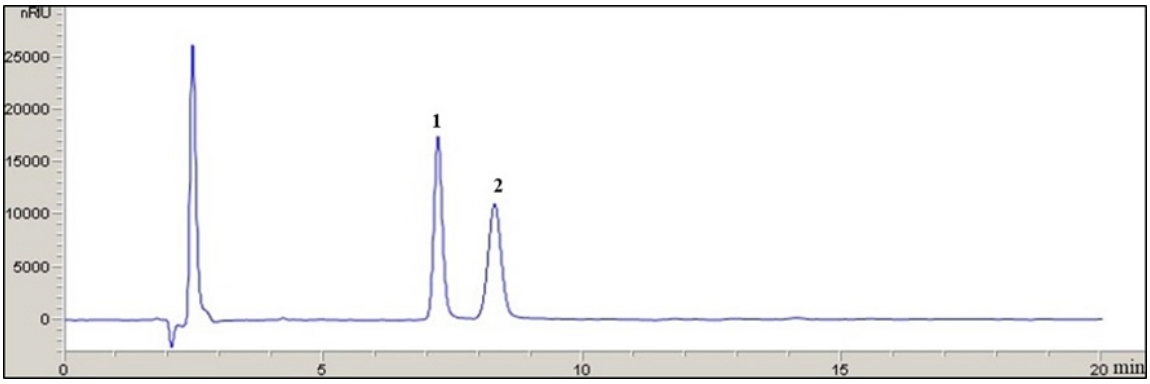

Figure 1. Chromatogram of HPLC sugars profile of YD (1: Fructose; 2: Glucose)

Table 3.Sugar compositions of the samples (g/100 g DW)

Samples	Fructose	Glucose	Total Sugar (Glucose +Fructose)
M1	44.80±0.41^{ghı}	42.68±0.69^{efghı}	87.48±0.95^{efg}
M2	44.83±0.11^{ghı}	43.67±1.38^{cde}	88.05±1.02^{def}
M3	43.86±0.30^{ıj}	41.62±0.10^{hıj}	85.48±0.54^{gh}
MH1	44.97±0.63^{fgh}	41.65±0.35^{ghıj}	86.62±0.85^{fgh}
MH2	45.83±0.13^{def}	42.91±0.44^{defgh}	88.74±0.30^{def}
OKG	45.43±0.90^{efg}	42.09±0.76^{fghıj}	87.52±1.21^{efg}
SCGJ	47.18±0.91^{b}	43.43±0.50^{cdef}	90.61±1.32^{cd}
IT	47.38±0.06^{b}	41.20±1.18^{ıj}	88.58±1.47^{def}
CS	24.54±0.05^{m}	28.45±0.32^{n}	52.99±1.12^{l}
SC	24.56±0.21^{m}	32.26±0.25^{m}	56.82±0.25^{k}
YD	15.88±0.15^{n}	36.28±0.42^{l}	52.16±1.36^{l}
BL	46.07±0.07^{cde}	40.99±0.18^{j}	87.06±0.18^{efgh}
EXL	44.33±0.10^{hıj}	41.63±0.47^{hıj}	85.96±0.61^{gh}
KH	46.80±0.20^{bc}	46.61±1.09^{b}	93.41±1.68^{b}
KY	46.44±0.52^{bcd}	44.60±0.28^{c}	91.04±1.01^{c}
TG	46.52±0.28^{bcd}	42.59±0.35^{efghı}	89.11±0.70^{cde}
KO	44.00±0.35^{hıj}	43.06±0.35^{cdefgh}	87.06±0.17^{efgh}
CU	43.37±0.25^{j}	41.69±0.69^{ghıj}	85.06±0.82^{h}
YDM	40.93±0.17^{l}	37.28±0.45^{k}	78.21±0.72^{j}
BK	41.03±0.39^{l}	40.95±0.65^{j}	81.98±0.70^{ı}
ED	42.43±0.16^{k}	43.22±0.14^{cdefg}	85.65±0.43^{gh}
KE	48.75±0.70^{a}	48.00±0.16^{a}	96.75±0.49^{a}
DK	46.90±0.33^{bc}	44.13±0.18^{cde}	91.03±0.10^{c}
KK	44.06±0.03^{hıj}	44.43±0.01^{cd}	88.49±0.11^{def}

Values indicated with different letters within each group and column are significantly different for p≤0.05

Ali et al (2010) noted that glucose and fructose were the major grape sugars while sucrose and other sugars were rarely found in *V. vinifera* grapes. The findings of the current study also revealed that fructose and glucose were the major sugars in grape juice. On the other hand, our results were not in agreement to some of the previous studies. The conflicting results concerning sugar compositions can be attributed to the differences in species, variety and maturity of grapes used.

Organic acid compositions of the samples

Table 4 presents the organic acid compositions (tartaric, malic and total acids) of the samples, which statistically significantly differed ($p \leq 0.05$) with respect to tartaric, malic and total acid. The tartaric acid amounts of the samples ranged from 0.53 to 13.16 g/100 g, with the lowest value being determined in ED and the highest in YD. The amounts of malic acid and total acid in grape juice and SGJ samples were 0.45-30.80 g/100 g and 1.21- 43.96 g/100 g, respectively. The highest total amount of acid was found in YD and the lowest in BL. The HPLC chromatogram of YD organic acid profiles was indicated on Figure 2. The organic acid organoleptic properties of grape juice and wine are very important because of their effects on microbiological quality and wine stabilization (Ali et al., 2010). Tartaric acid is the dominant organic acid in grapes and grape products. When the organic acid distribution in grape juice samples was analyzed, tartaric acid was found lower than malic acid in the unclarified red grape juice samples, but this was not observed in the clarified red grape juice samples. These differences might be due to the separation of pulp rich in malic acid during the production of grape juice.

Soyer et al (2003) investigated the organic acid compositions in grape and grape juice of 11 different grape varieties in Turkey and reported tartaric, malic, citric and total acid values as 4.98-7.48 g/L, 1.43-3.40 g/L, 30-164 mg/L and 6.61-10.62 g/L, respectively for grapes, and 4.07-4.92 g/L, 1.36-3.47 g/L, 31-181 mg/L and 6.00-7.83 g L^{-1}, respectively for grape juice. Lima et al (2014) determined that the amounts of tartaric, malic and total acid were 4.60-6.32 g/L, 2.12-4.15 g/L and 8.82-12.04 g/L, respectively in five new Brazilian grape varieties (*V. labrusca* L.). In another study investigating different maceration conditions, tartaric acid ranged from 4.30 to 5.64 g/L, malic acid 3.46 to 3.80 g/L and total acid 9.33 to 10.64 g/L in grape juice samples (Lima et al 2015). Toaldo et al (2015) found the tartaric, malic and total acid amounts as 2.09-3.11 g g/L, 1.29-3.22 g/L and 4.67-8.23 g/L, respectively in grape juice samples produced from organic and conventional grapes (*V. labrusca* L.). In another study on organic acid and sugar methodology in grape juice and wine, tartaric acid was found as 4.02-5.38 g/L, malic acid 1.56-1.92 g/L, and total acid 6.20-7.35 g/L (Coelho et al., 2018). In some commercial table grapes (Red Globe, Thompson Seedless and Crimson Seedless, *V. vinifera* L.), the tartaric, malic and total acid amounts were reported as 7.45-6.55 g/L, 47.78-29.92 g/L and 32.49-36.86 g/L, respectively seven weeks before harvest. In the same study, these values dropped to 1.28-2.05 g/L, 0.39-1.80 g/L and 1.93-3.85 g/L, respectively at harvest (Munoz-Robredo et al., 2011).

The organic acid amounts obtained from this study were generally similar to the previous reports. On the other hand, the tartaric acid amounts in some samples were lower than previously found. This may be due to the grape variety, ecology, harvest time, and grape juice production process. With respect to the differences between the malic acid amounts, species (*vinifera or labrusca*) is another factor that should be take into consideration.

Table 4. Organic acid compositions of the samples (g/100 g DW)

Samples	Tartaric Acid	Malic Acid	Total Acid (tartaric+malic)
M1	1.01±0.01^{i}	1.18±0.10^{g}	2.19±0.10^{f}
M2	1.10±0.01^{h}	0.80±0.01^{jkl}	1.90±0.01^{hij}
M3	1.16±0.01^{f}	1.01±0.07^{ih}	2.17±0.07^{f}
MH1	1.14±0.06^{g}	0.72±0.01^{klmn}	1.86±0.01^{ij}
MH2	1.16±0.10^{f}	0.89±0.17^{j}	2.05±0.17^{gh}
OKG	1.37±0.01^{d}	0.97±0.12^{hi}	2.34±0.11^{e}
SCGJ	0.87±0.12^{e}	0.76±0.01^{jklm}	1.63±0.01^{hi}
IT	0.97±0.04^{j}	0.66±0.01^{mn}	1.63±0.07^{l}
CS	4.98±0.07^{c}	21.36±0.08^{b}	26.34±0.14^{b}
SC	7.52±0.03^{b}	17.16±0.14^{c}	24.68±0.10^{c}
YD	13.16±0.16^{a}	30.80±0.10^{a}	43.96±0.05^{a}
BL	0.76±0.01^{p}	0.45±0.01^{o}	1.21±0.01^{n}
EXL	0.89±0.01^{l}	0.68±0.03^{lmn}	1.57±0.01^{l}
KH	0.93±0.01^{k}	0.89±0.01^{ij}	1.82±0.02^{jk}
KY	0.72±0.01^{q}	0.62±0.01^{n}	1.34±0.11^{m}
TG	0.84±0.01^{m}	1.30±0.01^{fg}	2.13±0.07^{fg}
KO	0.76±0.01^{p}	1.37±0.02^{f}	2.13±0.05^{fg}
CU	0.65±0.01^{s}	1.23±0.01^{g}	1.88±0.02^{hij}
YDM	0.79±0.01^{n}	2.07±0.01^{d}	2.86±0.02^{d}
BK	0.65±0.01^{s}	1.06±0.01^{h}	1.71±0.02^{kl}
ED	0.53±0.01^{u}	1.39±0.01^{f}	1.92±0.02^{hij}
KE	0.63±0.01^{t}	1.57±0.02^{e}	2.21±0.01^{f}
DK	0.77±0.06^{o}	0.89±0.01^{ij}	1.66±0.02^{l}
KK	0.67±0.01^{r}	1.19±0.01^{g}	1.86±0.01^{ij}

Values indicated with different letters within each group and column are significantly different for p≤0.05

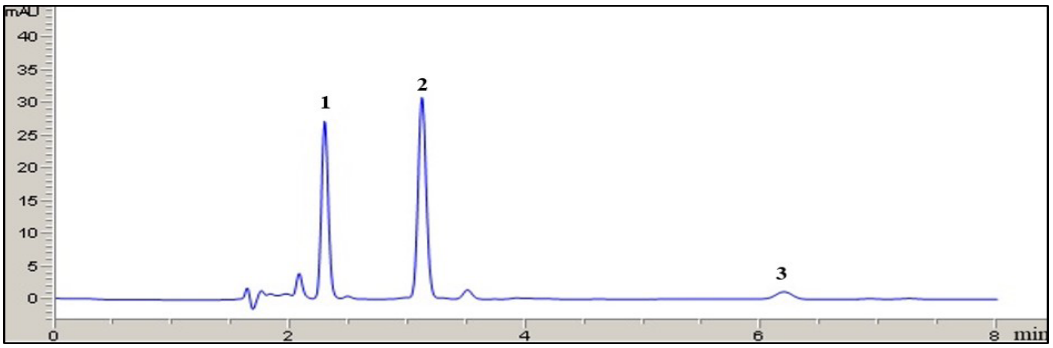

Figure 2. Chromatogram of HPLC organic acids profile of YD (1: Tartaric acid; 2: Malic acid; 3: Citric acid)

The SGJ samples were found to contain much higher amounts of organic acid compare to grape juice samples. These differences resulted from using sour grape samples with a high acid content in the production of SGJ. Besides, in the SGJ samples, the amount of malic acid was higher than tartaric acid due to the higher amounts of malic acid in sour grape samples than tartaric acid. Munoz-Robredo et al (2011) reported significantly higher amounts of malic acid than tartaric acid during the pre-harvest period (seven weeks before harvest) in the Thompson Seedless grape variety. In another study examining the maturation period of different grape varieties, tartaric acid was reported as 10.3-12.3 g/L, malic acid as 9.1-15.1 g/L and total acid as 21.8-30.7 g/L in sour grape samples before veraison (Sabir et al., 2010). Matos et al (2017) investigated the SGJ samples of six grape varieties at three maturation times and found the tartaric and malic acid amounts to range from 5.5 to 10.4 g/L and 10.9 to 30.4 g/L, respectively. In the same study, the total acid amounts were given as 17.4-40.5 g/L. The organic acid compositions of our SGJ samples are consistent with the values determined in previous studies.

Conclusion

In this work, the physicochemical characteristics, sugar and organic acid profiles of SGJ and grape juice samples from Turkey were demonstrated. In particular, the parameters having significant effects on fruit juice quality such as CI and turbidity were determined in detail. The results also revealed the major organic acids were malic acid for SGJ and tartaric acid for grape juice. Additionally, glucose and fructose constituted the majority of total sugar in all investigated samples. The study findings will contribute to the literature and sector regarding Turkish grape juice. On the other hand, more research need to characterize the Turkish grape and grape juice regarding physical, chemical and technological properties.

Compliance with Ethical Standards

Conflict of interest

The authors declare that for this article they have no actual, potential or perceived the conflict of interests.

Author contribution

The contribution of the authors is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

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Data availability

Not applicable.

Consent for publication

Not applicable.

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