The effect of boiling on qualitative properties of grape juice produced by the traditional method

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Abstract In this study, grape molasses produced by using the traditional methods from the from Taşkent town of Konya were analysed for their some quality values. Depending on the type of grape molasses and boiling periods, some differences were found in physico-chemical properties. Protein, pH, total acid, hydroxymethyl furfural, soluble dry matter, total phenol and viscosity values were found between 0.260 % and 0.421 %, 7.82 and 8.35 %, 0.477 % and 0.585 %, 3.312 mg/kg and 6.336 mg/kg, 20.447 mg/L and 25.813 mg/L, 61.5 and 67.0 % and 65.60 mPa.s to 91.75 mPa.s, respectively. Antioxidant activity values were determined between % 86.437 and % 93.395. L* values were established between 20.41 and 55.29, while a* values are found between 8.11 and 18.69 and b* values are between 34.94 and 47.47. The K, Mg, Na, P, Ca contents of all the molasses samples has been detected at high levels. At some quality parameters such as protein, total acid and L* values have been decreased towards to end of the boiling period. As a result, antioxidant activity and anthocyanin in the red grape molasses were superior to compared with other types of grape molasses.

Keywords Grape · Grape molasses · Grape molasses rescript · Liquid grape molasses · Molasses

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Pekmez is a traditional Turkish food which is produced from grape and other fruit juices containing high amounts of sugar like apple, carob, plum, watermelon, apricot, sugar beet and Fig. Boiled grape juice is known as “pekmez” in Turkish. It includes nourishment as in fresh grape and doesn’t include any additives (Şengül et al., 2005). Pekmez is very important energy food and is used as an ingredient in virtually hundred of manufactured foods, mainly in cereal based products such as pekmez havla, pelize, for sweetness, color, flavor and caramelization. It can be assumed as a natural food containing natural sugars such as glucose, galactose and minerals. Also, it is a very important food product due to high amounts of sugar, mineral and organic acid in human nutrition (Karakaya and Artık, 1990; Demiröz et al., 2002; Yoğurtçu and Kamışlı 2006). It can be assumed as a natural food containing sugars as glucose, galactose and minerals. It is produced by concentration of juice up to 70–80 % soluble solids content. Since pekmez contains high amounts of sugar, mineral and organic acid, it is a very important product in human nutrition (Bozkurt et al., 1999; Yoğurtçu and Kamışlı, 2006).

Heat treatment with a certain time affects not only HMF amount but also the viscosity, color and brix of the product. Heating has an important influence on the brix and consequently brix can be said to have an indirect effect on HMF occurrence. Non-enzymatic browning reactions during and storage is the common problem of pekmez. They take place either by caramelization or the Maillard reactions between the reducing sugars as glucose and fructose and the amino acids as arginine, glutamine and proline in pekmez. Maillard reactions result in undesirable color, odor and flavor changes and are followed by the formation of intermediates such as 5-hydroxymethyl furfural (HMF), particularly under acidic conditions and finally brown pigment formation (Bozkurt et al., 1999). Several studies were carried out on production, composition, standardization and health benefits of pekmez (Bozkurt et al. 1999; Karakaya and Artık 1990; Şengül et al.

2005; Topçu et al. 1997; Yoğurtçu and Kamlı 2006; Alpaslan and Hayta, 2002; Kayışoğlu and Demirci, 2006). But, there is limited information about mineral contents and soluble solid contents of several fruit pekmez samples. Therefore, the aim of this study was to determine the effect of boiling on quality of grape molasses produced by using the traditional methods from the types of red, black and white grapes from Taşkent town of Konya.

Material and method

Material

Grape molasses produced by using the traditional methods from the types of red, black and white grapes, and samples, which were taken during the stages of production of grape molasses, were used as materials in this study. These three types of grapes are grown in the vineyards around Bağcılar resort of Taskent, Konya. Stages of the process are respectively numbered from 1 to 7.

Must samples that are belonging to red, black and white grapes are respectively numbered as A1, A2, B1, B2, C1 and C2. Samples that are taken during the production of semi-finished and finished product derived from grape molasses are numbered from 1 to 36. On a total of 42 units samples were studied.

Method

Grape molasses production with the traditional methods

These grapes are locally named as red, black, and white grapes. For each type 80 kilograms fresh grapes were used. To boil 3 types of grape molasses, a total of 240 kilograms fresh grapes were supplied.

Grapes were washed for extracting of rotten, moldy and damaged parts of them before they brought to the must room. After taking the grapes to the must room, they were filled separately into the bags by type. Grape bags tightly connected as a precaution against the risk of explosion during the chewing. The grape-filled bags were taken into the wood container through the “yalak” that is named traditionally. Grapes juice flowing from pressed grapes that are pressed by chewing technique was accumulated in the gutter placed in the front of ‘yalak’. Thus, grape pulp and juice easily were separated from each other. 40 kilograms of grape juice were obtained from 80 kilograms grapes. In every stages of production of grape molasses, acidity and pH were measured. The output temperatures of grape must were varied between 15 °C and 16 °C. pH values of grapes must were found 7.45

for red grapes, 5.47 for black grapes and 5.18 for white grapes. 40 kgs of red, black and white musts evenly divided into two parts and put on two separate outdoor boiling containers. In total, 6 boiling containers that contain 20 kg must, was made ready for the production of grape molasses.

The output temperatures of grape must were varied between 15 °C and 16 °C. The temperature values of grape must were not enough hot to clarification to be effectively. Therefore, a 30-minute preheating was made to increase the temperature of grape must to 50 °C. Grape must in heated form in boiling containers was transferred to the large plastic containers, and then was subjected to process of grounding. White-colored grape molasses soil was used for removal of acidity and clarification process. While making the process of grounding, 1 kg white-colored soil was added to 20 kg grape must. After adding white-colored soil, grape must was taken to rest for 30 minutes. The particulars, which cause the blur, were precipitated to the bottom of plastic containers to clarifying grape must. Acidity of grape must was decreased because of the interaction between grape must and white-colored soil. Grape must was divided into two phases, which are with sediment and without sediment. The clear phase, which was at the top of the plastic containers, was taken to the boiling containers again. 250 ml samples were taken at every hour at the stages of prior to the grounding, after grounding and during the boiling process.

During the boiling process, dull and dirty foams were occurred. Dirty foams were taken with a wood spoon from the surface of boiling containers. While stiffing the grape must, boiling containers were mixed continuously to distribute the heat homogenously and to prevent occurring the taste of burn. To prevent a possible contamination between each types of grape must, different wood spoons and other equipments were used for every boiling container. To heat the boiling containers at the same temperature, woods were put on constantly to the bottom of stone stoves. To understand if the grape molasses were become to desired viscosity, the process of centrifuging was used with a spoon. The boiling process terminated based on the sensory observation. The boiling processes of grape molasses took 4 hours for every container. The boiling containers were taken from the top of the stone stoves to cool them down. Cooled samples of grape molasses were filled into 250 ml plastic bottlers. To prevent confusion between samples, plastic bottlers were labeled.

Chemical analyses

Protein analysis was performed by the Kjeldahl method. The results in percentage of N were multiplied by the factor of 6.25 and then percentage of protein was calculated (Bradford, 1976). pH analysis was performed using a portable electro pH meter (AOAC, 1995). 5 grams of samples was taken and 20 ml pure water added into it. After adding three drops of

phenolphthalein solution, it was titrated with 0.1 NaOH. The result is given the percentage of acidity (AOAC, 1995).

The principle of method based on the determination of the color differences that 5-Hydroxymethyl furfural (HMF) formed with the barbituric acid, on the spectrophotometer, which is set to a wavelength of 550 nm, in melted p-toluidine at isopropanol. Weighed and unheated 10 grams subtract that was taken from the test sample was solved in 20 ml distilled water. This solution was transferred to 50 ml flask and had been completed to 50 ml with distilled water. Two test tubes were prepared by taking 2 ml solution. And then 5 ml paratoluidine solution was added. 1 ml barbituric acid was added to one of the test tubes and 1 ml distilled water was added the other test tube that was separated for the blind test. Absorbance values were measured at a wavelength at 550 nm. While making the calculations, the measurement of the blind test was subtracted from the measurement of the test that was done with the barbituric acid, and then multiplied by a constant of 192 (Zappala et al. 2005).

0.5 ml solution of Folin Ciocalteu (1:4 diluted) was added to samples, which were prepared 0.1 ml. After adding 1.5 ml of 20 % Na_2CO_3 , the solution had been completed to 10 ml with the distilled water. And then, the solution was waited for two hours in dark. The reading was performed on spectrophotometer (Shimadzu UV–vis mini) at a wavelength of 760 nm. Total phenol amount per liter was calculated equivalently according to Gallic acid (Vasquez Roncero et al. 1973).

To determinate anthocyanin used a method that base on the loosening of color properties when these pigments and sodium bisulphate ions are combined. The optical density difference, between the sample that contains bisulphate and the sample that doesn't contain bisulphate, was multiplied by a constant of 875. The results were given to be Maldivin-3-Glycoside in the unit of mg/L (Ribereau-Gayon et al. 2000).

These analyses were performed on the red and the black grape molasses samples, which were taken at the last stage of grape molasses process. Anthocyanin analysis wasn't performed on the white grape samples.

Inhibition of DPPH free radicals of the samples, which were obtained while determining the antioxidant activity, was calculated and expressed as percentages (Gyamfi et al. 1999). After calibrating the refractometer with distilled water, the reading of samples was performed. Results were given as percentages (AOAC, 1984).

Physical analyses

Color

Color of samples that were used in our study, were measured by a device (Minolta CR 400 model colorimeter) that works according to Hunter (L^* , a^* , b^*) color measurement system. L^* (100: white, 0: black), a^* (+ red, – green) and b^*

(+ yellow, – blue) values were determined by measuring. Samples were put on glass petri plates that were waiting on the white surface. Three times reading was made and the average of these reading values was taken to find the result. (Rommel et al. 1990).

Viscosity

The viscosity of samples was measured with a viscometer that has a digital panel. The brand of the viscometer is AND-Vibro (SV-10). Results were found in mPa.s. (Matsuda and Sabato, 2004).

Determination of mineral contents

Mineral matters of samples were found by using the ICP-AES (Inductively Coupled Plasma- Atomic Emission Spectrometer) device and the values are given to be ppm (mg/kg). The results were found over from Mo, Ca, B, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Se and Zn mineral substances. About 0.5 g dried and pekmez sample was put into a burning cup and 15 ml pure HNO_3 were added. The sample was incinerated in a MARS 5 Microwave Oven at 200 °C and dissolved ash diluted to a certain volume with water. Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards, and samples. After digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 ml flasks and analysed by ICP-AES. The mineral contents of the samples were quantified against standard solutions of known concentrations which were analysed concurrently (Skujins, 1998).

Working conditions of ICP-AES:

Instrument	: ICP-AES (Varian-Vista)
RF Power	: 0.7–1.5 kw (1.2–1.3 kw for Axial)
Plazma gas flow rate (Ar)	: 10.5–15 L/min. (radial) 15 “(axial)
Auxiliary gas flow rate (Ar)	: 1.5 “
Viewing height	: 5–12 mm
Copy and reading time	: 1–5 s (max.60 s)
Copy time	: 3 s (max. 100 s)

Determination of colorless phenol compounds

50 ml samples of grapes molasses to be analyzed were taken and concentrated under vacuum. Then, 25 ml ethyl ether and 25 ml ethyl acetate were added to concentrated sample and made of liquid-liquid extraction. After that, obtained extracts were mixed, concentrated and injected into the HPLC (Kelebek, 2009). These analyses were done on the samples of the final product of grape molasses. These samples

belonged to red, black and white grapes and numbered as 11, 12, 23, 24, 35, and 36.

HPLC operating conditions are as follows:

Instrument	: Beckman Ultrasphere C ₁₈ ODS (250×4.6 mm×5 μ)
Software	: Shimadzu, Class-VP
Enjection volume	: 20 μl
Colon	: Nucleodur 100–5 C18 (250×4.6 mm, 5 micron)
Mobile phase	: A=Water / Acetic acid (95/5: h/h) B=Methyl alcohol / Acetic acid (95/5: h/h)
Flow rate	: 1 ml/minute
Detector	: Shimadzu SPD-M10Avp
Wave lengths	: 280 nm, 320 and 360 nm
Oven temperature	: 40 °C

Statistical analysis

In study, statistical analysis of data was performed by using SPSS, which is a software package to evaluate the trials. Duncan test ($P<0.05$) was applied at multiple comparisons. Trial pattern has been set in the form of (3×7×2).

Results and discussion

The results of physical and chemical analyses on red, black and white grape molasses that were produced by using the traditional methods, and samples that were taken during the process stages, are given as follows (Table 1).

Some physical and chemical properties of grapes molasses belonging to the red grapes were summarized in Table 1. Accordingly, the results showed differences depending on the stages of processing grape molasses. While pH value varied between 7.46 and 7.82, total acidity value ranged from

1.250 to 0.531 percent. Antioxidant activity increased depends on the viscosity of grape molasses. Protein rate was changed between 0.44 and 0.30 percent. The value of viscosity (mPa.s) was reached the max value at the final product process. HMF (mg/kg) values of grape molasses were varied depend on the effect of heat treatment. Min HMF value was determined at the must stage in which there was no heat treatment. Total phenolic substance (mg/L) was varied between 2.943 and 2.447. Water-soluble dry matter rate was raised from the must stage towards to the final product stage due to the increase in the concentration by the effect of heat treatment. Partly increasing of pH is probably due to soil added to decrease acidity of grape juice. Thus, total acidity value changed depending on added soil.

Results of color analysis of red grape molasses are given in Table 2. Accordingly, L* brightness values (0–100) varied between 43.21 and 70.94. While, a* (+ red, – green) value change between –1.69 and 18.59, b* (+ yellow, – blue) value varied between 5.20 and 41.66. At values, differences in grape molasses were occurred by the effect of time of grounding and boiling. Mineral values (mg/kg) of red grape molasses are given in Table 3. When the stages of processing red grape molasses examined for the presence of Molybdenum, it could not be identified. In the last stage of grape molasses, this amount was found 1.162 mg/kg. The presence of Calcium could not be identified at the stages of must and prior to the grounding. But after grounding stage, this amount continuously increased. Calcium was probably found in grape molasses due to including calcium of white soil that was thrown into the molasses. Boron was found 6.653 mg/kg in must and 24.380 mg/kg at the stage of final grape molasses in red grapes molasses. Chrome was found 13.781 mg/kg in must and 33.991 mg/kg at the stage of final grape molasses. The amount of Copper and Selenium were found less than the amount of the other elements in red grape molasses. Iron was found 44.432 mg/kg in must and 132.130 mg/kg at the stage of final grape molasses. Potassium and magnesium contents were found 125.450 mg/kg in must, and 42.076 mg/kg at the stage

Table 1 Some physicochemical properties of red grape molasses that are produced by using the traditional methods ($n:3$)

Stage of process	Protein (%)	HMF (mg/kg)	Antioxidant activity (%)	Water-soluble dry matter (%)	pH	Viscosity (mPa.s)	Total acidity (%)	Total Phenol (mg/L)
Must	0.44±0.08*	0.48±0.05	12.17±0.19	14.7±0.09	7.46	10.05±0.12	1.25±0.09	2.94±0.11
Prior to the grounding	0.27±0.03	1.10±0.03	19.17±0.58	18.5±1.12	6.39	2.25±0.34	1.53±0.04	5.06±0.28
After grounding	0.26±0.01	1.01±0.06	26.56±0.89	18.5±1.28	8.68	21.55±0.89	0.22±0.03	7.59±0.32
1st hour boiling	0.23±0.04	1.92±0.08	37.38±0.73	27.0±1.29	8.36	10.60±0.79	0.27±0.02	9.26±0.41
2nd hour boiling	0.24±0.02	2.02±0.03	48.52±0.78	35.0±0.98	8.15	17.10±0.45	0.32±0.05	8.31±0.56
3rd hour boiling	0.24±0.01	4.70±0.07	81.27±0.49	47.5±0.99	7.81	31.05±0.89	0.45±0.01	16.26±1.28
Final grape molasses	0.30±0.07	3.31±0.01	93.40±0.51	64.8±1.13	7.82	82.40±0.56	0.53±0.07	20.450.78
Average	0.28±0.06	2.08±0.04	45.49±0.38	32.3±0.78	7.81	25.00±0.17	0.65±0.05	9.98±0.09

*mean±standard deviation

Table 2 Results of color analysis of red grape molasses, which are produced by using the traditional methods (*n*:3)

Stages of process	L*	a*	b*
Must	61.48±1.67 ^a	1.06	12.92±0.19
Prior to the grounding	64.51±1.46	0.01	10.81±0.27
After grounding	70.94±1.67	−0.83	5.20±0.09
1st hour boiling	64.56±1.78	−1.69	10.31±0.17
2nd hour boiling	61.80±0.68	−1.08	28.70±0.21
3rd hour boiling	58.59±1.89	−0.08	30.50±0.36
Final grape molasses	43.21±1.03	18.59	41.66±0.41
Average	60.72±1.45	2.28	20.01±0.11

^a mean±standard deviation

of final grape molasses. After grounding, these values were increased to 2998.687 mg/kg and 123.881 mg/kg, respectively. The amount of Potassium and magnesium contents increased due to the increase in the concentration by the effect of grounding. The mineral amount of Manganese and sodium were increased from the must stage towards to the final product stage due to the increase in the concentration, and the values had respectively 8.063 mg/kg to 248.860 mg/kg. Also, the amount of Nickel was found 18.616 mg/kg in red grape molasses. The content of Phosphor was found 492.430 mg/kg. The amount of zinc mineral in the red grape molasses were increased due to the increase in the concentration depends on the stages of process. In red grape molasses, the highest value in terms of mineral content was potassium mineral.

Some physical and chemical properties of black grape molasses are presented in Table 4. The values showed differences depending on the stages of process of grape molasses. While pH value change between 5.44 and 9.04, total acidity value varied between 0.108 and 1.278 %. Antioxidant activity raised depend on the viscosity of grape molasses and reached to 86.44 % at the final product of grape molasses. Protein rate was changed between 0.23 and 0.59 %. The amount of protein in the must was at max value, but it is decreased timely by the effect of heat. The value of viscosity (mPa.s) reached the max

value at the final product process. HMF (mg/kg) values of grape molasses varied depend on the effect of heat treatment. Min HMF value was determined at the must stage in which there was no heat treatment. Total phenolic substance (mg/L) varied between 2.943 and 2.447. Water-soluble dry matter rate raised from the must stage towards to the final product stage due to the increase in the concentration by the effect of heat treatment, and this rate was found 67.00 %.

Results of color analysis of black grape molasses are given in Table 5. L* brightness value (0–100) varied between 54.43 and 68.23. While, a* (+ red, − green) value range between 0.58 and 8.12, b* (+ yellow, − blue) value varied between 5.80 and 47.47. At values, increasing and decreasing were occurred by the effect of time of grounding and boiling.

İnan et al. (2011) studied on effects of heat treatment on physicochemical characteristics and sensory properties of different fruit juice concentrates (pekmez). Apricot pekmez had the highest viscosity followed by mulberry and date pekmez. Apricot and date pekmez had higher scores for odour, taste and consistency than others. 5-Hydroxymethyl furfural concentration of all grape pekmez samples increased after heat treatments. Samples heated at 75 °C showed highest L* values while at 65 °C the lowest mean L* values. L* values of all pekmez samples were found similar while carob Pekmez had higher L* values. Also a development of the Fuzzy Expert System (FES) was made for prediction (İnan et al. 2011).

Mineral matter values (mg/kg) of black grape molasses were given in Table 6. When the stages of processing black grape molasses examined for the presence of Molybdenum, it could not be identified at must and final product stages. The presence of Calcium mineral could not be identified at the stages of must. In the last stage of grape molasses, this amount was found 1.555 mg/kg. Boron mineral was found 3.942 mg/kg in must and 11.806 mg/kg at the stage of final grape molasses in black grapes molasses. Chrome mineral was found 13.566 mg/kg in must and 14.294 mg/kg at the stage of final grape molasses. The amount of Zinc was found less than the amount of the other elements in black grape molasses. Also, the amount of Copper mineral was found

Table 3 Mineral matter content of red grape molasses that are produced by using the traditional methods (mg/Kg)

Stages of Process	Mo	Ca	B	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Se	Zn
Must	0.000	0.000	6.653	13.781	0.605	44.432	125.450	42.076	0.953	146.034	6.698	126.223	4.207	0.061
Prior to the grounding	1.329	0.000	9.429	35.203	1.143	112.335	887.948	93.103	2.605	158.502	21.007	202.407	12.410	0.726
After grounding	1.524	227.614	10.764	37.941	1.069	128.244	2998.687	123.881	4.581	169.031	21.816	186.026	6.995	0.732
1st hour boiling	1.427	959.388	15.872	36.362	1.156	126.113	4401.357	179.152	5.333	177.101	20.821	277.080	4.189	0.944
2nd hour boiling	1.252	1637.961	17.268	33.745	1.093	124.903	5718.787	223.018	6.293	187.868	18.968	331.235	7.386	1.079
3rd hour boiling	1.231	1123.620	21.773	31.958	1.254	123.358	7953.226	290.952	7.478	190.201	17.478	449.066	7.909	1.475
Final grape molasses	1.162	1491.654	24.386	33.991	1.621	132.130	9581.336	332.327	8.063	248.860	18.616	492.430	2.038	6.416
Average	1.132	777.177	15.163	31.854	1.134	113.073	4523.827	183.501	5.043	182.514	17.915	294.924	6.447	1.633

Table 4 Some physicochemical properties of black grape molasses that are produced by using the traditional methods (*n*:3)

Stages of Process	Protein (%)	HMF (mg/kg)	Antioxidant activity (%)	Water-soluble dry matter (%)	pH	Viscosity (mPa.s)	Total acidity (%)	Total Phenol (mg/L)
Must	0.59±0.07*	0.28±0.09	23.48±1.24	12.50±0.98	5.44	10.30±0.23	0.97±0.08	3.52±0.34
Prior to the grounding	0.28±0.01	8.45±0.26	40.40±1.28	12.50±0.89	7.45	9.25±0.08	1.28±0.09	8.15±0.89
After grounding	0.23±0.03	2.78±0.07	42.67±0.98	16.00±0.09	9.04	10.70±0.17	0.15±0.02	6.68±0.67
1st hour boiling	0.25±0.04	2.26±0.08	63.56±1.45	23.00±0.11	8.98	6.60±0.21	0.11±0.01	7.84±0.47
2nd hour boiling	0.25±0.01	8.59±0.11	82.19±2.47	36.50±0.34	8.78	12.45±0.44	0.19±0.03	15.16±1.47
3rd hour boiling	0.29±0.06	4.32±0.08	81.23±3.17	58.00±1.26	8.32	31.70±0.34	0.39±0.06	22.12±0.32
Final grape molasses	0.26±0.02	5.28±0.06	86.44±2.56	67.00±1.54	8.35	91.75±0.54	0.48±0.03	25.81±0.38
Average	0.31±0.08	4.57±0.03	59.99±1.67	32.21±0.78	8.05	24.68±1.67	0.51±0.06	12.75±0.69

*mean±standard deviation

16.530 mg/kg. Fe mineral was found 43.952 mg/kg in must and 53.420 mg/kg at the stage of final grape molasses. Potassium mineral was found 154.565 mg/kg in must stage, and after grounding this value reached to level of 1891.594 mg/kg. The amount of Potassium mineral was increased due to the increase in the concentration by the effect of grounding. The mineral amount of Manganese and Sodium was found equivalently in black grape molasses. The amount of Nickel mineral was found 7.111 mg/kg in black grape molasses. The content of Phosphor mineral was found 306.584 mg/kg. In black grape molasses, the highest value in terms of mineral content was potassium mineral.

Some physical and chemical properties of white grape molasses are given in Table 7. Accordingly, values, which are given at the table, was showed change depending on the stages of process of grape molasses. While pH value was varied between 5.19 and 8.73, total acidity value was varied between 0.144 and 1.360 percent. Antioxidant activity was raised depends on the viscosity of grape molasses and reached to 92.83 percent at the final product of grape molasses. Protein rate was changed between 0.19 and 0.45 percent. The amount of protein in the must was at the max value, but it was decreased timely by the effect of heat. The value of viscosity

(mPa.s) was reached the max value at the final product process. HMF (mg/kg) values of grape molasses were varied depend on the effect of heat treatment. Total phenolic substance (mg/L) was found between 3.225 and 24.188 depend on the increase in concentration. Water-soluble dry matter rate was raised from the must stage towards to the final product stage due to the increase in the concentration by the effect of heat treatment, and this rate was found 61.50 percent.

Results of color analysis of white grape molasses are given in Table 8. L* brightness value (0–100) was varied between 37.47 and 72.57. While, a* (+ red, – green) value change between 1.19 and 18.69, b* (+ yellow, – blue) value varied between 6.14 and 34.94. At values, increasing and decreasing were occurred by the effect of time of grounding and boiling. Mineral values (mg/kg) of white grape molasses are given in Table 9. When the stages of processing white grape molasses examined for the presence of Molybdenum, it could not be identified at must and final product stages. But after grounding stage, it was found 38.925 mg/kg and this amount was continued to increase. Calcium was found in grape molasses due to including calcium of white soil that was thrown into the molasses. Boron was found between 3.942 mg/kg in must and 11.806 mg/kg at the stage of final grape molasses in white grapes molasses. Chrome was found 13.566 mg/kg in must and 14.294 mg/kg at the stage of final grape molasses. The amount of Copper and Zinc were found less than the amount of the other elements in white grape molasses. Fe mineral was found 40.834 mg/kg in must and 49.528 mg/kg at the stage of final grape molasses. Potassium was found between 96.866 mg/kg in must stage, and after grounding this value was reached to level of 341.379 mg/kg. The amount of Potassium increased due to the increase in the concentration by the effect of grounding. The Manganese and sodium were found equivalently in white grape molasses. The amount of Nickel was found as 7.027 mg/kg in white grape molasses. The amount of Magnesium was found 39.035 mg/kg in must, and 195.988 mg/kg at the stage of final grape molasses. The amount of Potassium was found as 192.442 mg/kg at the last

Table 5 Results of color analysis of black grape molasses, which are produced by using the traditional methods (*n*:3)

Stages of process	L*	a*	b*
Must	66.30±1.67*	1.00	18.89±0.89
Prior to the grounding	63.39±2.34	−0.30	11.25±1.07
After grounding	68.23±1.89	−0.58	5.80±0.67
1st hour boiling	54.43±1.72	3.01	15.46±0.78
2nd hour boiling	56.66±2.89	3.37	17.52±0.67
3rd hour boiling	56.75±1.78	0.91	37.29±2.67
Final grape molasses	55.29±1.87	8.12	47.47±1.89
Average	60.15±1.59	2.22	21.95±1.78

*mean±standard deviation

Table 6 Mineral matter content of black grape molasses that are produced by using the traditional methods

Stages of process	Mo	Ca	B	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Se	Zn
Must	0.000	0.000	3.942	13.566	0.513	43.952	154.565	40.975	1.001	144.981	6.512	103.220	6.661	0.088
Prior to the grounding	0.864	120.355	4.640	28.968	1.283	93.539	1448.809	86.666	2.707	162.891	15.947	105.371	10.121	0.496
After grounding	0.330	170.344	3.226	19.821	0.912	67.813	1891.594	83.054	2.890	147.041	10.202	70.575	5.953	0.149
1st hour boiling	0.000	0.000	5.079	13.174	5.003	42.931	924.692	66.352	1.964	148.907	6.293	90.753	5.474	0.265
2nd hour boiling	0.000	9.904	7.536	13.006	6.109	45.552	1063.883	105.567	2.774	144.180	6.578	157.914	3.935	0.330
3rd hour boiling	0.024	15.696	11.163	14.895	13.783	53.622	2028.525	186.329	3.946	152.638	7.099	286.776	4.602	1.546
Final grape molasses	0.000	1.555	11.806	14.294	16.530	53.420	1811.792	187.340	4.004	153.141	7.111	306.584	4.873	1.273
Average	0.174	45.408	6.770	16.818	6.304	57.261	1331.980	108.040	2.755	150.540	8.534	160.170	5.945	0.592

stage of white grape molasses process. Sodium was found as 132.618 mg/kg in must and as 153.618 mg/kg at the stage of final grape molasses in white grapes molasses. (Kamal et al. 1985) reported that grape seeds were found to contain significant levels of Ca, Mg, P and K.

The results (mg/100 g) of colorless phenolic compounds, which are taken at the stage of final process of grape molasses that are produce by the traditional methods and are belonging to red, black and white grapes are given in Table 10. White grape molasses has the highest value in terms of amount of catechin and epicatechin acids. Red grape molasses has the highest value in terms of amount of procatechic and trans-cutaric acids. If we compare, white grape molasses has the highest value in terms of amount of Gallic and trans-caftaric acids.

The results (mg/100 g) of analysis of anthocyanins, which are taken at the stage of final process of grape molasses that are produced by the traditional methods and are belonging to red and black grapes. Red grape molasses has the highest value (mg/L) in terms of amount of anthocyanins. The content of anthocyanins is given to be Malvidin-3-glikozit.

Statistical evaluations of grape molasses produced in the traditional ways are analyzed and given averages in two ways. Averages, which are given horizontally, are averages of the results that were found by grape type. Averages, which are

given vertically, are the results that were found at the stages of process. The sections that are specified as 1, 2, 3, 4, 5, 6, 7, in table descriptions represent the stages of the process. Expansion of these expressions are to be specified respectively as must, prior to the grounding, after grounding, 1st hour boiling, 2nd hour boiling, 3rd hour boiling and final grape molasses. The letters placed at the right side of the values represent the statistical evaluations of Duncan test of each type of grape in their own process stages; the letters placed at the left side represent the statistical evaluations of Duncan test of each type of grape in their own process stages from over the average values at table. It could be reported that the same types of situations were happened in the black and white grapes. There is no difference for stages, which are numbered as 4, 5, 6 and 7, of red grape molasses. The rate of acidity is different at the stages of 5 and 6 in black and white grapes. According to results of variance analysis, the factors of grape, process and grape x process are important at level of $p < 0.01$ on the rate of total acidity and there is interaction. At the beginning, the pH was around 3.5 and it was raised to the desired level of 5.0–6.0 as fit for purpose (Batu and Gök, 2006). There is no difference between the average pH values of red, black and white grape molasses. When the pH values of process stages are examined, there is a difference between 1 and 2. There is no difference between 3, 4 and 5. Also, there is

Table 7 Some physicochemical properties of white grape molasses that are produced by using the traditional methods ($n:3$)

Stages of process	Protein (%)	HMF (mg/kg)	Antioxidant activity (%)	Water-soluble dry matter (%)	pH	Viscosity mPa.s	Total acidity (%)	Total Phenol (mg/L)
Must	0.45±0.03*	2.02±0.12	30.69±1.27	13.50±0.48	5.19	2.24±0.07	1.36±0.13	3.23±0.17
Prior to the grounding	0.19±0.07	10.56±0.49	37.83±1.87	14.50±0.58	7.74	2.10±0.04	1.71±0.12	4.55±0.04
After grounding	0.23±0.05	2.83±0.53	36.19±2.11	14.50±0.68	8.29	7.13±0.09	0.17±0.09	4.64±0.67
1st hour boiling	0.23±0.01	4.61±0.09	50.42±1.78	16.00±0.56	8.58	10.05±1.02	0.14±0.03	7.11±0.51
2nd hour boiling	0.27±0.06	1.39±0.08	72.96±2.31	23.50±0.09	8.73	13.94±1.32	0.18±0.01	8.36±0.98
3rd hour boiling	0.36±0.06	5.71±0.11	92.60±2.87	45.00±0.39	8.14	23.85±2.67	0.56±0.06	17.47±0.04
Final grape molasses	0.42±0.02	6.34±0.36	92.83±2.98	61.50±1.36	8.11	65.60±1.71	0.59±0.09	24.18±0.17
Average	0.31±0.08	4.78±0.14	59.07±1.67	26.93±0.67	7.82	17.84±0.89	0.67±0.11	9.94±0.09

*mean±standard deviation

Table 8 Results of color analysis of white grape molasses, which are produced by using the traditional methods ($n:3$)

Stages of process	L*	a*	b*
Must	41.85±1.12*	6.24	21.86±0.12
Prior to the grounding	66.02±1.39	−0.44	11.77±0.23
After grounding	69.31±1.27	−0.56	6.14±0.29
1st hour boiling	65.61±1.13	−0.60	12.48±0.79
2nd hour boiling	72.57±2.29	−1.19	17.19±0.11
3rd hour boiling	48.67±0.47	4.45	28.67±0.21
Final grape molasses	37.47±0.56	18.69	34.94±0.39
Average	57.35±1.09	3.80	19.01±0.32

*mean±standard deviation

no difference between 6 and 7. pH values were raised after adding white soil into grape must due to the neutralization of more acidity. According to results of variance analysis, the factor of process is important at level of $p<0.01$ on the rate of pH value and there is interaction.

When water-soluble dry matter values are examined, water-soluble dry matter values were stayed at the same level at the stages of 1, 2, and 3, but at the other stages a rising was measured due the effect of the heat treatment. A rising in the value of water-soluble dry matter was started to rise significantly from the 5th stage at the stages of black grape molasses. But, this value was started to rise significantly from the 6th stage at the stages of white grape molasses. According to results of variance analysis, the factors of grape and process are important at level of $p<0.01$ on the rate of water-soluble dry matter and there is interaction. There is no difference between the average viscosity values of red, black and white grape molasses. When the viscosity values of process stages are examined, there is no difference between the stages of 1, 2, 3, 4, 5, and 6. Viscosity value has reached the max value at the last stage that is numbered as 7, in all types of grapes molasses. According to results of variance analysis, the factor of process is important at level of $p<0.01$ on the rate of viscosity values of grape molasses and there is interaction. When the average value of antioxidant activity of grape molasses

belonged to red, black and white grape is examined, it is found that there is no difference in black and white grape molasses. If the average value of antioxidant activity is examined, it is found that there is a difference between 1 and 2 stages, and also there is a difference between the stages of 3, 4, 5, and 6. The value of antioxidant activity was raised constantly from the first stage (must) towards to the last stage (Final grape molasses) in red grape molasses. But, values of antioxidant activity were showed a fluctuation in black and white grape molasses. According to results of variance analysis, the factors of grape and process are important at level of $p<0.01$, and the factor of process x grape is important at level of $p<0.05$ on the antioxidant activity values of grape molasses and there is interaction.

When the average value of protein of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average value of protein is examined, it is found that there is a difference between 1 and 2 stages, but there is no difference between the stages of 2, 3, 4, and 6. The value of protein was varied from the first stage (must) towards to the last stage (Final grape molasses) in red, black and white grape molasses. According to results of variance analysis, the factor of process is important at level of $p<0.01$ on the protein values of grape molasses and there is interaction. When the average value of HMF of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average values of HMF that are measured at the all stages are examined, there is no difference between the process stages. The value of 5-HMF was varied from the first stage (must) towards to the last stage (Final grape molasses) in red, black and white grape molasses. According to results of variance analysis, the factors of grape, process and grape x process are important on the HMF values of grape molasses and there is no interaction. When the average value of total phenolic matter content of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average values of total phenolic matter content that are

Table 9 Mineral matter content of white grape molasses that are produced by using the traditional methods

Stages of Process	Mo	Ca	B	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Se	Zn
Must	0.000	0.000	2.835	12.817	0.677	40.834	96.866	39.035	0.960	132.618	6.526	113.745	5.568	0.581
Prior to the grounding	0.000	0.000	2.872	12.095	0.613	38.969	122.206	37.419	0.911	129.381	6.087	107.882	8.054	0.560
After grounding	0.000	38.925	3.127	13.497	0.370	45.055	341.379	50.347	1.884	138.334	6.876	94.960	9.613	0.499
1st hour boiling	0.008	107.049	4.012	13.652	0.337	45.802	423.353	59.290	2.323	147.614	6.757	107.340	7.915	0.473
2nd hour boiling	0.000	151.135	4.066	13.801	0.374	46.679	566.714	79.546	2.361	147.996	6.821	105.472	5.533	0.387
3rd hour boiling	0.000	1097.688	9.399	14.141	0.751	58.076	1216.712	157.187	3.801	154.463	7.230	207.614	3.167	1.049
Final grape molasses	0.000	940.013	11.567	13.597	0.647	49.528	1899.354	195.988	4.116	153.731	7.027	192.442	4.238	1.560
Average	0.001	333.544	5.411	13.371	0.538	46.420	666.655	88.401	2.336	143.448	6.760	132.779	6.298	0.730

Table 10 Colorless phenolic compounds, which are taken at the stage of final process of grape molasses that are produced by using the traditional (mg/100 g) ($n:3$)

	Black		Red		White	
	Average	Standard	Average	Standard	Average	Standard
Catechin	54.8±1.56*	0.57±0.03	59.5±1.21	0.5±0.1	67.9±2.36	0.28±0.03
Epicatechin	23.1±0.78	0.14±0.01	34.5±0.78	0.4±0.1	44.7±1.27	0.42±0.06
B1	93.7±2.89	0.30±0.07	61.2±0.98	0.1±0.01	117.4±4.56	0.42±0.02
B2	27.5±1.09	0.21±0.03	32.7±0.17	0.04±0.01	49.1±1.12	0.35±0.03
Total	199.1	1.220.11	187.6	1.03	279.1	1.48
Gallic acid	12.5±0.12	0.04±0.01	12.2±0.57	0.04±0.01	13.1±1.12	0.04±0.01
Protocatechic acid	2.2±0.3	0.02±0.01	2.6±0.3	0.02±0.01	0.56±0.09	0.04±0.01
Trans-caftaric acid	49.5±1.17	0.01±0.001	5.7±0.7	0.04±0.01	65.5±1.67	12.3±0.67
Trans-cutaric Acid	18.1±0.45	0.03±0.01	24.9±1.28	0.03±0.01	12.0±0.08	3.5±0.56
Total	82.3	0.11	45.5	0.12	91.2	15.9

*mean±standard deviation

measured at the all stages are examined, there is no difference between the process stages of 1, 2, 3, 4, and 5, but there is a difference between the stages of 6 and 7. Black grape molasses has the highest value in terms of total phenolic matter content. According to results of variance analysis, the factors of grape and process are important at level of $p<0.01$ on the total fenolic matter content of grape molasses and there is interaction. When the average value of L^* brightness (0–100) of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average values L^* brightness that are measured at the all stages are examined, there is no difference between the process stages. Black grape molasses has the max value in terms of L^* brightness value. According to results of variance analysis, the factor of process is important at level of $p<0.01$ on the L^* brightness value of grape molasses and there is interaction. When the average value of a^* (+ red, – green) color of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average values of a^* (+ red, – green) color that are measured at the all stages are examined, there is no difference at 1–6 stages of the process. White grape molasses has the max value that is closest the red in terms of a^* (+ red, – green) color value. According to results of variance analysis, the factor of process is important at level of $p<0.01$ on a^* (+ red, – green) color value of grape molasses and there is interaction. When the average value of b^* (+ yellow, – blue) color of grape molasses belonged to red, black and white grape is examined, it is found that there is no difference in red, black and white grape molasses. If the average values of b^* (+ yellow, – blue) color that are measured at the all stages are examined, there is a difference at the stages of 1 and 2. There is no difference at the stages of 2, 3 and 4. There is a difference at the stages of 5, 6, and 7. The results obtained were not close to blue in terms of b^* (+ yellow, – blue) color value. According to results of variance analysis, the factor of process is important at level of

$p<0.01$ on b^* (+ yellow, – blue) color value of grape molasses and there is interaction.

Conclusion

In our study, when obtained grape molasses samples were analyzed in terms of total acidity (%) value, total acidity of the final product was found to be 0.531 % for the red grape molasses, 0.477 % for the black grape molasses, 0.585 % for the white grape molasses. When the samples of grape molasses were analyzed in terms of pH value, the pH value was found to be 7.82 for the red grape molasses, 8.35 for the black grape molasses and 8.11 for the white grape molasses. When the samples of grape molasses were analyzed in terms of water-soluble dry matter value, the water-soluble dry matter value was found to be 64.75 for the red grapes molasses, 67.00 for the black grape molasses and 61.50 for the white grape molasses. When the samples of grape molasses were analyzed in terms of viscosity value, the viscosity was found to be 82.4 mPa.s for the red grape molasses, 91.75 mPa.s for the black grape molasses and 65.6 mPa.s for the white grape molasses. When the samples of grape molasses were analyzed in terms of 5-HMF value, the 5-HMF value was found to be 3.312 mg/kg for the red grape molasses, 5.280 mg/kg for the black grape molasses and 6.336 mg/kg for the white grape molasses. When the samples of grape molasses were analyzed in terms of antioxidant activity value, the antioxidant activity value was found to be 93.395 for the red grapes molasses, 86.437 for the black grape molasses and 92.833 for the white grape molasses. When the samples of grape molasses were analyzed in terms of content of phenolic matter value, the content of phenolic matter value was found to be 20.447 mg/L for the red grape molasses, 25.813 mg/L for the black grape molasses and 24.188 mg/L for the white grape molasses. When the samples of grape molasses were analyzed in terms of L^* value, a^* value and b^* value, the L^* value was found to

be 43.21 for the red grape molasses, 55.29 for the black grape molasses and 37.47 for the white grape molasses, the a^* values were found to be respectively 18.59, 8.12, 18.69 and the b^* values were found to be respectively 41.66, 47.47, 34.94.

When the samples of grape molasses were analyzed in terms of content of colorless phenolic matter value, the amount of catechin was found to be 59.45 mg/100 g, epicatechin 34.25 mg/100 g, B1 dimer 61.20 mg/100 g, B2 dimer 32.68 mg/100 g, Gallic acid 12.18 mg/100 g, protocatechic acid 2.62 mg/100 g, trans-caftaric acid 5.72 mg/100 g, trans-cutaric 24.98 mg/100 g for the red grape molasses. The amount of catechin was found to be 54.80 mg/100 g, epicatechin 23.10 mg/100 g, B1 dimer 93.66 mg/100 g, B2 dimer 27.50 mg/100 g, Gallic acid 12.46 mg/100 g, protocatechic acid 2.19 mg/100 g, trans-caftaric acid 49.51 mg/100 g, trans-cutaric 18.10 mg/100 g for the black grape molasses. The amount of catechin was found to be 67.90 mg/100 g, epicatechin 44.70 mg/100 g, B1 dimer 117.40 mg/100 g, B2 dimer 49.10 mg/100 g, Gallic acid 13.12 mg/100 g, protocatechic acid 0.56 mg/100 g, trans-caftaric acid 65.53 mg/100 g, trans-cutaric 12.01 mg/100 g for the white grape molasses.

When the samples of grape molasses were analyzed in terms of content of anthocyanins, the content of Malvidin-3-glikozit value was found to be 64.75 mg/L for the red grape molasses, 54.25 mg/L for the black grape molasses. 5-HMF values of our study values were found lower, but when we compare pH values, our results were found higher. The reason for this might be different duration of action of using white soil amount during the grounding. The results of protein values were compatible. When we evaluated results of mineral analyses, Ca, Mg, P, and Fe minerals are compatible. But in our study, result of Na values was found lower for the red, black and white grapes. The result of Cu value was found lower for the red and white grape molasses, but was found higher for the black grape molasses. Our result for Zn was compatible for the red grape molasses, but the results for the black and white grape molasses were found lower. In our study, values were found for Sn. We might say that the structure of soil and types of grapes were the reasons of differences in mineral values. 5-HMF value was found to be higher in our study. Gunbali molasses values are lower than our values due not to a direct flame treatment process. But, when we compared to the rate of protein, the values were found higher than ours. We could assume that the differences are the effect of grape types and process effect.

It was compatible by the water soluble dry matter content for black grape molasses, but it was found at low level for red and white grape molasses. When it is analyzed in terms of pH values, the pH values in our study were higher. If we compare these results, L^* values were found higher in our study. a^* and b^* values were found higher in our study. When we compared the results, our values were found low for the value of L^* , but

a^* and b^* values were found higher. If we examine our study in terms of content of Fe and Zn; the amount of Fe was found 132.130 mg/kg for the red grape molasses, 53.420 mg/kg for the black grape molasses and 49.528 mg/kg for the white grape molasses. The amount of Zn was found 6.416 mg/kg for the red grape molasses, 1.273 mg/kg for the black grape molasses, and 1.560 mg/kg for the white grape molasses. In terms of pH value, the pH value was found higher in our study. The results were suitable in terms of total acidity.

We could say that the factors of element content of soils in which grapes grown, types of grapes, the effect of process stages, chemical composition of soil added into grape must, and the amount of soil are the reason for having different values of mineral analyses.

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References

- Alpaslan M, Hayta M (2002) Rheological and sensory properties of pekmez (grape molasses) / tahin (sesame paste) blends. *J Food Eng* 54:89–93
- AOAC (1984) Official methods of analysis. Association of official analytical chemists, 14 thth edn. Association of Official Analytical Chemists, Arlington, VA, USA
- AOAC (1995) Association of Official Analytical Chemists. Official Methods of Analysis, 16th Edition. Edited by Patricia Cunniff. Virginia, USA
- Batu A, Gök V (2006) Pekmez üretiminde HACCP Uygulaması. *Gıda*, 3: 1–18
- Bozkurt H, Göğüş F, Eren S (1999) Nonenzymatic browning reactions in boiled grape juice and its models during storage. *Food Chem* 64:89–93
- Bradford M (1976) A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal Biochem* 72:248–254
- Demiröz B, Sökmen M, Uçak A, Yılmaz H, Gülderen S (2002) Variation of copper, iron and zinc levels in pekmez products. *Bull Environ Contam Toxicol* 69:330–334
- Gyamfi MA, Yonamine M, Aniya Y (1999) Free radical scavenging action of medical herbs from Ghane: *Thonningia sanguinea* on experimentally-induced liver injuries. *Gen Pharmacol* 32(6): 661–667
- İnan Ö, Arslan D, Taşdemir Ş, Özcan MM (2011) Application of fuzzy expert system approach on prediction of some quality characteristics of grape juice concentrate (Pekmez) after different heat treatments. *J Food Sci Technol* 48:423–431
- Kamal BS, Dawson H, Kakuda Y (1985) Characteristics and composition of melon and grape seed oils and cake. *J Am Oil Chem Soc* 62(5): 881–883
- Karakaya M, Artık N (1990) Zile hard grape pekmez production technology and determination of its components (Zile pekmezi üretim tekniği ve bileşim unsurlarının belirlenmesi). *Gıda* 15(3):151–154
- Kayışoğlu S, Demirci M (2006) Effects of storage time and condition on mineral contents of grape pekmez produced by vacuum and classical methods. *J Tekirdağ Agric Fac* 3(1):1–7
- Kelebek H (2009) Değişik Bölgelerde Yetiştirilen Öküzgözü, Boğazkere ve Kalecik Karası Üzümlerinin ve Bu Üzümlerden Elde Edilen

- Şarapların Fenol Bileşikleri Profili Üzerinde Araştırmalar. Çukurova Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği Anabilim Dalı Doktora Tezi. Adana s 259
- Matsuda AH, Sabato SF (2004) Effect of irradiation on Brazilian honeys' consistency and their acceptability. *Rad Physics Chem* 71:107–110
- Ribereau-Gayon P, Dubourdieu D, Doneche B, Lanvoud A (2000) *Handbook of Enology, Volume 1: The Microbiology of Wine and Vinification*. John Wiley and Sons Ltd., England
- Rommel A, Heatherbell DA, Wrolstad RE (1990) Red raspberry juice and wine: Effect of processing and storage on anthocyanin pigment composition, colour and appearance. *J Food Sci* 55:1011–1017
- Şengül M, Ertugay MF, Şengül M (2005) Rheological, physical and chemical characteristics of mulberry pekmez. *Food Control* 16:73–76
- Skujins S (1998) *Handbook for ICP-AES (Vartian-Vista). A Short Guide to Vista Series ICP-AES Operation*. Variant Int. AG, Zug version 1.0 Switzerland.
- Topçu AA, Besler HT, Yurttagül M (1997) Pekmez (Grape juice molasses) mineral contents. *Food Technol* 2:46–49
- Vasquez Roncero A, Janer Del Valle C, Janer Del Valle ML (1973) Determinacion de los polifenoles totales del aceite de oliva. *Grasas Aceites* 24(6):350–357
- Yoğurtçu H, Kamışlı F (2006) Determination of rheological properties of some pekmez samples in Turkey. *J Food Eng* 77:1064–1068
- Zappala M, Fallico B, Arena E, Verzera A (2005) Methods for the determination of HMF in honey: a comparison. *Food Control* 16(3):273–277