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Research on Chemical Composition of Some Varieties of European Plums (*Prunus domestica*) Adapted to the Aegean District of Turkey

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The physical characteristics and chemical composition of 11 plum varieties adapted to the Aegean region of Turkey at Ege Agricultural Research Institute, Izmir, were investigated. Variety Giant had the most fruit weight within all the plum varieties and it was followed by Krikon Damson, Tuleu Timpuriu, and Baneasa 3/5. Mean chemical compositions for all varieties were as follows: moisture, 837.4 g kg^{-1}; soluble solids, 155.5 g kg^{-1}; titratable acidity, 15.1 g kg^{-1}; soluble solids to titratable acidity ratio, 12.6; total sugar, 96.5 g kg^{-1}; total sugar to acidity ratio, 7.59; reducing sugar, 51.9 g kg^{-1}; sucrose, 42.4 g kg^{-1}; ascorbic acid, 157.9 mg kg^{-1}; protein, 7.5 g kg^{-1}; ash, 5.5 g kg^{-1}; sodium 161.53 mg kg^{-1}; potassium, 2228.12 mg kg^{-1}; calcium, 25.47 mg kg^{-1}; iron, 4.70 mg kg^{-1}; pH 3.46. Imperial Epineuse was the most suitable variety for drying. Grand Prize had the highest ascorbic acid content.

Keywords: *European plums; Prunus domestica; Chemical composition; Physical characteristics*

INTRODUCTION

European plums (*Prunus domestica*) have potential as a fresh market and processing crop. About one-half of the plums produced in the world are consumed freshly while the rest are processed. The major processed European plum products are whole canned plums, prunes, prune juice, paste, sauce, juice concentrates, and prune bits (Chang et al., 1994).

Turkey is the tenth country in plum production in the world. Plum ranks third in total production of stone fruits in Turkey. The annual production of plum in Turkey is 188 000 tons (Anon., 1990). The varieties of plum produced in Turkey are *Prunus domestica*, *Prunus cerasifera*, *Prunus institia*, *Prunus spinosa*, *Prunus divericata*, and *Prunus salicina* (Özçağıran, 1976). Aegean district is the region where plum is produced mostly in Turkey (Anonymous, 1989).

The plum adaptation program at Ege Agricultural Research Institute (EARI) has released 14 European-type plum (*P. domestica*) varieties since 1986 which have the highest scores in total of yield, average fruit weight, attractiveness, soluble solids, flavor of fresh fruit, stone adhesion, and percentage of stone (Özakman et al., 1994).

Blaha (1981) studied chemical compositions of 40 local varieties of *P. domestica* grown in central Moravia and reported that the plums showed a composition of 87.9% total extract, 43.8% invert sugar based on dry matter (DM), 6.3% sucrose (DM), 7.0% titratable acidity (DM), 2.3% ash (DM), and 28.6 mg % vitamin C. Cociu (1993) reported that the characteristics of the major commercial cultivars of *P. domestica* developed in Romania.

Although studies in relation to pomological characteristics of these adapted varieties have been done, no research has reported on the chemical compositions of these plum varieties adapted to the Aegean district of Turkey. The main objective of this study was to investigate the physical characteristics and chemical composition of the eleven plum varieties adapted by EARI.

MATERIALS AND METHODS

Plums were obtained from Ege Agricultural Research Institute, Izmir. The fruits were harvested when they reached to color maturity of each variety according to Özakman et al. (1994). Harvest of plums were made in July and August (Table 1). Between 43 and 101 fruits were hand-picked from all sides of seven trees which were seven years old for each cultivar. The samples were immediately transported to the laboratory and stored at 0−4 °C. The samples were analyzed within seven days after harvest.

Average weight of fruit was determined by weighing. The fruits were cut in half, and the stones were removed and weighed. The stone ratio was calculated by dividing the stone weight by the fruit weight. About 400 g of fruit flesh (8−10 fruits) was blended in a Waring model mechanical blender, and three homogenates were prepared. For the analysis, aliquots from each of the homogenates were used. Each analysis was made induplicate.

All analyses were done on the edible portion of plum fruit. Moisture content was determined by oven-drying at 105 °C. Total nitrogen content (N) was determined using the standard Kjeldahl method (AOAC, 1990). Crude protein was expressed as 6.25 × N. Ash content was determined by incineration of the sample in a muffle furnace at 550 °C. Total and invert sugar were estimated by the Lane−Eynon volumetric method. Sucrose content was calculated by subtracting the reducing sugar content from the total sugar content and multiplying the result by 0.95. Soluble solids (SS) were determined with a 2WAJ refractometer on a filtered aliquot of the puree. Titratable acidity (*A*), as malic acid, was determined by titration to pH 8.1 with N/10 NaOH. pH value was measured using a WTW pH 537 digital pH meter. Ascorbic acid content was estimated spectrophotometrically by xylene extraction of 2,6-dichlorophenolindophenol dye. The concentrations of sodium, potassium, and calcium were determined using a flame emission photometer (Jenway PFP 7 model). Lanthanum chloride was added to all samples and calibration solutions to

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Table 1. Harvest Date and Physical Characteristics of Plum Varieties

variety	harvest date	fruit weight[a] (g)	stone weight[b] (g)	stone ratio (%)
Baneasa 3/5	July 11	43.22 ± 6.54	1.83 ± 0.23	4.22
S. Frühzwetche	July 11	34.78 ± 5.77	1.64 ± 0.21	4.72
Tuleu Timpuriu	July 11	43.26 ± 6.71	1.48 ± 0.18	3.42
Baneasa 9/13	July 11	40.45 ± 6.51	1.73 ± 0.29	4.28
Prune 2740	August 10	41.33 ± 7.45	1.96 ± 0.44	4.00
Grand Prize	August 10	40.21 ± 8.85	1.56 ± 0.17	3.88
Krikon Damson	August 31	45.95 ± 9.49	1.37 ± 0.26	2.98
Giant	August 31	49.96 ± 9.40	1.35 ± 0.29	2.70
Imperial Epineuse	August 31	40.07 ± 6.67	1.15 ± 0.20	2.87
Victoria	August 31	40.31 ± 6.48	1.31 ± 0.23	3.26
Stanley	August 31	38.28 ± 6.50	1.86 ± 0.24	4.85
mean		41.62	1.57	3.74

[a] Average value of 40 determinations ± SD. [b] Average value of 25 determinations ± SD.

Table 2. Chemical Characteristics of Plum Varieties[a]

variety	moisture (g kg^{-1})	soluble solids (g kg^{-1})	titratable acidity (g kg^{-1})	SS/A	protein (g kg^{-1})	pH	ascorbic acid (mg kg^{-1})
Baneasa 3/5	863.5 ± 0.6	128.4 ± 0.00	12.8 ± 0.10	10.03 ± 0.08	7.2 ± 0.25	3.35 ± 0.03	71.7 ± 0.00
S. Fruhzwetche	856.6 ± 2.6	141.7 ± 0.20	18.6 ± 0.20	7.62 ± 0.24	10.9 ± 0.06	3.62 ± 0.08	116.3 ± 1.65
T. Timpuriu	867.0 ± 0.7	125.3 ± 1.23	22.0 ± 0.08	5.70 ± 0.08	7.6 ± 0.24	3.35 ± 0.01	96.6 ± 0.00
Baneasa 9/13	898.5 ± 0.9	93.9 ± 0.00	10.4 ± 0.08	9.03 ± 0.07	8.5 ± 0.03	3.20 ± 0.01	132.4 ± 5.51
Prune 2740	844.3 ± 1.6						
G. Prize	860.4 ± 0.8	130.0 ± 0.85	23.4 ± 0.05	5.56 ± 0.05	6.3 ± 0.07	3.30 ± 0.01	284.2 ± 4.65
K. Damson	806.8 ± 0.9	191.9 ± 0.47	9.8 ± 0.08	19.58 ± 0.21	6.7 ± 0.03	3.38 ± 0.01	165.1 ± 1.30
Giant	820.6 ± 0.9	174.6 ± 0.70	22.3 ± 0.05	7.83 ± 0.01	5.9 ± 0.01	3.32 ± 0.01	227.9 ± 7.15
I. Epineuse	745.2 ± 0.7	244.5 ± 0.00	9.2 ± 0.00	26.58 ± 0.24	8.5 ± 0.43	4.00 ± 0.05	58.2 ± 2.60
Victoria	814.6 ± 0.1	166.2 ± 0.12	10.1 ± 0.00	16.46 ± 0.01	6.9 ± 0.01	3.28 ± 0.01	192.6 ± 0.00
Stanley	834.1 ± 0.1	158.6 ± 0.00	12.0 ± 0.05	13.22 ± 0.05	6.4 ± 0.02	3.80 ± 0.01	234.3 ± 7.55
mean	837.4	155.5	15.1	12.16	7.5	3.46	157.9

[a] Average value of three determinations ± SD.

Table 3. Sugar Contents and Sugar/Acid Ratios of Plum Varieties[a]

variety	total sugar (g kg^{-1})	reducing sugar (g kg^{-1})	sucrose (g kg^{-1})	sugar/acid
Baneasa 3/5	94.5 ± 0.54	75.0 ± 0.45	18.7 ± 0.26	7.40 ± 0.8
S. Frühzwetce	84.0 ± 0.12	42.1 ± 0.21	39.8 ± 0.08	4.52 ± 0.5
T. Timpuriu	89.1 ± 0.12	50.1 ± 0.08	37.1 ± 0.12	4.05 ± 0.2
Baneasa 9/13	64.0 ± 0.41	56.0 ± 0.29	7.6 ± 0.12	6.15 ± 0.7
Prune 2740	86.9 ± 0.37	37.6 ± 0.16	46.8 ± 0.20	
G. Prize	82.1 ± 0.90	53.4 ± 0.53	27.3 ± 0.33	3.51 ± 0.5
K. Damson	117.6 ± 0.16	52.1 ± 0.22	62.2 ± 0.08	12.0 ± 0.1
Giant	103.6 ± 0.69	39.8 ± 0.16	60.6 ± 0.53	4.65 ± 0.5
I. Epineuse	147.4 ± 0.21	56.6 ± 0.24	86.3 ± 0.05	16.02 ± 0.2
Victoria	98.3 ± 0.21	48.2 ± 0.33	47.6 ± 0.28	9.73 ± 0.2
Stanley	93.9 ± 0.12	59.8 ± 0.51	32.4 ± 0.40	7.83 ± 0.1
mean	96.5	51.9	42.4	7.59

[a] Average value of three determinations ± SD.

prevent interference in the calcium analysis. Iron was determined by flame atomic absorption spectrophotometer (Pye Unicam model SP 8).

RESULTS AND DISCUSSION

The physical and chemical characteristics of plum varieties adapted to the Aegean district of Turkey at EARI in Izmir are shown in Tables 1−4. The moisture of the varieties averaged 837.4 g kg^{-1}, ranging from 745.2 to 898.5 g kg^{-1} (Table 2). These results are in good agreement with the values reported by Forni et al. (1992). Imperial Epineuse had the lowest moisture content, which is reflected in its high drying quality. Imperial Epineuse and Krikon Damson had the highest soluble solid contents, respectively (Table 2). The SS contents of the plums examined were significantly lower than the SS contents reported by Scott et al. (1993) except Imperial Epineuse. Their values were 208−241 g kg^{-1}. Robertson et al. (1992) reported that the threshold values of SS for acceptable quality was 125 g kg^{-1} for plums. The titratable acidity of the varieties averaged 15.1 g kg^{-1}, ranging from 9.2 to 23.4 g kg^{-1} (Table 2). Titratable acidity of stone fruits generally was expressed as malic acid. Acidity of peach was 4.0−9.8 g kg^{-1} (Schobinger, 1978). The results showed that the titratable acidity of the plum varieties was two to three times greater than the acidity of peaches. It was reported that the SS/A ratio in European plums (*P. domestica*) should be between 12 and 24 (Robertson et al., 1992). In the present study, the highest ratio obtained was 26.58 for Imperial Epineuse. Krikon Damson, Victoria, Stanley, and Baneasa 3/5 had ratios between 12 and 24, and other varieties had ratios lower than ten. pH values of the plum varieties ranged between 3.20 and 4.00. Koyuncu and Aşkın (1993) reported that the plums grown in Van, Turkey, had pH values between 3.00 and 3.78. The results obtained in this study are in accordance with the values above except for the varieties Imperial Epineuse and Stanley. Their pH values were higher than the values reported above. This may originate in the difference in variety characteristics. The plum varieties contained low pro-

Table 4. Ash Content and Mineral Distribution of Plum Varieties[a]

variety	ash (g kg/$^{-1}$)	sodium (mg kg^{-1})	potassium (mg kg^{-1})	calcium (mg kg^{-1})	iron (mg kg^{-1})
Baneasa 3/5	3.7 ± 0.37	105.77 ± 1.28	2870.80 ± 26.37	41.49 ± 1.64	3.45 ± 0.63
S. Frühzwetche	6.3 ± 0.87	94.81 ± 2.96	2463.43 ± 1.08	27.17 ± 1.44	2.85 ± 0.06
T. Timpuriu	5.1 ± 0.24	84.21 ± 3.87	1934.80 ± 1.04	18.43 ± 1.46	4.94 ± 0.29
Baneasa 9/13	5.3 ± 0.08	110.86 ± 0.78	2129.44 ± 2.04	19.81 ± 0.23	5.15 ± 0.12
Prune 2740	6.3 ± 0.17	213.23 ± 0.79	1613.87 ± 5.95	40.07 ± 1.32	6.72 ± 0.07
G. Prize	4.9 ± 0.05	139.45 ± 4.22	1601.74 ± 58.55	32.23 ± 0.45	2.27 ± 0.32
K. Damson	4.9 ± 0.25	174.51 ± 7.23	1738.03 ± 78.24	20.24 ± 0.89	3.53 ± 0.01
Giant	4.3 ± 0.08	190.14 ± 1.28	2563.96 ± 53.79	23.69 ± 0.65	1.15 ± 0.01
I. Epineuse	9.0 ± 0.50	261.81 ± 7.78	3135.42 ± 55.59	18.08 ± 1.20	7.06 ± 0.10
Victoria	4.6 ± 0.39	202.79 ± 0.09	2268.99 ± 14.88	18.15 ± 1.30	5.15 ± 0.10
Stanley	6.0 ± 0.45	199.22 ± 0.01	2177.95 ± 48.03	18.73 ± 0.72	9.43 ± 0.18
mean	5.5	161.53	2228.12	25.47	4.70

[a] Average value of three determinations ± SD.

tein (5.9−10.9 g kg^{-1}). These results are in good agreement with the values reported by Brand et al. (1983) and Schobinger (1978).

In the present study the ascorbic acid content of plum varieties ranged from 58.2 to 284.2 mg kg^{-1}. Different values in ascorbic acid were reported among the plum varieties. Cociu (1993) reported that Tuleu Timpuriu contained 120−150 mg kg^{-1} vitamin C. It was also reported that the amount of ascorbic acid of the European plums varied between 20 and 286 mg kg^{-1} (Blaha 1981; Katıyar, 1990). Bush plum (*Santalum lanceolatum*) and green plum (*Terminalia ferdinandiana*) grown in Australia contained 164 and 31 500 mg kg^{-1} vitamin C, respectively (Brand et al., 1983). The results are similar to the values reported by Blaha (1981) and Katıyar (1990), while it is lower than green plums reported by Brand et al. (1983). In general the ascorbic acid content of stone fruits ranges between 105 and 206 mg kg^{-1}. For example, apricot, peach, white cherry, and morello cherry contained 105, 131, 113, and 132 mg kg^{-1} ascorbic acid, respectively (Tomasevic and Naumovic, 1974). We can conclude that the plum varieties have higher amounts of ascorbic acid than the other stone fruits above. The RDA for vitamin C is 60 mg for healthy adults (Tolonen, 1990). Our findings indicate that plum varieties could contribute partially to the overall daily dietary intake of vitamin C.

Total sugar, invert sugar, and sucrose contents of the varieties are shown in Table 3. Imperial Epineuse and Krikon Damson had the highest total sugar and sucrose contents, and Baneasa 3/5 had the highest invert sugar contents. The sugar/acid (S/A) ratio of the plum varieties ranged between 3.51 and 16.02. Forni et al. (1992) reported that the S/A ratio, for good quality plums, should be between 12 and 24. In the present study the highest ratio obtained was 16.02 for Imperial Epineuse and 12.00 for Krikon Damson, and the others had ratios lower than 10. This may be due to the differences in varieties and geographical factors.

Ash contents of the plum varieties are in agreement with the values reported by Schobinger (1978) and Katiyar (1990). A comparison of the mineral content of the varieties with literature values indicates that the major differences are in the amounts of calcium. The variety Baneasa 3/5 contained 41.49 mg kg^{-1} calcium and Imperial Epineuse had the lowest value in calcium (18.06 mg kg^{-1}). Schobinger (1978) reported the calcium in plums varied from 100 to 180 mg kg^{-1}. In general our findings in all plum varieties were lower than the reported values by Schobinger (1978). This may be due to differences in varieties and to environmental factors. The plum varieties contained high potassium (average 2228.12 mg kg^{-1}). This result is in accordance with the values reported by Cemeroğlu (1982). However, a difference was found in sodium contents. Cemeroğlu (1982) and Katıyar (1990) reported that the average sodium content of *P. domestica* is 20 and 200 mg kg^{-1}, respectively. As seen in Table 4 the sodium content of all plum varieties was found to be higher. This may be due to the characteristics of the varieties. Iron contents of the varieties averaged 4.7 mg kg^{-1}, ranging from 1.15 to 9.43 mg kg^{-1} (Table 4). Cemeroğlu (1982) and Katiyar (1990) reported that the plums (*P. domestica*) contained 4−360 mg kg^{-1} iron, respectively. This may be due to differences in varieties and geographical factors.

The results showed that the varieties Imperial Epineuse and Krikon Damson were more suitable for drying than the others because of lower moisture content and higher soluble solids and total sugar. Baneasa 9/13, Tuleu Timpuriu, and Baneasa 3/5 were considered less suitable for canning than the other varieties because of lower soluble solids.

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