Fruit Physical and Chemical Characters in Twelve European and Japanese Plum Genotypes during Two Harvesting Years

P.D. Drogoudi and G. Pantelidis
Pomology Institute
National Agricultural Research Foundation
PO Box 122, 59200 Naoussa
Greece

A. Papachatzis[a]
Technological Educational Institute (TEI)
of Larissa
Department of Plant Production
41110 Larissa
Greece

Keywords: antioxidant capacity, ascorbic acid, fruit quality, harvest year, phenolics, *Prunus domestica*, *Prunus salicina*

Abstract

The aims of the present study were to evaluate the effects of genetic and environmental factors on the phenolic content and antioxidant capacity in plum and prune genotypes; knowledge that can be utilized by breeding programs and health concerned consumers. Measurements of fruit fresh weight, skin and flesh color, total antioxidant capacity, using the radical DPPH, total phenolic, ascorbic acid, and total soluble and acid contents were made in 8 European and 4 Japanese cultivars. Measurements of antioxidant compounds were made during two harvesting years. The ascorbic acid content varied between 2.6 and 10.5 mg 100 g^{-1} FW in 2005, and considerable variation was found in the total phenolic content and antioxidant capacity in 2004 (0.9-3.5 mg g^{-1} DW and 3.4-17.5 mg g^{-1} DW, respectively), and 2005 (1.1-7.2 mg g^{-1} DW and 3.8-18.7 mg g^{-1} DW, respectively). Our results revealed a great genetic diversity among genotypes in terms of their fruit antioxidant contents, with cultivars 'Valor' and 'Reine Claude' being the most prominent. There were no significant correlations found between fruit physical and chemical characters. The similarity among cultivars was examined using a principal component analyses.

INTRODUCTION

Plums and prunes contain phenolic compounds, which are known to have a clear role to combat degenerating diseases, increase the fruit storability and resistance to post harvest diseases, probably due to their anti-oxidative activities. The aims of the present study were to a) describe the variability in the concentration of bioactive compounds in the fruit of different plum and prune genotypes, b) study the effects of harvesting year on the content of antioxidant compounds, and c) find whether there are associations between the plum harvest quality characteristics and antioxidant content.

MATERIALS AND METHODS

Fruit was harvested at commercial maturity from 8 European and 4 Japanese cultivars maintained in a collection orchard at the Pomology Institute, Naoussa, Greece (40°37'13.40"N; 22°06'59.80"E, at 119 m elevation). The trees were 14 year old, planted in 5 x 4 m distance in a randomized block design of four trees per genotype in two replicate trees per block. Two trees per cultivar were used and ten fruits were collected from each experimental tree. Upon harvest the fruit fresh weight and the flesh and skin CIELAB L* (brightness or lightness; 0= black, 100= white), a^* ($-a^*$= greenness, $+a^*$= redness) and b* ($-b^*$= blueness, $+b^*$= yellowness) color variables were measured using the chromatometer Minolta (Minolta, Ramsey, NJ). Flesh color was measured after removing with a knife 1 cm depth of the fruit's cheek and skin color was measured on the fruit surface (ground skin color). Soluble solids content (SSC) and total acidity (TA) were analysed in juice from six fruit using a digital refractometer (model PR-1, Atago, Japan), and TA by titration with 0.1 N NaOH and expressed as citric acid content (g 100 ml^{-1}).

[a] papachad@teilar.gr

Eight replicate fruits were rinsed with water, dried using tissue paper and stored at -20°C for chemical analyses. For the antioxidant activity and total phenolics assays flesh samples from five replicate stored fruit were removed using a sharp knife, immediately lyophilized, homogenized using a pestle and mortar and stored at -20°C. For the ascorbic acid assay, samples were readily extracted from the remaining three replicate frozen fruit.

Total antioxidant capacity was measured spectrophotometrically at 517 nm using the stable 1, 1-diphenyl-2-picryl hydrazyl (DPPH) free radical, as described by Drogoudi and Tsipouridis (2007). Total soluble phenolics were determined with the Folin-Ciocalteu reagent and results were expressed as mg gallic acid 100 g^{-1} DW. Ascorbic acid content was measured using the reflectometer Merck RQflex following the manufacture's instructions. All analyses were made in triplicate.

Data were subject to one- or two-way analysis of variance and LSD values were calculated in cases that significant at $P \leq 0.05$ variance was found among cultivars. Correlation and principal component analysis (PCA) analyses were performed. Statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, Illinois, USA).

RESULTS AND DISCUSSION

The cultivars 'Valor' and 'Angeleno' (mean 76.7 g) produced the largest fruit, whereas the smallest fruit were found in the rootstock 'Feher Besztercei' (20.0 g) and the prune 'Čačanska Rodna' (29.6 g) (Table 1). Fruit skin color varied from deep purple ('President') to yellow ('Washington'). Fruit flesh color varied from red ('Calita') to yellow ('Laroda'). Greatest values of SSC were found in 'President' and 'Valor', compared to the rest studied cultivars.

The fruits of 'Valor', followed by 'Reine Claude', contained the greatest total phenolic content (5.2 and 4.2 mg g^{-1} DW, respectively, means of two years) and total antioxidant capacity (17.8 and 11.4 mg dsc g^{-1} DW, respectively), which were up to 3.7 and 4.6 times greater, respectively, compared to the rest cultivars (Fig. 1). Values of total phenolic content were similar to those reported by Gil et al. (2002), and lower than Rupasinghe et al. (2006). The highest contents of ascorbic acid were found in cultivars 'Valor' and 'Laroda' (mean of 10.1 mg 100^{-1} g FW), which was up to 3.9 times greater, compared to the rest cultivars.

Values of total phenolic content and total antioxidant capacity were usually lower in 2004, compared to 2005. In 2004 the mean 24-h temperature from May to August was 1.1°C lower, compared to 2005 (24.4°C and 25.3°C, respectively).

Correlation analyses showed that total phenolic content was highly correlated with total antioxidant capacity (r=0.812), which suggests that phenolic compounds greatly contribute to the total antioxidant capacity. Similar results were reported for other plum cultivars (Gil et al., 2002). Total ascorbic content was also positively correlated with total antioxidant capacity (r=0.882). There was little relationship between fruit fresh weight or color parameters and chemical characteristics (data not shown).

PCA was applied to mean values of measured traits in order to study which parameters contributed mostly to the total data variation (Table 2). The PCA carried out produced five components accounting for 37.8, 16.8, 13.7, 11.8 and 8.9% of variance, respectively. The most important variables integrated in the first component PC1 were total antioxidant capacity, total phenol content and flesh L, while negative correlations had the skin L.

The similarity among cultivars was examined when each sample was plotted using the first and second PC components, which retained 54.4% of the total variance (Fig. 2). Positive values for PC1 indicate cultivars with higher antioxidant capacity, ascorbic acid content and flesh L ('Valor' and 'Laroda'). Positive values in PC2 indicate cultivars with lower skin b values ('Washington', 'Reine Claude' and 'Angeleno').

CONCLUSIONS

Relatively high antioxidant contents were found in cultivar 'Valor', which was also previously reported to have very good pomological traits by Blažek et al. (2004).

Antioxidant contents were usually higher in 2005, compared to 2004, which coincided with warmer summer months.

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Tables

Table 1. Mean values of fruit fresh weight (FW) (g), color parameters L^*, a^* and b^* in fruit flesh and skin, total soluble solid (TSS) (%) and total acid (TA) (g citric acid L^{-1}) contents of 8 plum and 4 prune cultivars.

			Flesh			Skin				
		FW	L^*	a^*	b^*	L^*	a^*	b^*	TSS	TA
Prunus domestica	'Anna Späth' Pitesti	44.2	51.9	-3.6	26.3	39.9	14.2	-12.1	16.6	7.3
	'Čačanska rodna'	29.6	55.1	-6.3	24.4	33.8	12.7	-2.5	14.9	7.3
	'Fehér besztercei'	20.0	45.0	4.7	22.9	65.4	-1.7	12.4	14.2	6.9
	'President'	59.3	54.0	5.6	29.3	43.9	11.8	-23.3	18.6	8.0
	'Reine Claude'	73.4	53.6	-2.8	13.7	33.0	17.0	-2.8	11.7	12.8
	'Tuleu gras'	42.3	46.0	-3.8	23.2	35.1	16.0	-4.4	15.4	8.9
	'Valor'	76.8	53.1	2.2	23.4	36.1	8.6	-16.1	18.5	12.0
	'Washington'	60.9	47.7	1.4	19.2	55.0	-8.4	21.8	13.5	10.0
P. salicina	'Angeleno'	76.5	62.3	1.5	12.4	32.3	5.2	-13.5	12.4	7.2
	'Calita'	71.2	50.4	5.4	26.7	28.4	10.7	-9.0	12.0	10.0
	'Florentia'	63.9	58.2	4.4	30.0	31.2	22.7	-3.9	13.7	12.6
	'Laroda'	60.0	60.6	4.2	32.8	27.9	12.1	-8.6	14.5	11.5

Table 2. Characters with factor loadings and explained cumulated proportion of variation.

Characters	PC 1 (37.8)	PC 2 (16.6)
Fruit fresh weight	0.685	0.377
Skin –L	-0.786	0.131
Skin –a*	0.575	-0.463
Skin –b*	-0.665	0.558
Flesh –L	0.706	-0.058
Flesh –a*	0.069	-0.053
Flesh –b*	0.101	-0.772
Total phenolics	0.671	0.236
Antioxidant capacity	0.811	0.298
Ascorbic acid	0.841	0.089
Total soluble solids	0.131	-0.642
Total acids	0.574	0.371

Figures

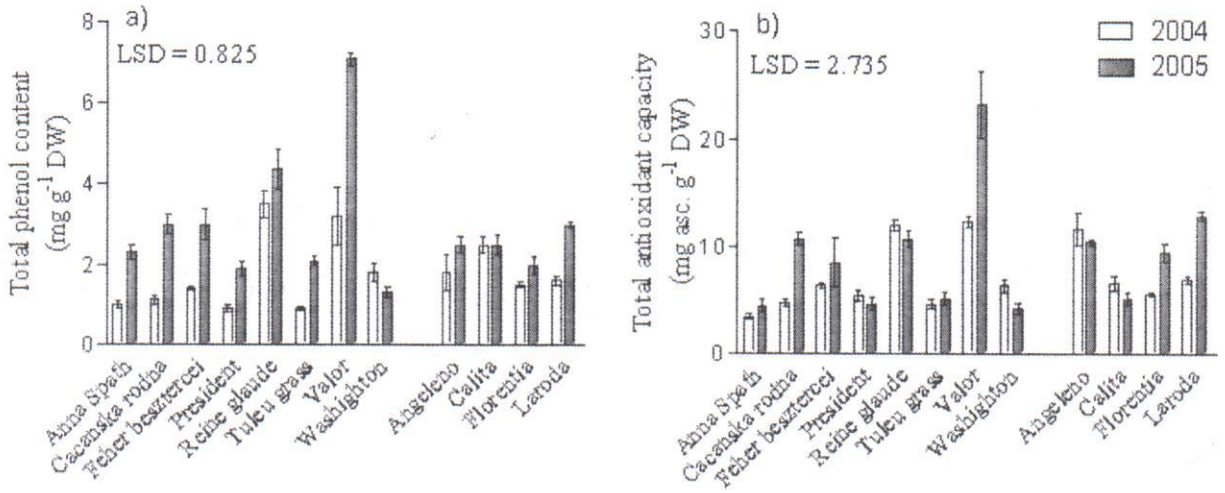

Fig. 1. Total phenol content (a) and total antioxidant capacity (b) in flesh tissue of 8 European and 4 Japanese cultivars, during 2004 and 2005.

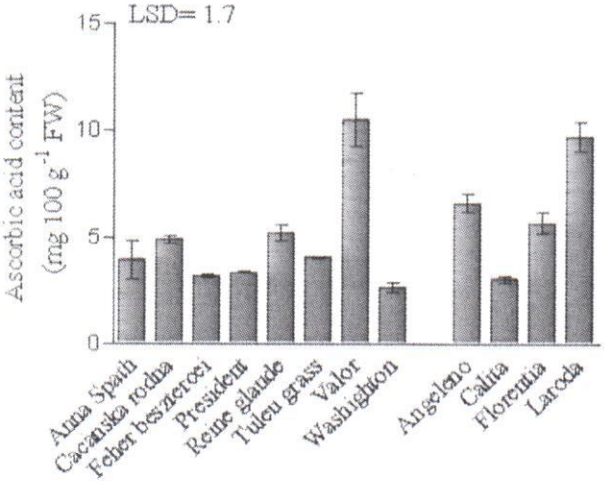

Fig. 2. Ascorbic acid content in flesh of 8 European and 4 Japanese cultivars, during 2005.

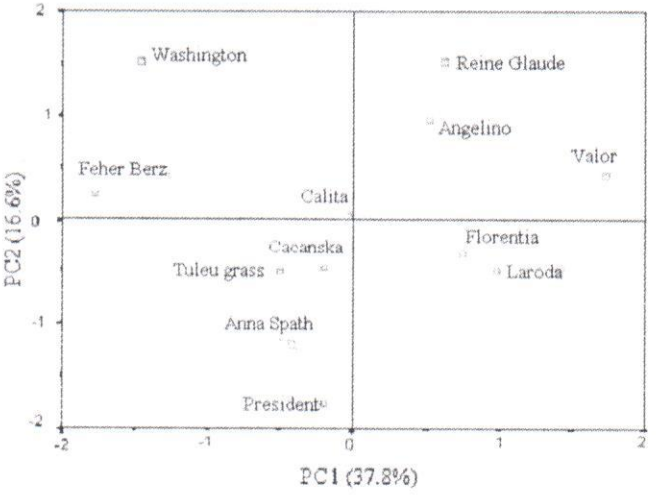

Fig. 3. Segregation of 12 plum and prune cultivars according to their quality characteristics determined by PCA.