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ORGANIC ACID, PHENOLIC CONTENT, AND ANTIOXIDANT CAPACITY OF FRUIT FLESH AND SEED OF *Viburnum opulus*

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Viburnum opulus L., belonging to the plant family of Caprifoliaceae, is known as "gilaburu" in Turkey and "Guelder rose" in Europe. Fruits and fruit juice of *V. opulus* began to be sold in the markets of Turkey recently. Due to the lack of information in the literature, major organic acids, antioxidant capacity, total phenolic content (TPC), total flavonoid content (TFC), and total anthocyanin content (TAC) as well as some chemical characteristics, including pH, total titratable acidity (TTA), moisture, ash, and oil content of *V. opulus* fruit flesh and seed were determined. The chemical characteristics of samples are listed in Table 1.

Four organic acids in fruit flesh and two organic acids in seed were detected and quantified (Table 2). The predominant organic acids in fruit flesh and seed were found as malic (86% of total acids) and oxalic (68% of total acids), respectively. The sum of all quantified acids in fruit flesh and seed were 1.25 g/100 g and 0.82 g/100 g, respectively.

TPC, TFC, TAC, EC_{50}, and ARP values of samples are given in Table 3. Average total phenolic content in *V.opulus* fruit flesh and seed was 355.59 and 1231.03 mg GAE/100 g FW, respectively. The seed showed about 4 times higher phenolic content compared with fruit flesh. Generally, total phenolic content and antioxidant capacities of fruit seeds were higher than edible portions of fruits. Similar results were reported for tamarind, avocado, jackfruit, longan, and mango (**1**) and grape seed and grape skin (**2**). Average total flavonoid content in fruit flesh and seed was 151.70 and 1032.39 mg CE/100 g fresh weight, respectively. These results clearly show that the phenolic content of seed is mainly composed of flavonoids.

EC_{50} and ARP are widely used parameters to express the antioxidant capacity [3]. The higher the antioxidant capacity, the lower the EC_{50}. Average EC_{50} values of fruit seed and fruit flesh were found 2.35 mg /mg DPPH· and 24.56 mg/mg DPPH·, respectively. The antioxidant capacity of *V. opulus* fruit seed was higher than fruit flesh, which is attributable to the amount of phenolic content of fruit seed. The antioxidant capacity of seed was about 10 times higher than fruit flesh, where the total phenolic content of fruit seed was about 4 times higher than fruit flesh. The nonlinear increment in the antioxidant capacity of fruit seed may be due to a proportionally high amount of flavonoids. The proportion of total flavonoids to total phenolics (TFC/TPC) was 0.426 for fruit flesh and 0.838 for seed.

In conclusion, fruit seeds have not generally received much attention as antioxidant sources. This may be due to their lack of popularity and commercial applications. Our study shows that the seed of *V. opulus* is a good source of antioxidants, especially flavonoids, TPC, and TFC, and the antioxidant capacity of seed is significantly higher than that of fruit flesh. Owing to these properties, future studies can be extended to exploit them (especially seed) for their possible application as natural antioxidant for functional food products. Because of cheap raw material, fruit flesh of *V. opulus* can be used in making mixed fruit juices.

Samples and Sample Preparation. *V. opulus* fruits were harvested after full maturation from Kayseri city (Turkey) at the end of September 2005. Fruits (about 20 kg) were washed with water and stored at –25°C until analyzed. All analysis were performed with *V. opulus* fruit flesh and seed. The seeds were sieved (280 μm mesh) to obtain a uniform particle size and stored at –40°C until analyzed. Fruit flesh was prepared just before the experiments.

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TABLE 1. Chemical Characteristics of *V. opulus* Fruit Fresh and Seed

V. opulus	pH	TTA[a]	Moisture	Oil[b]	Ash
Fruit flesh	2.95	1712.85	89.16	1.92	0.38
Seed	5.19	194.59	9.31	13.88	1.68

[a]TTA (mg/100 g fresh weight) is given as malic acid equivalent for fruit fresh, oxalic acid equivalent for seed; [b]dry weight basis.

TABLE 2. Organic Acid Composition of *V. opulus* Fruit Fresh and Fruit Seed (mg/100 g)

V. opulus	Organic acids			
	Oxalic	Malic	Ascorbic	Citric
Fruit flesh	80.5±2.4	1082.6±10.5	52.7±1.1	38.6±0.9
Seed	562.9±23.8	261.5±9.7	N.d.	N.d.

TABLE 3. TPC, TFC, TAC, and Antioxidant Capacity of *V. opulus* (1 - fruit flesh and 2 - seed)

V. opulus	TPC[a]	TFC[b]	TAC[c]	EC_{50}[d]	ARP[e]
1	355.59±3.72	151.70±1.64	11.27±1.12	24.56±2.38	0.041
2	1231.03±8.93	1032.39±2.26	N.d.	2.35±0.56	0.425

[a]mg gallic acid equivalent per 100 g of sample; [b]mg catechin equivalent per 100 g of sample; [c]mg cyanidin 3-glucoside equivalent per 100 g of sample; [d]mg sample per mg DPPH·; [e]antiradical power: $1/EC_{50}$.

Determination of Chemical Characteristics, Organic Acids, TPC, TFC,TAC, and Antioxidant Capacity. The pH, total soluble solids, total titratable acidity, ash, and oil and moisture content were determined according to the standard methods [4]. Organic acids were determined by a Hewlett-Packard 1050 series HPLC apparatus [5], and the other analyses, TPC [6], TFC [7], TAC [8], *in vitro* antioxidant capacity [9], were determined by a Cary-50 UV-vis. spectrophotometer. Chemical characteristics were run in duplicate and results averaged. The other analysis were performed at least in triplicate, and results were given as mean and standard deviation.

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