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Anthocyanidins of *Sarracenia* L. Flowers and Leaves

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The pitcher plant, *Sarracenia* L., is becoming an important potted plant, and several breeding programs are creating interspecific hybrids with improved leaf and flower colors (Gardner, 2000). Three different types of pigments - chlorophyll, flavonoids, and carotenoids — are responsible for flower and leaf color (Griesbach, 1984). The red flowers and leaves of *Sarracenia* are due to flavonoid pigments, which can be subdivided into the anthocyanins and co-pigments. In vitro, the anthocyanins are colored red through blue, while the co-pigments appear white through pale yellow.

Romeo et al. (1977) identified the co-pigments kaempferol and quercetin in the leaves of S. *alata* Wood, S. *flava* L., S. *Ieucophylla* Raf., S. *minor Walt., S. oreophila* (Kearney) Wherry, S. *psittacina* Mich., S. *purpurea* L., and S. *rubra Walt.* Unidentified leucoanthocyanidins occur in the leaves of S. *flava, S. Ieucophylla, S. minor, S. psittacina,* and S. *purpurea* (Jay and Lebreton, 1972). Further studies (Schnell, 1978), using thin layer chromatography, found seven red and six blue anthocyanins in the petals of S. *Ieucophylla, S. rubra, S. psittacina,* and S. *purpurea.* Based upon additional biochemical data, the existence of pelargonidin and cyanidin was predicted (Sheridan and Mills, 1998).

We obtained leaf and flower samples of S.*flava, S. Ieucophylla, S. psittacina, S. purpurea,* and S. *rubra* from several different geographic sites. The anthocyanins were isolated by high-performance liquid chromotagraphy (HPLC) as previously described (Griesbach, et al., 1999). The isolated anthocyanins were acid-hydrolyzed to release the corresponding anthocyanidins, which were then analyzed by HPLC and characterized by diagnostic spectrophotometry as previously described (Griesbach, 1999).

The anthocyanins from the various species were compared by co-elution on HPLC. The HPLC profiles for the different accessions of the same species were identical. *Sarracenia purpurea* contained all of the anthocyanins that were found in the other species. Because of the ready availability of *S. purpurea* leaves and flowers, the anthocyanins were characterized using pigments isolated from this species (Table 1).

Cyanidin was the only anthocyanidin found in leaves of all the species examined, and was also the only one present in the petals of S. *rubra* and S. *Ieucophylla* (Table 2). Both cyanidin and delphinidin were found in petals of S. *psittacina* and S. *purpurea* (Table 2). A large quantity (44%) of delphinidin was present in S. *purpurea* petals, while a smaller quantity (11%) was present in S. p*sitticina. Sarracenia flava* has yellow flowers and contained no anthocyanidins. Romeo et al. (1977) reported that quercetin glycosides were the principal flavonols present in *Sarracenia.* In the biochemical pathway, dihydroquercetin is a precursor of both quercetin and cyanidin. Therefore, we expected to find cyanidin as the principal anthocyanidin in *Sarracenia* leaves and flowers. Romeo et al. (1977) found a small amount of kaempferol in *Sarracenia,* but we did not detect pelargonidin, which is derived from dihydrokaempferol. This also was not unexpected because many *Petunia x hybrida* Hort. Vilm. cultivars contain small amounts of kaempferol and produce no pelargonidin (Griesbach and Asen, 1990; Griesbach et al.,1991).

The discovery of delphinidin was not unexpected since Schnell (1978) had reported the presence of blue pigments in S. *psittacina* and S. *purpurea.* This current study identifies those blue pigments as delphinidin glycosides. Schnell, using TLC analysis, reported the presence of 13 different floral pigments. Our HPLC profiles of the floral anthocyanins of S. *rubra* and S. *Ieucophylla* before hydrolysis showed only a single anthocyanin peak (data not shown). In S. *purpurea* and S. *psitticina,* five different anthocyanin peaks were present, two of which were present in only trace amounts (data not shown). Many of the 13 pigments reported by Schnell were probably breakdown products. Further studies are needed to identify the sugar(s) attached to the two major anthocyanidins.

Table 1. Retention time on HPLC and spectral properties of purified standards and the anthocyanidins extracted from *Sarracenia purpurea* flowers in the HPLC profile of S. *purpurea,* peak #I corresponded to delphinidin and peak #2 to cyanidin.

Anthocyanidin	Time (min)	λ max (nm)	E_{440}/E_{max} (%)	Al Shift (+/-)
Pelargonidin	14	520	39	-
Cyanidin	10	535	19	+
Peonidin	17	532	25	-
Delphinidin	7	546	16	+
Petunidin	12	543	17	+
Malvidin	19	542	19	-
Peak #l	8	548	16	+
Peak #2	10	538	22	+

Table 2. Cyanidin and delphinidin in red-flowered petals of four *Sarracenia* species as a percentage of total anthocyanidins. (Means for three samples +/- SD).

	Anthocyanin	
Species	Cyanidan	Delphinidin
S. leucophylla	100 +/- 0	0
S. psitticina	89 +/- 5	11 +/- 5
S. purpurea	56 +/- 2	44 +/- 2
S. rubra	100 +/- 0	0

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