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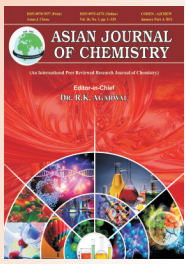

Phenylpropanoids in *Agastache foeniculum* and Its Cultivar *A. foeniculum* 'Golden Jubilee'

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The present study describes the level of phenylpropanoids in the organs (leaf, flower, stem and root) of *Agastache foeniculum* and its cultivar *Agastache foeniculum* 'Golden Jubilee.' Analysis confirmed the presence of 3 different phenylpropanoids *i.e.*, rosmarinic acid, tilianin, and acacetin. Rosmarinic acid accumulation was higher in the roots of both species, it being 6.3, 4.3 and 11.3 times higher in the roots of *A. foeniculum* 'Golden Jubilee compared to the flower, leaf and stem, respectively of the same. Tilianin accumulation was higher in all 'Golden Jubilee' organs compared to *A. foeniculum*; in particular, the Golden Jubilee flower contained 50 times more tilianin compared to the root of *A. foeniculum*. Tilianin was not detected in the stem of *A. foeniculum*. Acacetin accumulation was lower in the various plant parts of both *A. foeniculum* compared to other phenylpropanoids, even though the greatest amount of acacetin was accumulated in the flower. The findings of this study indicate that the flower and root of *A. foeniculum*, particularly the cultivar Golden Jubilee, might be important for higher rates of phenylpropanoid production, which are of high medicinal value.

Keywords: *Agastache foeniculum* 'Golden jubilee', phenylpropanoid, Leaf, Stem, Flower, Root.

INTRODUCTION

Agastache rugosa Kuntze is a perennial herb of the mint family (labiatae) that is widely distributed throughout east Asian countries. This plant is a widespread herb that has been used as a wild vegetable and herbal drug in traditional therapies in Korea[1]. The leaves of *A. rugosa* are used in cooking to season fish-based foods and its flowers are a prime source of nectar for honey[2-4]. Studies have indicated that *A. rugosa* has a range of pharmacological activities, including anti-HIV integration activities and antifungal effects[5-6]. Extracts of *A. rugosa* are also believed to be valuable in the treatment of inflammatory and oxidative stress-induced disorders[7-8].

Another species in the genus *Agastache*. *Agastache foeniculum* (Pursh) Kuntze, is also a perennial herb. This herb originates from the north-central and northern regions of North America and was traditionally used by Native Americans as a medicine to treat coughs, fevers, wounds and diarrhea. The special feature of this herb is its anise-scented leaves, which are used as a seasoning to prepare tea and in potpourri. Moreover, the characteristic purple flower spike attracts bees, which collect the nectar to make a fragrant honey[9,10].

Many different species and cultivars of *Agastache* may be purchased from nurseries, including Agastache 'Purple Haze,' Agastache 'Blue Fortune,' *Agastache* 'Golden Jubilee,' *Agastache* 'Black Adder,' and *Agastache* rupestris (www.northcreeknurseries). These cultivars have been named based on the color of the flowers and sometimes leaves. Among the cultivars, *Agastache* 'Golden Jubilee' received the 2003 quality award in the fleuroselect trials across Europe, in addition to the All-American Selections (ASS) gold medal when trialed across the USA in the same year. In the ASS award, this cultivar scored the highest ranking for length of bloom time and ease of growth. The name 'Golden Jubilee' commemorates the 50-year reign of the United Kingdom by Queen Elizabeth II. It was the very first golden-leafed *Agastache* and was bred by K. Sahin Zaden in Holland[11] (http://www.sahin.nl/2012/items/AG2075.php).

Agastache spp. contain several types of essential oils, including sesquiterpenes, diterpenes, triterpenes, flavonoids and carotenoids[12-15]. At present, natural product chemists and clinicians are interested in tilianin because of its important biological activities, including its antiinflammatory, antiatherogenic, antihypertensive and vasorelaxant effects[7,16,17]. In the

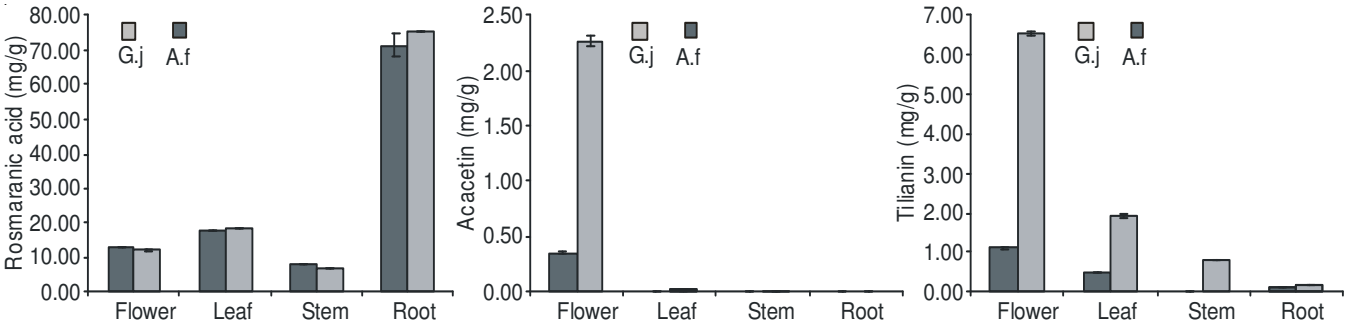

Fig. 1. Accumulation of rosmarinic acid, tilianin and acacetin in the different organs of *A. foeniculum* and its cultivar *A. foeniculum* 'Golden Jubilee.' The values and error bars represent the mean and standard error of 3 independent measurements, respectively. A.f, *Agastache foeniculum*; G.j, *Agastache foeniculum*, Golden Jubilee

plant kingdom, rosmarinic acid is believed to be a preformed, constitutively accumulated defense compound[18]. Due to its pharmacological properties, the biosynthesis and production of rosmarinic acid in plants has been extensively studied[19,20]. Therefore, in the present study, we compared the levels of phenylpropanoid content and potential for accumulation in various plant organs (*i.e.*, the leaf, stem, flower and root) of *A. foeniculum* and an important cultivar *Agastache foeniculum* 'Golden Jubilee.' This information is important to identify the optimal cultivar to extract phenylpropanoids for medicinal purposes.

EXPERIMENTAL

Seeds of *A. foeniculum* and *A. foeniculum* 'Golden Jubilee' (referred to as 'Golden Jubilee' from this point) were grown at the experimental farm of Chungnam National University (Daejeon, Korea). The flowers, leaves, stems and roots were excised from mature plants. The samples were immediately frozen in liquid nitrogen and then stored at -80 °C and/or freeze-dried for high-performance liquid chromatography (HPLC) analysis.

Extraction and HPLC analysis: Samples (0.1 g) were frozen in liquid nitrogen, ground to a fine powder using a pestle and mortar and then extracted with 10 mL of 70 % ethanol for 1 h at 60 °C. After centrifugation, the supernatant was filtered through a 0.45-mm poly filter (Acrodisc Syringe Filters; Pall, Port Washington, NY) and analyzed using HPLC. The analysis was performed with a C_{18} column (250 mm × 4.6 mm, 5 µm; RStech, Daejon, Korea) at 30 °C. The mobile phase was a gradient mixture of acetonitrile, methanol and 0.2 % acetic acid. The flow rate was maintained at 1 mL × min^{-1}, with an injection volume of 20 µL and a detection wavelength of 275 nm. The concentration of tilianin, acacetin and rosmarinic acid in the samples was calculated using a standard curve. Mean values were obtained from 3 independent replicates.

RESULTS AND DISCUSSION

HPLC was used to measure tilianin, its precursor acacetin and rosmarinic acid in the flowers, leaves, stems and roots of both *A. foeniculum* and its cultivar Golden Jubilee (Fig. 1). Rosmarinic acid accumulation was much higher in the roots of both *Agastache* spp., but was 23 % higher in Golden Jubilee (Fig. 1). The root of Golden Jubilee contained 6.3, 4.3 and 11.3 times more accumulated rosmarinic acid compared to the flower, leaf and stem, respectively. Both *A. foeniculum* and Golden Jubilee accumulated similar amounts of rosmarinic acid in the different plant parts; however, rosmarinic acid levels were slightly higher in the flower and root of *A. foeniculum* and in the leaf and root Golden Jubilee. More tilianin accumulated in all organs of Golden Jubilee compared to *A. foeniculum*. Tilianin accumulation was greatest in the flower of *A. foeniculum*, followed by the leaf, stem and root (Fig. 1). The flowers of Golden Jubilee accumulated 50 times more tilianin compared to the root of *A. foeniculum*. Tilianin was not detected in the stem of *A. foeniculum*. Lower levels of acacetin were accumulated in the different parts compared to other compounds. However, the highest amount of acacetin accumulated in the flower of 'Golden jubilee' with a concentration of 2.27 mg/g dry weight. Acacetin concentrations were much lower in the stem (0.01 mg/g dry weight) and leaves (0.02 mg/g) of Golden Jubilee and could not be detected at all in the leaf, stem, or root of *A. foeniculum*.

Recently, our research group demonstrated a variable carotenoid content in *A. rugosa* and *A. foeniculum*, with considerable variation among organs[21]. In another study, our research group also confirmed that there is variation in the chemical composition of essential oils from the flower and leaf of Korean mint, *A. rugosa*[22]. Significant variation was recorded in the oil content of the leaves and flowers of different *Agastache* spp. cultivars[22]. However, variation in essential oil composition was higher in *A. foeniculum* cultivars compared to *A. rugosa* cultivars[23]. In the current study, we also demonstrated that different plant organs and species exhibit different levels of phenylpropanoid content, supporting previous reports[21-23]. There was wide variation in the phenylpropanoid content (rosmarinic acid, tilianin and acacetin) of the different plant organs from both *A. foeniculum* and *A. foeniculum* 'Golden Jubilee.' However, the roots contained the highest levels of rosmarinic acid, while the flowers contained the highest levels of tilianin and acacetin in both *Agastache* species.

Conclusion

Of interest, the cultivar *A. foeniculum* 'Golden Jubilee' contained a higher amount of all the phenylpropanoids compared to the original species. Therefore, the flowers and roots of *A. foeniculum* 'Golden Jubilee' might be a potential commercial source for the production of medicinally important phenylpropanoids.

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