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SHORT COMMUNICATION

Phenolic constituents of the aerial parts of *Impatiens glandulifera* Royle (Balsaminaceae) and their antioxidant activities

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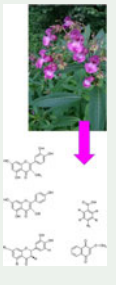
ABSTRACT

As a continuation of investigating *Impatiens* L. genus, eight flavonoids, eriodyctiol, eriodyctiol 7-*O*-β-D -glucoside, kaempferol 3-*O*-β-D -glucoside, kaempferol 3-*O*-β-D -galactoside, kaempferol 3-rhamnosyl-di-glucoside, kaempferol 3-*O*-β-D -rutinoside, quercetin 3-*O*-β-D -glucoside and quercetin 3-*O*-β-D -galactoside, two phenolic acids – p-hydroxybenzoic acid and protocatechuic acid, and 2-methoxynaphthalene-1,4-dione were isolated from the aerial parts of *I. glandulifera* collected in Poland. The structures of the compounds were established by analysis of their spectroscopic (^{1}H and ^{13}C NMR) and spectrometric (MS) data, as well as by comparison of these with those reported in the literature. Quercetin 3-*O*-β-D -glucoside, kaempferol 3-*O*-β-D -galactoside and kaempferol 3-*O*-β-D -rutinoside were isolated for the first time from the investigated taxon. In addition, the antioxidant activities in different tests of all obtained compounds were evaluated. The results clearly showed that among analyzed constituents, quercetin 3-*O*-β-D -glucoside exhibited antioxidant activity comparable or better than ascorbic acid and Trolox which were used as a positive control.



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1. Introduction

Impatiens glandulifera Royle (Himalayan balsam), belonging to the Balsaminaceae family, is perennial plant growing in riparian zones along rivers on humid soils and in wet woodlands (Vieira et al. 2016). The species is among the invasive plants, originally native to Asia, that is rapidly spreading across Europe (Tříska et al. 2013).

It has been reported that some species in the genus, I. balsamina L. and I. walleriana Hook.f. especially, have valuable biological activities. *I. balsamina* have been applied for a very long time in traditional Asian and American medicine. Depending on the kind of disease, dried herb and leaves of the species have been used as a compresses on the skin or as a tea (Yang et al. 2001). The specimen found also an application in Chinese medicine in rheumatism therapy, and in fractures, swellings, contusions, as well as in the beriberi disease (Fukumoto et al. 1996; Jiang et al. 2017).

In our previous study, we confirmed that the methanol extract from the aerial parts of *I. glandulifera* contained significant amounts of phenolics and flavonoids and has antimicrobial and antioxidant activities (Szewczyk et al. 2016).

The present study deals with the isolation and identification of phenolic constituents from the aerial parts of *I. glandulifera* collected in Poland. The antioxidant activity of the isolated compounds was also evaluated.

2. Results and discussion

2.1. Identification of isolated compounds

In the course of a phytochemical study of the methanolic extracts from the aerial parts of *I. glandulifera*, eight flavonoids, two phenolic acids and 2-methoxy-1,4-naphthoquinone were isolated using column chromatography and preparative HPLC.

The compounds were identified as 3,4-dihydroxybenzoic acid, protocatechuic acid (**1**) (Chang et al. 2009), p-hydroxybenzoic acid (**2**) (Cornelius et al. 2010), eriodictyol 7-*O*-β-D-glucoside (**3**) (Ragab et al. 2010), quercetin 3-*O*-β-D-galactoside, hiperoside (**4**) (Ye and Huang 2006), quercetin 3-*O*-β-D-glucoside, isoquercitrin (**5**) (Zinsmeister et al. 1977), kaempferol 3-*O*-β-D -galactoside, trifolin (**6**) (Wolbiś et al. 2007), kaempferol 3-*O*-β-D-rutinoside, nicotiflorin (**7**) (Nishina et al. 2017), kaempferol 3-*O*-β-D-glucoside, astragalin (**8**) (Demirezer et al. 2006), eriodictyol (**9**) (Ye and Huang 2006), kaempferol 3-rhamnosyl-diglucoside (**10**) (Fukumoto et al. 1994), and 2-methoxynaphthalene-1, 4-dione (**11**) (Ortin and Evans 2013) based on NMR and MS data as well as by comparison with literature data of the above and related compounds. The structures of all isolated compounds are shown in Figure S1.

The presence of compounds **1** and **2** were previously described in the leaves, flowers, and roots of *I. glandulifera* (Szewczyk and Olech 2017) but these acids were isolated for the first time in this study. Moreover, Vieira and co-authors (2016) isolated **3**, **4**, **8** and **10** from the the flowers of *I. glandulifera*, collected in Germany. Compound **11**, isolated in this study, was earlier identified in the leaves (Chapelle 1974; Lobstein et al. 2001), flowers (Lobstein et al. 2001; Ortin and Evans 2013), seed pods (Ortin and Evans 2013), stems (Lobstein et al. 2001; Cimmino et al. 2016) and methanol extract from the roots (Tříska et al. 2013; Cimmino et al. 2016) of *I. glandulifera*.

Isoquercitrin (**5**), trifolin (**6**) and nicotiflorin (**7**) were isolated for the first time from the investigated species. Although, **5** was earlier described in the leaves and stems of *I. balsamina* (Chua 2016), leaves of *I. bicolor* Royle (Hasan and Tahir 2005), herb of *I. noli-tangere* L. (Paun et al. 2018), and the aerial parts of *I. parviflora* DC. (Szewczyk et al. 2016). Trifolin (**6**) was only found in the leaves of *I. bicolor* (Hasan and Tahir 2005).

2.2. Antioxidant activities

In our earlier report (Szewczyk et al. 2016), methanolic extract from the aerial parts of *I. glandulifera* showed the highest antiradical activity among six species studied. Based on these results, we decided to verify the antioxidant potential of isolated compounds from this taxon.

The antioxidant activities of all isolated compounds were determined employing the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2-azino-bis-(3-ethyl-benzthia-6-sulfonic acid) (ABTS) radical scavenging assays. For all samples it was found that the radical scavenging activity depended on concentration. At a dose of 1.0 mg/mL, the DPPH scavenging abilities were the highest for compound **2** (98.69%), **5** (97.95%) and **3** (95.75%), and in the ABTS· test for **5** (99.05%), **2** (97.26%) and **4** (96.32%). The EC_{50} values for scavenging DPPH and ABTS radicals are presented in Supplementary Table S1. Among the analyzed compounds, isoquercitrin (**5**) ($EC_{50} = 0.01 \pm 0.03$ mg/mL for ABTS and 0.11 ± 0.01 mg/mL for DPPH radicals) exhibited antioxidant activity comparable or better than ascorbic acid ($EC_{50} = 0.18 \pm 0.01$ for ABTS and 0.11 ± 0.01 mg/mL for DPPH radicals) and Trolox ($EC_{50} = 0.20 \pm 0.01$ for ABTS and 0.09 ± 0.01 mg/mL for DPPH radicals) which were used as a positive control.

The most active compound, **5** showed even up to eighteen-times higher EC_{50} value than the Trolox. This is not in accordance with results reported for this compound reported by Lee et al. (2015). The authors studied antioxidant activity of pure chemical compounds, e.g. hiperoside and isoquercitrin, and these compounds also showed high activity, however worse than ascorbic acid used as positive control.

3. Conclusions

The phytochemical investigation of the aerial parts of *I. glandulifera* let to isolation and identification eleven phenolic compounds. Among these, hiperoside was the predominant compound. Isoquercitrin, trifolin and nicotiflorin were isolated for the first time from the investigated species.

Moreover, our findings demonstrated that isolated compounds, especially p-hydroxybenzoic acid, eriodictyol 7-*O*-β-D-glucoside, hiperoside and isoquercitrin, exhibit a strong activity against DPPH and ABTS radicals.

Taking into account results of present as well as previously published studies, it is reasonable to conclude that *I. glandulifera*, is an abundant source of health benefitial secondary metabolites.

Disclosure statement

No potential conflict of interest was reported by the authors.

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