Biochemical Systematics and Ecology 80 (2018) 94–121

Contents lists available at ScienceDirect

Biochemical Systematics and Ecology

journal homepage: www.elsevier.com/locate/biochemsyseco

Phytochemistry of the genus *impatiens* (Balsaminaceae): A review

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ARTICLE INFO

Keywords:
Balsaminaceae
Impatiens
Chemosystematics
Flavonoids
Quinones
Terpenes

ABSTRACT

The genus *Impatiens* L. belongs to the Balsaminaceae family and includes more than 480 accepted species. This genus grows in tropical and subtropical regions, mostly in tropical Africa, India, southwestern part of Asia, and southern China. Various phytochemical studies have been conducted; however, there are no recent reports that provide a comprehensive summary of the phytochemistry of *Impatiens* L. The review summarizes literature data on chemical components identified in the species of *Impatiens* L. The available information was collected from scientific databases through a search using the keyword '*Impatiens*'. Phytochemical studies led to the identification and/or isolation of 300 different compounds that have been reported from 27 species. These compounds encompass flavonoids, phenolic acids, coumarins, quinones, triterpenoid saponins, sterols, and alkaloids. Additionally, phytochemical compositions of the essential oils of some species have been evaluated.

1. Introduction

The genus *Impatiens*, belonging to the Balsaminaceae family, encompasses approximately 500 (Fischer, 2004; Grey-Wilson, 1980; Yu et al., 2016). In the eighteenth century, Carolus Linnaeus distinguished seven species of *Impatiens* ("Species Plantarum", 1753). Early research focused primarily on species found in Asia and eastern Africa, and then gradually began to include species from other parts of the world. Hooker (1908) presented the first thorough study of 158 species that was focused on plant morphology and encompassed a preliminary classification. Apart from these early studies, attempts to describe the whole genus were not performed for a long time. One of the reasons was that *Impatiens* taxa were deemed particularly difficult research objects due to their morphology. Difficulties for scientists resulted primarily from the large number of species and the inability to conduct comparative research on all of them. In addition, examination of herbarium material is demanding due to semi-succulent stems, fleshy leaves, and fragile flowers. Moreover, capsules and seeds are heterogenous, and due to the ballistic form of seed dispersal prevalent in the genus, explosive dehiscence, mature seedpods are nearly impossible to study morphologically. These factors may affect the clarity of test results (Grey-Wilson, 1980; Lu and Chen, 1991; Yu et al., 2016). According to the current listing in the taxonomical internet database (www.theplantlist.org; accessed 05 February 2018), the genus comprises 488 accepted taxa.

Impatiens species have been identified especially in tropical and subtropical regions, primarily in the Old World flora in such areas as tropical Africa, India, southwestern part of Asia, southern China, but also in Japan, in the northern zone of Europe, Russia and North America (Fischer, 2004; Grey-Wilson, 1980; Song et al., 2003; Utami, 2012; Yu et al., 2016). The taxa occur from sea level to 4000 m altitude (Yu et al., 2016) and often grow in forests margins, in valleys, roadside troughs, and along streams, generally on humid soils (Vrchotová et al., 2011; Yu et al., 2016).

Some species in the genus, *I. balsamina* L. and *I. walleriana* Hook. f. in particular, have pharmaceutical importance. Furthermore, some taxa are planted as ornamentals. However, due to such cultivations outside the respective home ranges, some species have become invasive pests, e.g. *I. capensis* Meerb., *I. parviflora* DC., and *I. glandulifera* Royle (Bartomeus et al., 2010; Skálová Jarosik, 2013). On the other hand, some species have become endangered in their native ranges and currently 32 species of *Impatiens* are listed in the Red List as threatened (IUCN, 2018).

In the present review, the phytochemistry of the genus *Impatiens* is discussed. For a comprehensive literature overview, published phytochemical data were retrieved from the ISI®Web of Science, ®Scopus, ®GoogleScholar, ®SciFinder, and ®Reaxys databases. Entries were considered until the end of February 2018. Exact spelling of scientific botanical names, including the abbreviations for botanical authors was brought in line with standard usage as recommended by "The International Plant Names Index" (www.ipni.org) and "The Plant List" (www.theplantlist.org).

2. Summary of literature data

The current literature contains studies describing the chemistry of

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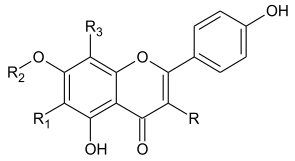
https://doi.org/10.1016/j.bse.2018.07.001
Received 18 April 2018; Received in revised form 1 July 2018; Accepted 4 July 2018
Available online 09 August 2018



Compound	R	R_1	R_2	R_3	MW
1	OH	H	H	H	286
2	*O*-glc	H	H	H	448
3	*O*-[2"-*O*-α-L-rha-3"-*O*-β-D-glc]-β-D-glc	H	H	H	756
4	*O*-rha-glc	H	H	H	594
5	*O*-glc-rha	H	H	H	594
6	*O*- p-coumaroyl-glc	H	H	H	594
7	H	H	glc	H	448
8	gal	H	H	H	448
9	H	H	xyl	H	418
10	*O*-hexosyl	hexosyl or H	hexosyl or H	hexosyl or H	610
11	*O*-mal-6-glc	H	H	H	534
12	*O*-rha	*O*-gal	H	*O*-gal	756
13	*O*-α-L-rha-(1→6)-β-D-glc	H	H	H	594
14	*O*-α-L-rha-(1→6)-β-D-glc	H	H	H	594
15	*O*- β-D-all	H	H	H	448
16	*O*-α-rha-β-glc-β-glc	H	H	H	756

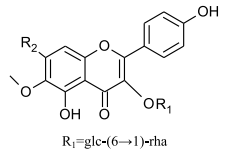
Fig. 1. Kaempferol and kaempferol *O*-glycosides.

27 *Impatiens* species. In the phytochemically studied species, the following classes of compounds have been identified: phenolic compounds, including flavonoids, phenols, coumarins; quinones, including naphthoquinones and antraquinones; and triterpenes, consisting of triterpenoid saponins. In the following sections these metabolites are discussed.

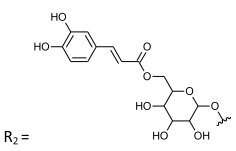
2.1. Flavonoids

Phytochemical investigations of *Impatiens* species have led to the isolation different types of flavonoids, represented mostly by flavonols, flavones, and anthocyanins. Their structures are summarised in Figs. 1–11.

One of the first study on the occurrence of flavonoids in taxa of the genus *Impatiens* genus stems from 1958. Clevenger (1958) described the occurrence of kaempferol (**1**), quercetin (**27**), and myricetin (**45**) in the flowers of *I. balsamina* L.



R_1=glc-(6→1)-rha



R_2 =

Fig. 2. Chemical structure of compound **17** [MW = 950].

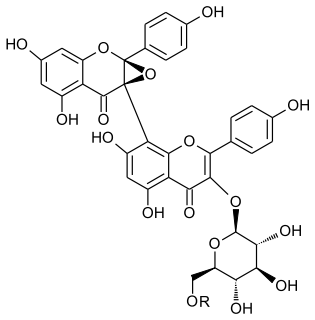


Fig. 3. Chemical structure of compound **18** (R = H; MW = 732) and **19** (R = α-L-rha; MW = 878).

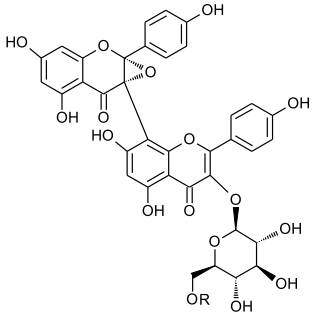
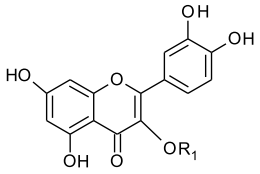


Fig. 4. Chemical structure of compound **20** (R = H; MW = 732) and **21** (R = α-L-rha; MW = 878).



Compound	R_1	R_2	R_3	R_4	R_5	MW
27	H	H	H	H	H	302
28	β-D-glc	H	H	H	H	464
29	rut	H	H	H	H	610
30	α-L-rha-(1→2)-β-D-glc	β-D-glc	H	H	H	772
31	6""-*O*-caffeoyl-α-L-rha-(1→2)-β-D-glc	β-D-glc	H	H	H	934
32	gal	H	H	H	H	464
33	α-L-rha-(1→6)-β-D-glc	H	H	H	H	610
34	rut	H	CH_3	CH_3	CH_3	638
35	hexosyl	H	H	H	H	464
36	mal-6-glc	H	H	H	H	550

Fig. 5. Quercetin and derivatives.

Hagen (1966) reported that stems of *I. balsamina* (genotype $1IHHP^rP^r$) contained astragalin (**2**), isoquercitrin (**28**), and sepals compounds **1** and **28**.

From the 35% ethanol extract from fresh white petals of *I. balsamina* (Japan) **1**, **2**, kaempferol-3-*O*-[2″-*O*-α-L-rhamnopyranosyl-3″-*O*-β-D-glucopyranosyl]-β-D-glucopyranoside (**3**), nicotiflorin (**4**), **27**, and rutin (**29**) were isolated (Fukumoto et al., 1994, 1996). Among these compounds, **2–4**, and **27–28** were shown to significantly inhibit platelet-activating factor (PAF) - induced hypotension (Oku and Ishiguro,